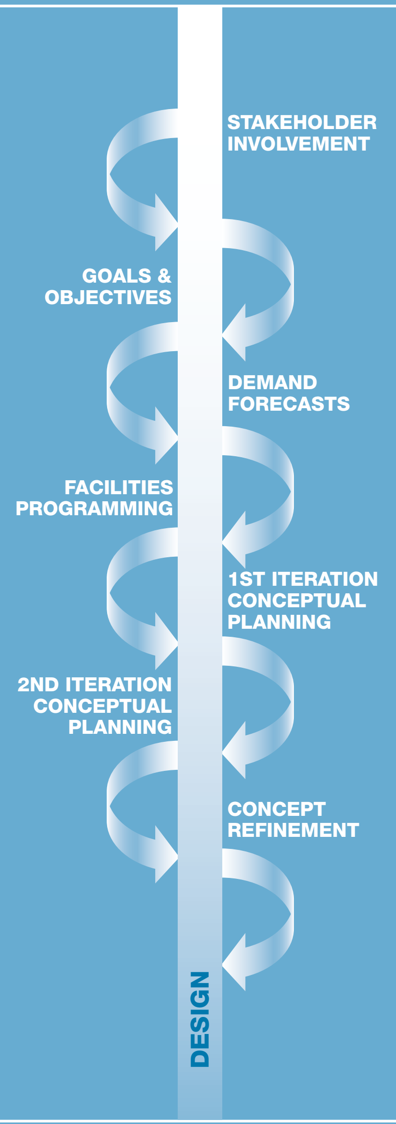
ACRP

REPORT 25

AIRPORT
COOPERATIVE
RESEARCH
PROGRAM

Airport Passenger Terminal Planning and Design

Volume 1: Guidebook



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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 25

Airport Passenger Terminal Planning and Design

Volume 1: Guidebook

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), and the Air Transport Association (ATA) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

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FOREWORD

By Theresia H. Schatz
Staff Officer
Transportation Research Board

ACRP Report 25: Airport Passenger Terminal Planning and Design comprises a Guidebook, Spreadsheet Models, and a User's Guide in two volumes and a CD-ROM to provide guidance in planning and developing airport passenger terminals and assist users in analyzing common issues related to airport terminal planning and design. Volume 1 describes the passenger terminal planning process and provides, in a single reference document, the important criteria and requirements needed to address emerging trends and create solutions for airport passenger terminals. This comprehensive Guidebook addresses the airside, terminal building, and landside components of the terminal complex. Volume 2 consists of (1) a CD containing 11 spreadsheet models, which include practical learning exercises and several airport-specific sample data sets to assist users in determining appropriate model inputs for their situations, and (2) a User's Guide to assist the user in the correct use of each model. The models on the CD include such aspects of terminal planning as design hour determination, gate demand, check-in and passenger and baggage screening, which require complex analyses to support planning decisions.

The Guidebook and Spreadsheet Models will be beneficial for airport operators, planners, designers, and other stakeholders involved in planning functional and cost-effective airport passenger terminals by providing tools that can be used immediately.

Planners and designers for all sizes of airports are struggling with how to design passenger terminals that provide good value and level-of-service efficiency that meet the criteria of many aspects of airport terminals, from security requirements and procedures to the needs of low-cost carriers and concessionaires. Practical information is needed not only to address current issues but also to provide the flexibility to accommodate emerging trends and issues. Airport passenger terminal planners and designers need up-to-date information on how to provide good value and efficiency to meet the needs of stakeholders and accommodate changing technologies, materials, regulations, and operational factors for both large and small airports.

ACRP Report 25 is the result of two separate research projects—ACRP 07-04, "Spreadsheet Models for Terminal Planning and Design," and ACRP 07-05, "Airport Passenger Terminal Planning Guidebook." Both projects were performed by Landrum & Brown as the prime contractor with the assistance of a variety of subcontractors: Hirsh Associates, Ltd.; Kimley-Horn and Associates, Inc.; Jacobs Consultancy; The S-A-P Group; TranSecure, Inc.; Steven Winter Associates, Inc.; Star Systems, LLC—A Subsidiary of Five Star Airport Alliance; Planning Technology, Inc.; and Presentation & Design, Inc.

ACRP Report 25 provides a foundation for understanding and using the results of related ACRP research projects on airport terminal planning. For a list of related projects and published reports, see Appendix B of Volume 1.

AUTHOR ACKNOWLEDGMENTS

The research reported was performed under ACRP Project 07-05 by Landrum & Brown as the prime contractor with the assistance of subcontractors Hirsh Associates, Ltd.; Kimley-Horn and Associates, Inc.; Jacobs Consultancy; The S-A-P Group; TranSecure, Inc.; Steven Winter Associates, Inc.; Star Systems, LLC—A Subsidiary of Five Star Airport Alliance; and Presentation & Design, Inc.

Bruce Anderson, Vice President of Landrum & Brown, served as the Principal Investigator and Joel Hirsh, Principal of Hirsh Associates, was the Co-Principal Investigator. The other valuable contributors to this research project included, from Landrum & Brown, Edward (Gary) Blankenship, Elizabeth Bosher, Russell Blanck, Shane Wirth, Matthew H. Lee, Rob Adams, Radhika Mathur, Barb Castro, and Stella Harward; from Kimley-Horn and Associates, Inc., Foster de la Houssaye and Adam Novak; from Jacobs Consultancy, Spencer Ballard; from The S-A-P Group, Bill Matz; from Steven Winter Associates, Inc., Andrew Zumwalt-Hathaway and Kristy O'Hagan; from TranSecure, Inc., Art Kosatka and James I. McGuire; from Star Systems, LLC—A Subsidiary of Five Star Airport Alliance, Dan Stricklin and John Swillie; and from Presentation & Design, Inc., Patti Douglas.

The authors are very grateful for the guidance and help provided by the project panels for ACRP 07-05 and ACRP 07-04.

The research team would also like to acknowledge the contribution of information provided by the FAA in the form of research White Papers prepared by various authors and provided in Appendix C of this volume.

Additionally, the research team would like to acknowledge the contributions of ACRP Project 07-04 Co-Principal Investigators Matt Lee, for his overall vision in the development of the Spreadsheet Models and their integration with the Guidebook, and Joel Hirsh, for his in-depth knowledge of terminal facilities programming and overall technical review of the Guidebook.

Finally, the authors are grateful for the time and dedication of numerous Landrum & Brown staff in the final production of the Guidebook.

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CHAPTER I

Introduction

I.1 Purpose and Organization of the Guidebook

I.1.1 Purpose

The purpose of this Guidebook is to provide an updated and focused overview regarding the planning and design of airport terminal buildings in the United States. This Guidebook's intended audience includes airport managers and their staff, airport planners, architects, and the aviation industry-at-large.

This Guidebook is intended to supplement the guidebooks provided by the International Air Transport Association (IATA) and the Federal Aviation Administration (FAA) with updated information and a fresh outlook for terminal planners and designers. This Guidebook represents a snapshot in time within a continuously evolving set of industry planning principles and regulations. As such, the reader must remain vigilant to possible updates and changes to the contents of this document.

This Guidebook attempts to provide a thorough understanding of all the issues to consider when undertaking the planning and design of terminal facilities in an ever-evolving commercial aviation market. To plan and/or design an airport passenger terminal appropriately, it is important that any future terminal facility is based on a sound quantitative program of functional requirements that are based on future forecasts of air passenger and aircraft activity. For this reason this Guidebook also includes the results of Airport Cooperative Research Program (ACRP) Project 07-04, "Spreadsheet Models for Terminal Planning and Design." Additionally, this Guidebook makes reference to other ACRP projects that have relevance to the planning and design of airport passenger terminals.

Passenger terminal projects typically arise out of a particular purpose or need at a specific airport location. A new terminal can be part of a totally new airport or an addition to an existing airport's infrastructure. There are also projects that involve the expansion or replacement of an existing terminal while other projects look to simply renovate a current facility. More often than not, the primary purpose of the majority of these terminal projects is to add capacity or improve level of service through the addition of gates and the expansion of passenger processing capacity.

There are numerous ways in which these terminal projects can be undertaken. The conceptual definition of a terminal project can be formulated under an FAA Airport Master Plan that will determine the demand forecasts, facility requirements, and a general site plan configuration of the terminal complex, which then becomes a part of the Airport Layout Plan. Other airport-sponsored studies can focus just on the development of the terminal and are sometimes labeled a "Terminal Area Master Plan," which can vary in detail from a simple conceptual vision of the future terminal to a Program Criteria Document that sets out a detailed facilities requirement program tailored to a particular concept, depicts the terminal complex site plan, and diagrammatically depicts the terminal building floor plans. Individual terminal projects also can be initiated by an air carrier's strategic business plan as related to a particular airport or can be sponsored by a government entity associated with an airport looking to implement a new terminal through the non-traditional source of a third-party developer. Once a terminal project is sufficiently defined relative to its mission, facility requirements, and planning configuration, it can move forward toward its design and implementation.

Regardless of the terminal's mission or the way the project is to be implemented, it is the intent of this Guidebook to set forth guidelines for undertaking the terminal planning process and to provide insights on potential issues and future trends that may affect and influence the ultimate airport terminal facility solution.

I.1.2 Organization of the Guidebook

This Guidebook is organized to reflect the fundamental sequence of events that are undertaken during a typical terminal project, including organizing the project approach; gaining an understanding of the project as a whole by gathering existing information and interacting with stakeholders; forecasting demand activity; preparing facility requirements; and iteratively developing conceptual terminal planning options that collectively address the airside, terminal, and landside components resulting in the selection of a preferred alternative. More specifically the Guidebook includes the following:

- Chapter I, Introduction—provides the reader with an overview of previous industry-recognized terminal planning guides and the underlying need for new guidance in the planning of airport passenger terminals. This overview is followed by a brief retrospective of air passenger terminals.
- Chapter II, Terminal Planning and Design Process—provides a general overview of the terminal planning and design process. The terminal complex is divided into three distinct components—airside, terminal, and landside—which then serve as the framework for discussion in the subsequent terminal facilities sections of the Guidebook.
- Chapter III, Planning Considerations—describes a multiplicity of macro-level factors that should be considered during the planning and design processes.
- Chapter IV, Forecasts—provides an overview of the forecasting techniques for future aircraft and passenger demands with emphasis on how this relates to the terminal planning process.
- Chapter V, Terminal Airside Facilities; Chapter VI, Terminal Building Facilities; and Chapter VII, Terminal Landside Facilities—describe the technical planning aspects of the three primary components of the terminal complex: airside, terminal, and landside facilities.
- Appendices A through I—provide the reader with checklists; information on other pertinent ACRP studies; aircraft types and key dimensional criteria; dimensions of airline equipment; regulations; issues and trends; and a comprehensive glossary of key terms.

Throughout the Guidebook, other ACRP references are identified. Volume 2 of this report comprises (1) a CD-ROM containing the Terminal Planning Spreadsheet Models for the calculation of gates and critical passenger processing functions of the terminal building and terminal curbfront and (2) the User's Guide for the Spreadsheet Models.

I.2 Previous Terminal Planning Guides

In the early 1970s, two terminal planning guides were sponsored by the FAA. Participation in the creation of these was orchestrated by a leading architecture and engineering contractor—The Ralph M. Parsons Company (now called Parsons) of Pasadena, California.

Participants or stakeholders in the guides included the Air Transport Association and its representative airlines (United Airlines, American Airlines, Eastern Air Lines, Piedmont Airlines, Delta Air Lines, Trans World Airlines, Allegheny Airlines, Frontier Airlines, National Airlines, and Pan American Airways); the Airport Operators Council International and representative airports (Miami International Airport, Dallas/Fort Worth International Airport, Port Authority of New York and New Jersey, O'Hare International Airport, Los Angeles International Airport, Cincinnati/North Kentucky International Airport, and Ottawa International Airport); as well as all major divisions within the FAA.

The first FAA terminal planning guides were titled:

- *The Apron-Terminal Complex,* 1973 (*1*)
- *The Apron* & *Terminal Building Planning Manual,* 1975 (*2*)

These planning guides served the U.S. aviation industry for many years. Figure I-1 depicts the first FAA terminal planning guides.

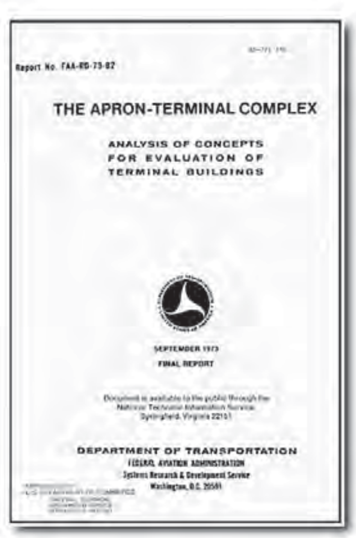
In addition to the FAA guidelines, the IATA began to publish comprehensive airport planning guides entitled the *Airport Development Reference Manual* (ADRM) (*3*) that have proved to be a significant and valuable terminal planning resource. The IATA ADRM (depicted in Figure I-2) is based on guidelines that in some cases are not indicative of U.S. practices.

Where applicable, information from these FAA and IATA sources has been included in this Guidebook for the user's convenience, but because these guidelines frequently change, please check for the latest version for potential revisions.

Participants in the development of the latest version of the ADRM (9th Edition published in 2004) included IATA and representative airlines, as well as other airport industry contributors. The IATA ADRM is available online at http://www.iata.org/ps/publications/ADRM.htm.

I.3 Current Need for Terminal Planning Guidance

The FAA guidelines were published in 1988 as *Planning and Design Guidelines for Airport Terminal Facilities,* Advisory Circular 150/5360-13 (*4*). The basis for this document was the 1973 and 1975 planning guides produced by the FAA. Since then there have been only minor changes (made in 1994), principally to sections dealing with Federal Inspection Services (FIS) facilities.



Report No. FAA-RD-73-82

THE APRON-TERMINAL COMPLEX

ANALYSIS OF CONCEPTS
FOR EVALUATION OF
TERMINAL BUILDINGS

SEPTEMBER 1973
FINAL REPORT

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20591

The Apron Terminal Complex, 1973

Report No. FAA-RD-75-191

THE APRON & TERMINAL BUILDING
PLANNING MANUAL

JULY 1975

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

NATIONAL TECHNICAL INFORMATION SERVICE

The Apron & Terminal Building Planning Manual, 1975

Figure I-1. First terminal planning guides.

Courtesy of: International Air Transport Association

Figure I-2. IATA Airport Development Reference Manual.

Since the last update, significant changes in technology, industry structure, and airline operations have occurred, which have shifted the balance of importance of certain planning factors for airport terminal buildings. These shifts in balance have occurred in areas that include, but are not limited to, the following:

- Passenger security screening
  - Carry-on baggage restrictions
  - Trusted/registered traveler programs
  - Additional screening requirements
- Baggage security screening
  - In-line/explosives detection system screening
  - Lobby screening
- Electronic check-in
  - On–airport
  - Off–airport
  - Airline goals for electronic check-ins
- Low-cost airlines
  - Gate utilization
  - Space requirements
  - Level of service standards
  - Design criteria
- Concessions
  - Secure/non-secure
  - Demand increases
- Cost effectiveness
  - Revenue generation
  - Cost per enplanement
  - Capital cost factors (fuel, steel, long-lead items)
- Consolidation of FIS agencies and procedural changes

While each of the foregoing factors have had a profound effect on airport operations, they are part of an evolution that began at the threshold of the commercial jet age around 1960 and will, in all likelihood, continue to evolve and change as long as air travel is the preeminent means of transport for millions of people worldwide.

It is the intent and purpose of this Guidebook to achieve a balance in the terminal planning and design process by addressing recent changes that have occurred, as well as future potential issues, trends, anticipated effects, and solutions that may need to be considered in the future.

I.4 Retrospective

From a historical perspective, airport terminals are a relatively new building concept that has evolved in step with the requirements of the commercial aviation industry, which is today still less than 100 years old. In spite of their relative "newness," airport terminals have acquired a significant place in the lives of U.S. citizens, many of whom travel regularly by air domestically and, to a lesser extent, to international destinations. In recent years expectations of the scale and grandeur of airport terminals have grown as cities increasingly regard their major airports as iconic symbols of their status and economic success, fulfilling a position much like the great railway stations of the 19th Century and the great European cathedrals of the Middle Ages. Figure I-3 depicts Saint Peter's Basilica, Grand Central Station, and the terminal interior at John Wayne Airport (JWA).

The earliest terminals in the United States date from the late 1920s, when commercial aviation was in its infancy. Figure I-4 depicts one of the earliest terminals built at an airport. Given the limited capacity and range of passenger aircraft, most people still traveled by train throughout the 1930s and 1940s. The relatively high cost and limited availability meant that air travel was essentially restricted to a wealthy elite and most commercial flights offered exclusively what we would now consider "First Class" service well into the 1950s. At the same time, airport terminals evolved as important civic or national symbols and with designs often tailored to meet the needs

(i) St. Peter's Basilica (ii) Grand Central Station (iii) Interior JWA Terminal

Courtesy of: (i) Landrum & Brown; (ii) Bettmann Archive; (iii) Gensler

Figure I-3. European cathedrals, 19th Century railway stations, and modern airports are iconic symbols of city status.

Courtesy of: Los Angeles World Airports

Figure I-4. LAX 1927 Flying Service Club.

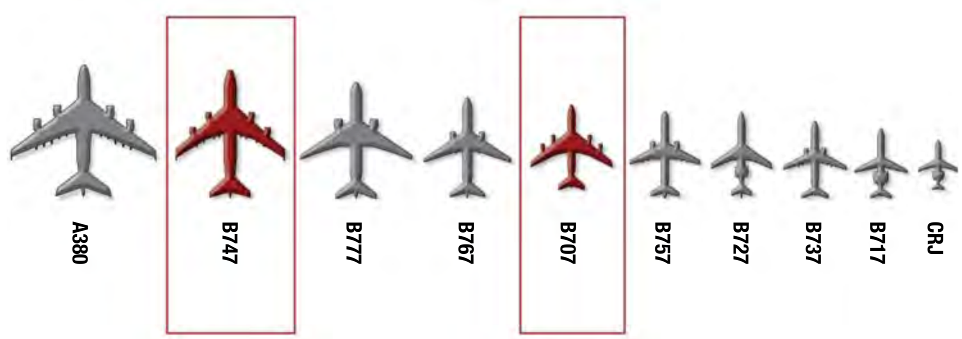
of a particular airline. Aesthetic considerations typically predominated over functionality and flexibility, a trend that would be significantly reversed after 1960.

The advent of jet-engined aircraft in the 1960s transformed civil aviation. Between 1960 and 1970, most airline fleets converted to jets, which were larger, faster, and more comfortable than their piston-engined counterparts. Coach travel was introduced making it more economical for people to fly. Between 1960 and 1970, air passengers in the United States increased approximately 173%—the largest percentage increase ever recorded in a decade in U.S. aviation history.

This same decade saw jet aircraft evolve from the B707/DC-8/CV880-990 in the early 1960s (typical capacity of 125 to 150 passengers) to the B747-100 in 1969 to 1970 (typical capacity of 350 to 450 passengers). Figure I-5 depicts the 300% growth in aircraft capacity. Travel by air began to replace rail and ocean liner as the favored modes of transport for long-distance travel.

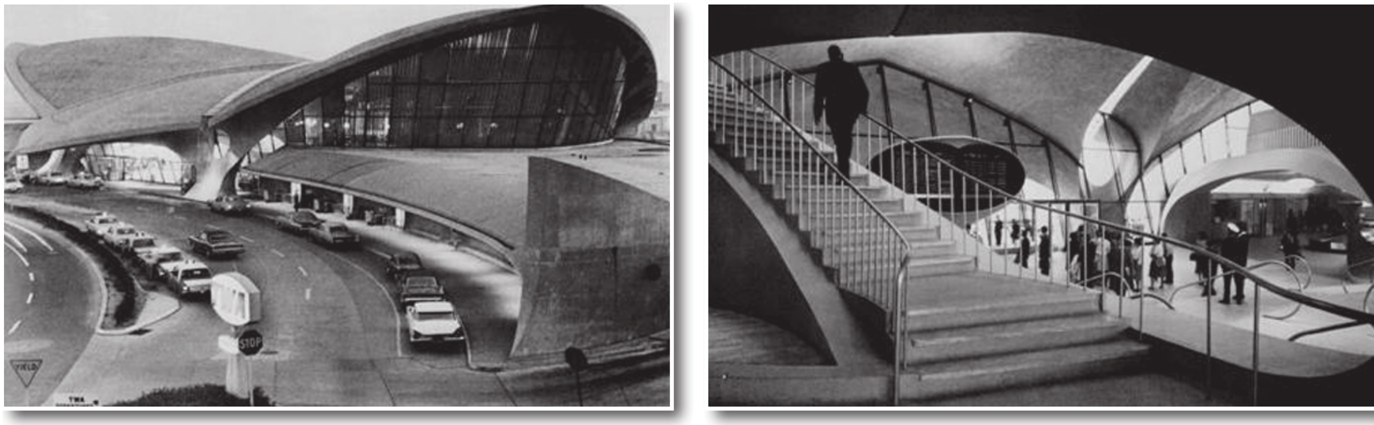
With the larger capacity jet aircraft came increased demands on terminal buildings. Greater efficiency and flexibility were needed to accommodate higher numbers of passengers and baggage. Terminal buildings had to move beyond niche designs, catering to a few wealthy patrons, to become vast "processors" capable of accommodating thousands of passengers and the associated baggage during peak periods. Airport terminal planners of the 1960s had no guidelines to work from. Experimentation was the rule. Today we have the good fortune to be able to look back and see which terminal designs have worked and which have not, which have proved flexible enough to grow with demand, and which were inflexible to change.

Perhaps the most dramatic examples of flexibility and inflexibility in airport terminal design in the 1960s were created by the same architect, Eero Saarinen, in 1961 and 1962. Saarinen's



Source: Landrum & Brown

Figure I-5. Aircraft capacity growth.



Courtesy of: *The Airport,* Edward G. Blankenship: Ezra Stoller Associates, Rye, NY, and Trans World Airlines, Inc., New York, NY

Figure I-6. Art form of TWA Terminal at JFK Airport.

TWA Terminal at New York City's John F. Kennedy International Airport (JFK) opened to rave reviews for its innovative beauty and creative design in 1961. As a work of art, the TWA Terminal, called "Bird in Flight," was an unparalleled success, but as a terminal building, it proved over time to be functionally deficient due to its spatial complexity and structural rigidity. Figure I-6 depicts JFK's TWA Terminal, created in the 1960s.

Saarinen's second terminal design at Dulles International Airport (IAD) was a significant planning departure from the JFK terminal and visualized a bold new direction in operational flexibility—the mobile lounge concept. Completed in 1962, Saarinen's main terminal at IAD has been able to successfully adapt and change, primarily as a result of its modular design and the visionary planning that situated the airport on almost 12,000 acres of land in the Virginia suburbs of Washington, DC. While brilliant in concept, the operation and maintenance costs of the mobile lounge vehicles combined with the added complexity of closing out flights early to allow for the delivery of passengers to the aircraft precipitated the abandonment of the mobile lounges. Expanded several times in its modular framework, IAD has been converted to a satellite configuration with an underground automated people mover system. Figure I-7 depicts the IAD terminal.

While the IAD terminal continues to serve as a major international hub, the TWA Terminal has been preserved, but is unused for passenger processing, and has been consigned to the National Register of Historic Places since 2001.

Source: *The Airport,* Edward G. Blankenship: FAA, DOT, Washington, DC

Figure I-7. Functional aesthetics of Dulles International Airport.

Saarinen's terminals, like many others built in the 1960s, were planned and designed without benefit of any guidelines, and without having had the experience provided by precedent. By the end of the decade, it was clear that more systematic terminal planning and design guidance was needed.

I.5 Airline Deregulation

The Airline Deregulation Act of 1978 (*5*) has had the greatest impact on the commercial aviation industry and ultimately on the planning and design of terminal facilities. The Act removed restrictions on entry, pricing, and routes. Between 1978 and 1985, the number of non-commuter airlines increased from 43 to 87; the number of revenue passenger miles (RPMs) almost doubled; and the share of total traffic of incumbent trunk airlines declined from 94% to 77%. Commuter/regional airlines (operating aircraft with fewer than 60 seats) increased their RPMs by a factor of seven by 1989. As competition increased, however, the number of new entrants declined and many failed. By 1990, only 44 of 148 new entrants reporting to FAA remained. During the early 1990s, higher fuel costs combined with a global recession and increased industry capacity caused the financial failure of a number of both new and long-established airlines. While new airlines continued to be attempted, most eventually failed and airlines also continued to consolidate after 2000 as costs increased and fare pricing power decreased.

However, deregulation also saw the emergence of two significant trends that have directly affected terminal planning. The most obvious is the development of airline hubs. While hubbing did exist prior to deregulation, the ability to build routes through hubs was a slow process. After deregulation, hub routing could be established quickly. The impact on terminals was dramatic. Hubs had to accommodate much higher peak volumes of passengers than originally planned, and most of these passengers would need to connect. The development of "banks" of flights had significant impacts on aircraft maneuvering in the terminal area as well as runway capacity impacts.

Passenger security screening, already required prior to deregulation, needed to be re-worked to avoid having connecting passengers go through screening again at a hub. An example of this was Dallas/Fort Worth International Airport (DFW). As American Airlines built its hub, the terminals, which were originally conceived as an origin and destination (O&D) "drive to gate" concept, required a major internal reconfiguration to provide a continuous secure corridor along its linear gate configuration (*6*).

Deregulation also saw the development of the low-cost carrier (LCC) model as typified by Southwest Airlines. This model focused on short-haul, high-frequency services that bypass hubs and use a single aircraft type. Although both Southwest and other LCCs have developed "focus cities," which allow passengers to build connections, the scheduling of flights is not based on concentrated banks of flights. The impact on terminals is a more continuous use of facilities through the day, but LCCs' emphasis on the bottom line resulted in some airport operators re-thinking how they designed and operated terminals. Many LCC operating concepts (such as no food served during a flight) have been adopted by so-called legacy carriers and have required airports to increase concessions to both serve the passengers and provide additional income (*7*).

It is likely that the industry landscape will continue to shift as airlines change their operating procedures and markets. This likelihood emphasizes the need for consideration of alternative futures in terminal planning, and flexibility in terminal design. Terminal planning and design guidelines by their nature will always have a limited life and need to be re-evaluated periodically to consider developing trends. However, history shows that not all trends will survive, and terminal planners need to look at the latest "next big thing" very carefully before making it the basis of a terminal concept.

CHAPTER II

Terminal Planning and Design Process

The process of planning airport passenger terminal facilities needs to take into account a multitude of safety, operational, commercial, financial, and environmental considerations, as well as have regard to local government and airline industry interests and aspirations. Chapter III, Planning Considerations, provides a detailed description of these interrelated factors. This chapter focuses on describing the terminal planning and design process.

The first step in this process is to gather together and catalogue all of the existing data, information, and parameters that will have a bearing on the planning and subsequent design of the terminal facilities. The next step involves determining future forecasts of passenger, cargo, and aircraft movements that will form the demand basis for programming the future terminal and associated apron facility requirements. Once the facility requirements have been determined, the conceptual planning process can begin. This typically involves an iterative process of developing initial, and then progressively more refined, terminal complex concepts. These iterative conceptual development steps involve evaluation assessments that assist in narrowing the field of promising solutions, culminating in the selection of a single preferred option. The preferred terminal option then forms the basis for the initial architectural and engineering schematic design, design development, preparation of construction drawings, and specifications and cost estimation.

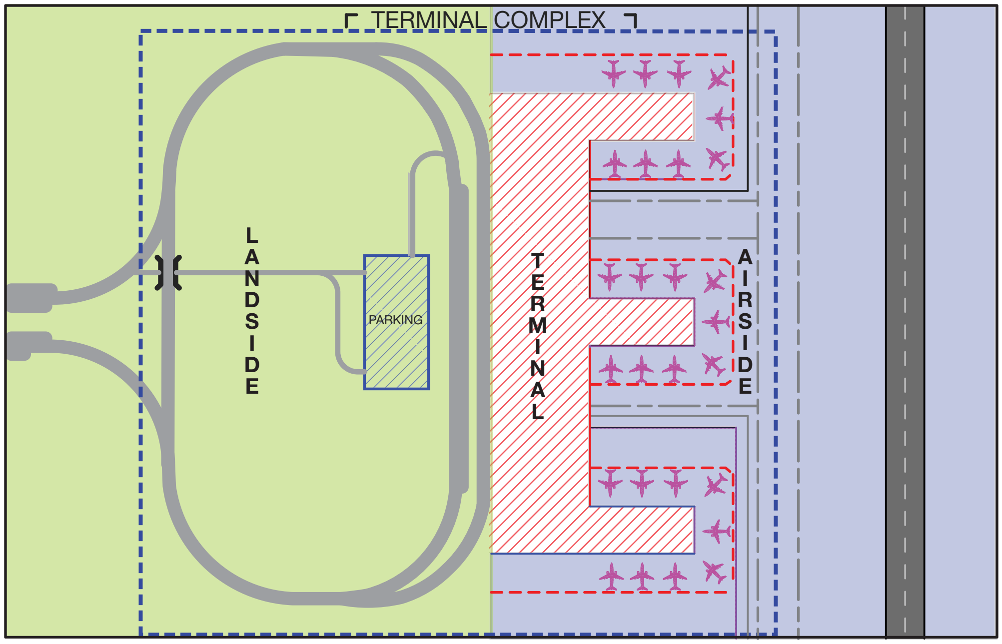
This chapter is organized into two sections: Section II.1, Defining the Terminal Complex, and Section II.2, Terminal Planning and Design Project Process.

II.1 Defining the Terminal Complex

The primary users of airport terminals are airlines, air travelers, well-wishers and meeters/greeters, and a wide range of employees of airport management, government regulatory authorities, air carriers, concessionaires, and other airport tenants. While terminal facilities must, first and foremost, provide a good level of service (LOS) to these users, the planning and design of an overall terminal facility is greatly influenced by the more rigid requirements needed to accommodate maneuvering aircraft and ground access systems. The terminal complex consists of the interface between aircraft, travelers, and the various modes of landside transportation. It is for this reason that this Guidebook has defined the terminal complex as including three primary components: airside, terminal, and landside. Figure II-1 depicts a diagram of a generic terminal complex that shows these three key components.

II.1.1 Airside Terminal Facilities

For the majority of new terminal planning and design projects, it is important from the outset to formulate solutions based on the airside component. This requires identifying gate requirements and



Source: Landrum & Brown

Figure II-1. Terminal complex.

locating aircraft parking positions and their supporting taxilanes that optimize the overall efficiency of the airfield prior to developing the internal layout of the terminal building and the landside curb and terminal roadway systems. The efficiency of airfield operations will, to a very large extent, drive the overall efficiency of passenger processing through the terminal, and the ability of aircraft to park at the terminal and maneuver safely around the airfield in accordance with taxilane/taxiway requirements contained in FAA Advisory Circulars is paramount. The airside's large spatial requirements and fixed requirements for aircraft wingtip separations and maneuvering clearances typically drive the physical geometry of the terminal complex more than either the passenger processing requirements within the terminal building, or its associated landside components.

The primary elements to consider when dealing with the airside component of a terminal complex include the following:

- Aircraft parking restrictions
  - *Code of Federal Regulations* (CFR), Title 14, Part 77 requirements
  - U.S. Standard for Terminal Instrument Procedures (TERPS) requirements
  - Air traffic control tower line-of-sight
- Aircraft maneuvering
  - Taxiway requirements
  - Taxilane requirements
  - Pushback areas
- Aircraft parking
  - Terminal gates
  - Remote aircraft parking positions
  - Wingtip clearances
  - Aircraft parking guidance systems
- Aircraft parking apron
  - Apron gradients
  - Hydrant fueling

  - 400 hertz power
  - Preconditioned air
- Apron service roads
  - Tail-of-stand
  - Head-of-stand
- Ground service equipment
  - Staging
  - Movement/maneuvering
  - Storage
- Aircraft servicing
- Security and emergency response
- Environmental
  - Fuel spillage
  - Waste disposal
- Blast Fences
  - Public and employee protection
- Winter operations
  - Aircraft deicing
  - Apron snow removal

These airside component elements are discussed in detail in Chapter V, Terminal Airside Facilities.

II.1.2 Terminal Building Facilities

The ever-evolving airport and aviation industry requires today's airport terminal buildings to be planned and constructed in ways that safeguard flexibility for future modification at the least expense, while also responding to variations in demand and/or the changing needs of passengers, airlines, and aircraft. To help achieve these objectives for the airport and its operators, the planning itself needs to be flexible, balanced, and visionary. Maintaining a broad and balanced view of the planning process is the key to terminal planning that is functional today and flexible for the future.

The terminal planning process should acknowledge the key functional and operational drivers, including business considerations that affect the airport and its operators, as well as the local community. These drivers include the following:

- Concessions planning, which aims to provide interesting and pleasing offerings to passengers, well-wishers, and meeters/greeters and revenue generation for the airport
- Security planning to respond both to specific threat and vulnerability levels, as well as the routine screening process of passengers and baggage
- People mover and baggage handling systems
- The wide range of information technology–based systems that underpin overall management and maintenance of the building, and through which essential information and data is disseminated to passengers and staff
- The application of sustainability and demand management concepts

The primary elements to consider when dealing with the terminal building component of the terminal complex include the following:

- Programmatic parameters
  - LOS performance standards
  - Demand/capacity assessment

- Terminal facility requirements
  - Ticketing/check-in
  - Passenger screening
  - Holdrooms
  - Concessions
  - Baggage claim
  - Circulation
  - Airline offices and operations areas
  - Baggage handling
  - Baggage screening system
  - International facilities—Federal Inspection Services
  - Support areas
  - Special requirements
  - Building systems
- Functional relationships
- Flow sequences
  - Passengers
  - Visitors
  - Employees
  - Baggage
  - Deliveries
  - Waste removal
- Passenger movements
  - People mover systems
  - Passenger wayfinding and signage
- Terminal concept development
  - Domestic and international terminals
  - Concourse configurations
  - Centralized and decentralized terminals
  - Single vs. multi-level terminals
  - Flexibility and efficiency
  - Common-use terminal equipment
  - Swing gates

These terminal building component elements are discussed in detail in Chapter VI, Terminal Building Facilities.

II.1.3 Landside Terminal Facilities

There are planning situations when the landside components may be the driving force behind the most appropriate terminal complex solution. Planning of landside terminal facilities requires considerable care because the efficiency, or lack thereof, can greatly influence the air travelers' perceptions of the overall efficiency and user friendliness of the terminal.

The terminal landside system provides the interface between the airport and the regional ground transportation system. Ideally, passenger connectivity between the various points of landside access to the terminal by road and, when applicable, rail should be as seamless and convenient as possible with a minimum of pedestrian level changes. Pedestrian and vehicular movements on the landside are particularly vulnerable to congestion at many airports due to peaks of demand associated with air travel and a historic pattern of growth in enplanements. Expansion of these facilities is often difficult, so intensive and proactive management of the landside curb and roadway systems is required to cope with increased activity and congestion. This management can be performed using manpower or by the use of technology.

The primary elements to consider when dealing with the terminal building component of the terminal complex include the following:

- Curbfront pedestrian facilities
  - Sidewalk—adjacent to terminal
  - Curb islands
  - Pedestrian crosswalks
  - Curbside baggage check-in
- Curbfront vehicle lanes
  - Loading/unloading lanes
  - Bypass lanes
  - Through lanes
- Parking
  - Terminal passenger parking
  - Remote passenger parking
  - Off-airport parking
  - Valet parking
  - Employee parking (FAA, airlines, tenants, staff)
  - Rental car parking
  - Cell phone lots
- Entry/exit roadways
  - Primary terminal access and exit roadways
  - Recirculation roadways
  - Service roads/loading docks
- Commercial vehicle/transit staging areas
  - Taxi and bus holding areas
  - Ground transportation centers
- Rail transit
  - Platform configuration
  - Station location

These landside component elements are discussed in detail in Chapter VII, Terminal Landside Facilities.

II.2 Terminal Planning and Design Project Process

This section of the Guidebook provides an overview of the terminal planning and design process including the types of projects, types of services, and a typical approach associated with addressing terminal facility projects.

II.2.1 Types of Projects

Terminal projects vary by an airport's size, whether it is on a new site or is part of an existing infrastructure, and also by its specific mission.

II.2.1.1 Large, Medium, and Small Hub Airport Terminals

One goal of this Guidebook is to provide planning and design guidelines that are applicable to the majority of terminal projects including large, medium, and small hub airports as defined by the U.S. Department of Transportation (U.S.DOT). (See Table II-1). It should be noted that the use of the word "hub" by U.S.DOT does not imply that the airport is a connecting hub.

Table II-1. Definition of airport categories.

<table>
<tr><th colspan="2">Airport Classifications</th><th>Hub Type: Percentage of Annual Passenger Boardings</th><th>Common Name</th></tr>
<tr><td rowspan="5">Commercial Service: Publicly owned airports that have at least 2,500 passenger boardings each calendar year and receive scheduled passenger service §47102(7)</td><td rowspan="4">Primary: Have more than 10,000 passenger boardings each year §47102(11)</td><td>Large: 1% or more</td><td>Large Hub</td></tr>
<tr><td>Medium: At least 0.25%, but less than 1%</td><td>Medium Hub</td></tr>
<tr><td>Small: At least 0.05%, but less than 0.25%</td><td>Small Hub</td></tr>
<tr><td>Non-Hub: More than 10,000, but less than 0.05%</td><td>Non-Hub Primary</td></tr>
<tr><td>Non-Primary</td><td>Non-Hub: At least 2,500 and no more than 10,000</td><td>Non-Primary Commercial Service</td></tr>
<tr><td colspan="2">Non-Primary (Except Commercial Service)</td><td>Not Applicable</td><td>Reliever §47102(18)</td></tr>
</table>

§ indicates section of *U.S. Code,* Title 49, Transportation; Subtitle VII, Aviation Programs; Part B, Airport Development and Noise, Chapter 471, Airport Development; Subchapter I, Airport Improvement
Source: 14 CFR Part 139 – Airport Certification

II.2.1.2 New, Expansions, and Renovations

Terminal planning and design projects can typically be categorized as either "greenfield" (a new terminal on a new site) or the expansion or renovation of an existing terminal. In some cases there may be a need to classify a project as a "replacement" terminal if it is to replace an existing terminal with a totally new facility, but does not provide significant additional aircraft gate or passenger processing capacity. Significant increases in passenger or aircraft activity can trigger the need for additional environmental study requirements under the project purpose and need as presented in Section III.7, Environmental Protection.

II.2.1.3 Terminal Missions

In addition to the airport's size and whether the terminal project is new, an expansion of an existing terminal, or the renovation of a current facility, the underlying mission of the terminal is a parameter that is best defined early in the planning process. The terminal's mission—whether to provide facilities for domestic and/or international passengers, a legacy carrier, or a low-cost carrier or to accommodate multiple carriers on a common-use basis—will have significant effects on the size and configuration of the terminal. Whether the terminal is to accommodate a hubbing operation with a large percentage of connecting traffic or it is to be primarily an origin and destination operation, these factors will also have implications for the facility requirements and design. Likewise, within the context of an overall Airport Master Plan, whether traffic projections will best be met by planning for a single consolidated terminal or multiple unit terminals greatly influences the specific size and configuration of the terminal complex as a whole. The effect of a terminal's particular mission is presented in more detail in Section VI.3, Terminal Facility Requirements.

Each of these various types of terminal planning projects typically need to go through a similar process of (1) setting the project parameters during the gathering of current inventory data,

(2) preparing facility requirements based on forecasts, (3) creating a variety of conceptual alternatives, (4) evaluating terminal concepts, and (5) selecting a preferred alternative for further refinements. While these general process steps are involved in the majority of terminal projects, there are many other types of services that occur during, and sometimes independently from, this process. These types of services are described more completely in the following section.

II.2.2 Types of Services

The process undertaken to determine the best course of action for a new, renovated, or expanded terminal is a synergistic blend of technical analysis and qualitative reasoning. The technical and creative services involved in terminal planning and design can be grouped into four main categories: facilities programming, planning, design, and specialized technical analyses.

- Facility programming services: This category of services involves the general startup of the project and sets the ground rules for all of the process to follow.
  - Project parameters: The input parameters include interacting with key stakeholders to set the project's goals and objectives; defining the opportunities and constraints associated with the site of the project; conducting an inventory of previous studies; gathering together pertinent aerials and plans; and conducting observations, surveys, and user interviews.
  - Demand/capacity assessment: The demand/capacity assessment is typically a service performed when an existing terminal(s) is involved. This service consists of analyzing current passenger demand against the ability of the existing facility to meet this demand at an acceptable LOS. This analysis involves establishing a baseline condition for the existing terminal(s), which identifies the size and number of the various facilities that compose the terminal complex. The results of this analysis indicate whether additional facilities are needed just to meet current demand.
  - Terminal space program: The majority of terminal projects will include services to prepare future facility requirements for the terminal complex based on forecast projections. The methodology for developing facility requirements for the airside gates, the terminal building, and terminal curb are addressed further in the following sections:
    - Section V.3, Aircraft Gate Requirements
    - Section VI.3, Terminal Facility Requirements
    - Section VII.4, Terminal Curb Requirements
- Planning services: Services in this category are at the heart of the synergistic process of applying the facilities requirements program and transforming it into conceptual plans.
  - Conceptual planning services: These services focus on taking the terminal facilities program and preparing various conceptual terminal complex site plans and terminal building diagrammatic floor plans.
  - Advanced planning services: These services address an additional level of detail in the evolution of the terminal concepts. As terminal concepts are narrowed down to a manageable number of preferred options (typically ranging from a single concept to as many as three concepts), more detailed conceptual plans and sections are developed based on a refined space program that now reflects the specificity of the terminal concept type. Site plans, building plans, site and/or building sections, and three-dimensional (3D) massing perspectives are developed during these advanced planning services. Floor plans typically remain a single-line diagram that reflects the refined program. Advanced planning allows for more accurate definition of the project, resulting in better cost estimates prior to engaging a full complement of architectural/engineering services.
- Design services: Architectural and engineering services are brought into the process to articulate the terminal building through various stages of design—schematics, design/development, and contract documents. Architectural services may also be brought into the process earlier during the conceptual and advanced planning services as determined by the sponsor.

- Specialized technical analysis services: Some services in the terminal planning and design process are very specialized to airport terminal facilities. These include terminal simulation modeling, trigger point analysis, aircraft parking and maneuverability, passenger loading bridge analysis, and in-ground fuel pit placements as examples.
  - Terminal simulations: Simulation modeling is an excellent tool for quantitatively assessing the LOS performance of an existing terminal, determining the trigger point for the need of future facilities, or cross-checking the performance of a schematic design prior to embarking on the design/development phase of the architectural design process. Other important assessments can include the simulation of airside taxilanes/taxiways, terminal curb, and supporting roadway network.
  - Trigger point analysis: Similar to the demand/capacity analysis, the trigger point analysis examines when the particular functions of the terminal will no longer meet demand at an acceptable LOS. This service may be performed using various programmatic formulas or through the use of simulation modeling.
  - Aircraft parking positions and maneuverability: There are computer software tools available that assist in testing the viability of aircraft parking positions at the terminal gate or at a remote parking stand. The services involved with these computer tools assist in assuring that aircraft parking positions, lead-in lines, and wingtip clearances are working appropriately within the configuration being explored.
  - Loading bridge analysis: This service involves a combination of the previously described aircraft parking position analysis and determining the type and location of the passenger loading bridge needed to correctly dock with the aircraft being parked. While this service can be performed as a spreadsheet analysis, there are excellent computer software programs that simplify this important analysis.

II.2.3 Typical Project Approach

Whether the project is a new terminal or the expansion/renovation of an existing facility, there is a benefit in using a consistent and thorough study approach to identifying a preferred terminal facility solution. Figure II-2 depicts an approach that has proven effective in identifying the best alternative for implementation. This section describes the major steps in this process.

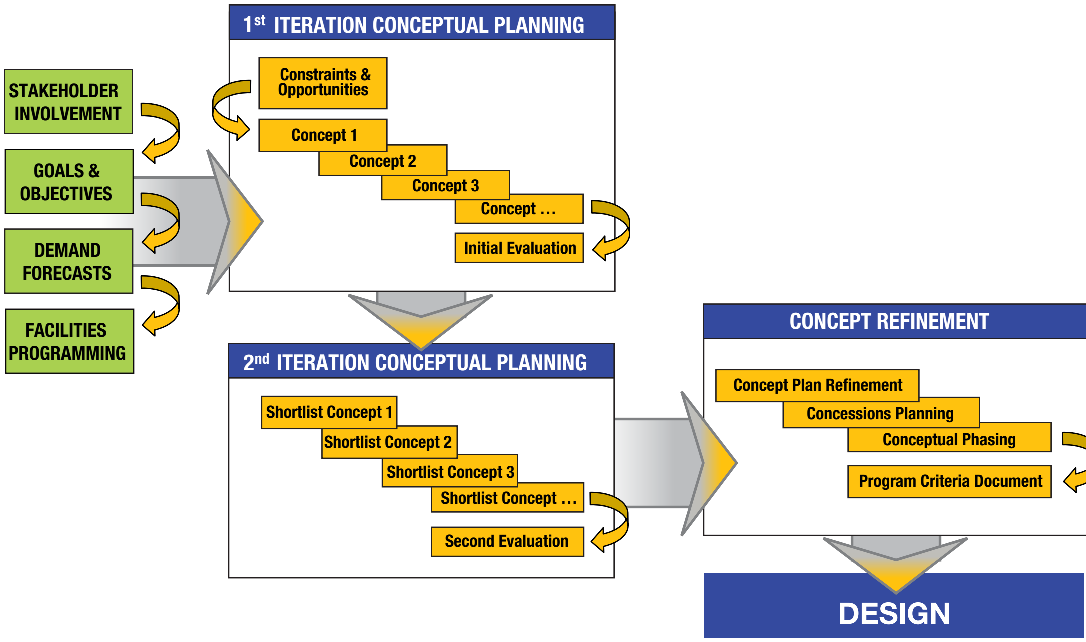
II.2.3.1 Stakeholder Involvement

This section provides an overview of individuals and groups who have a special interest in, or involvement with the terminal planning and design process. Referred to as stakeholders, these parties are integral to the implementation process, and their contributions should be reflected in its critical path.

The road to a successful terminal development program is paved through teamwork and interrelationships that offer open opportunities for participation and buy-in throughout the planning process. Participants vary from airport to airport, and interests are almost invariably diverse.

It is the responsibility of the terminal planner to encourage, acknowledge, and as far as possible, synthesize the input of all stakeholders. Conflicts may occur, but they can be overcome through a proactive process of communication. Listening and responsiveness are most important. Small issues often escalate into big ones if they are not addressed quickly and responsibly. Carefully managed, stakeholder buy-in should be there when it is needed.

Stakeholder participants in the terminal planning process are normally identified by the client; however, it is incumbent on the terminal planning manager to recommend stakeholders who should be encouraged to participate. The most successful planning processes are those that are kept open. Efficient stakeholder communication can strengthen relationships that are important to the acceptance and support of a recommended plan.



Source: Landrum & Brown

Figure II-2. Typical terminal planning study approach.

Typical stakeholders in a terminal planning process include, but are not limited to, air travel customers/terminal users, airport management, airlines, and concessionaires.

Air Travel Customers/Terminal Users. The primary and most numerous terminal building stakeholder group is the traveling public. Together with other terminal users (meeters/greeters, etc.), these air travel customers are the group most closely associated with evaluating terminals once they are up and running. This input is normally seen in the form of periodic surveys performed at many airports in the United States. Although this input is often “after the fact,” it is useful in determining future needs of the traveling public in new terminal projects.

Apart from surveys, there are also public outreach programs that are offered during the terminal planning process. These outreach programs may enlist the input of public stakeholders through the airport’s website, printed mailers, and public meetings including City Council or other publicly attended governmental sessions. Survey forms may also be used to solicit public input, and planning-specific questionnaires are also helpful if information is received as input in a timely manner. Timing is the key.

Airport Management. For almost every terminal project, airport management will have an important stake. Even airports that feature individual airline terminals require the overarching involvement of the airport management group. This involvement ensures that broad issues such as the following are kept in focus:

- Prudent utilization of all airport land
- Balanced development of airside/terminal/landside facilities
- Compatibility with the Airport Master Plan
- Financial feasibility/affordability
- Representation of key stakeholders in the planning process

Airlines. At most U.S. airports, there is a close relationship between airport management and the number one stakeholder group, the airlines. This situation differs somewhat from the

European or Asian model in which the relationship and financial involvement between the two groups are more indirect. Terminal development in the United States is typically supported and financed through airline rates and charges. This means that airlines have an intrinsic interest or "stake" in development at the airport. Involvement may take many forms depending on the need; however, typical arrangements include the following:

- Individual airline meetings that address specific needs related to the terminal or airport
- Airport/airline affairs committees that provide a collective open forum for communications between the airport and its airline stakeholders
- Ad hoc technical or other types of committees that are created to address specific needs or issues affecting airlines or airport stakeholders

In the United States, terminal facilities' rates and charges are a significant airline expense, ranking, on average, in third place after fuel and employee costs. For this reason it is important that airline stakeholders participate in the terminal planning process throughout all stages.

In certain cases the Air Transport Association (ATA) and the International Air Transport Association (IATA) may be considered stakeholders in a terminal planning and design process. Both groups have been instrumental in providing terminal planning guides, particularly in establishing the use of service levels as measures of performance. IATA's *Airport Development Reference Manual* (*3*) contains a substantial amount of terminal-related planning material, and the ATA was a major contributor to the FAA's *Apron & Terminal Building Planning Manual* (*2*). In most cases ATA or IATA stakeholder involvement will be determined through airline/airport committees serving a specific airport.

Concessionaires. One of the most important revenue-generating components in any terminal plan today is the concessions/retail area. The successful concessions/retail plan is one that is conceived early and integrated into the terminal plan as key functional elements are set.

Concessions/retail stakeholders are often represented by retail planning specialists on the terminal planning or design team. This early involvement facilitates the process of collecting input and providing planning expertise before specific concessions/retail companies are contracted. Because the revenue generated by concessions/retail is potentially so great, there are planning factors that stakeholders almost always want to see included in the planning process:

- Location—Concessions/retail areas should preferably be located in, or adjacent to, major passenger flows in the terminal. Locations should also take into consideration that passengers typically are anxious about potentially missing their flight. If passengers feel assured that they can make their flight they are more assured about using time to shop or dine.
- Massing—Plans that provide for a synergistic grouping of concessions/retail areas together in one space.
- Exposure—Maximum frontage display and ease of access for patrons into and out of the concessions/retail area.
- Storage—Convenient access and capacity for supplies and sales goods.
- Access—Both deliveries and removals provided in the most discreet manner available, out of public view.

Other Stakeholder Groups. Each airport may be expected to have additional groups of stakeholders who will need to review the project and have an opportunity to provide input. Identification of these groups of stakeholders typically is provided by airport management but, in some cases, may be suggested by airlines or other core stakeholders.

Other stakeholders may include, but are not limited to, the following:

- Architectural review boards
- Arts commissions

- Airport support groups (Friends of the Airport, etc.)
- Special interest groups and other interested persons (including state or local accessibility officials, individuals with disabilities, and organizations representing individuals with disabilities)

II.2.3.2 Agency Involvement

The proactive involvement of the various agencies is an important component of the planning and design process. It should be included in the work plan outline in terms of time allocated for reviews and input at certain key planning milestones. It is recognized that the quality and usefulness of this input will vary among agencies, but it is incumbent on the planning and design team to encourage agency involvement and incorporate constructive input whenever possible.

Federal Aviation Administration. For many years the FAA was involved only peripherally in the terminal planning process. Since the advent of Passenger Facility Charges (PFC) that are used to underwrite the cost of many terminal projects today, FAA involvement in the review process is mandatory to ensure that the PFC revenues are appropriately deployed for terminal improvements.

When airport owners or sponsors, planning agencies, or other organizations accept funds from FAA-administered airport financial assistance programs such as Airport Improvement Program (AIP) entitlement or discretionary grants, they must agree to certain obligations (or assurances). Airport grant requests are evaluated by the FAA with a priority toward safety, airfield capacity, and pavement projects; although non-airfield projects, such as terminal buildings, are also eligible. These obligations require the grant recipients to maintain and operate their facilities safely and efficiently, and in accordance with specified conditions. The assurances appear either in the application for federal assistance and become part of the final grant offer or in restrictive covenants to property deeds. Some of the assurances that involve terminal developments include consistency with local plans, consideration of local interest, consultation with users, and terminal development prerequisites (*8*).

FAA involvement is also frequently needed to ensure that terminal projects comply with the relevant environmental requirements applicable to the airport. FAA review may also have a role in ensuring that terminal building heights or aircraft parking plans conform to airfield navigational restrictions such as imaginary surfaces and transitional slopes [refer to 14 CFR Part 77 (*9*) and TERPS (*10*)].

Transportation Security Administration. The Transportation Security Administration (TSA) is an integral agency in terminal projects. The TSA is responsible for regulatory oversight through enforcement of the Airport Security Program and is the sole authority responsible for passenger and baggage screening. Airports are responsible for all other security, throughout the terminal and other facilities, and for law enforcement response. The TSA's *Recommended Security Guidelines for Airport Planning, Design, and Construction* (*11*) provides the basis for planning all aspects of terminal building security, with the caveat that it is a series of practical recommendations, not mandated requirements. The TSA should be included in periodic reviews during planning and design.

U.S. Customs and Border Protection, U.S. Department of Homeland Security. For terminals with international arrivals facilities, the U.S. Customs and Border Protection (CBP) is an important stakeholder. The CBP's planning guide, *Airport Technical Design Standards—Passenger Processing Facilities* (*12*), provides the detailed basis for planning and designing international terminal processing facilities in the United States. Because every international terminal is unique, it is advisable to provide multiple opportunities for the CBP to review the planned facilities during the planning and design process.

Local and National Building Code Review Boards. During the conceptual terminal planning process, it is important to take into account many of the basic principles that are encompassed in the local building codes. In particular attention should be paid to regulations such as the Americans with Disabilities Act (ADA) and local building codes that may influence occupancy egress requirements and plumbing fixture counts. In general the building codes are rules that specify minimum acceptable levels for requirements related to the protection of public health, safety, and general welfare as they relate to the construction and occupancy of buildings and structures. These building code requirements and formal reviews become increasingly important as terminal projects move from conceptual into the realization of the architectural design during the design/ development phase.

Local Fire Marshal. For the majority of municipal fire departments, the Fire Marshal typically supervises and coordinates activities of local firefighting personnel and inspects equipment and premises to ensure adherence to fire regulations. It is important to consider the role that this indirect agency has relative to the specific operational procedures and policies specific to each airport. All fire codes require that the terminal building must be provided with access for fire department apparatus and firefighters. This requirement is difficult to implement for most airport terminals due to the airside and landside delineations dividing the building. This delineation results in portions of the building not being accessible for normal fire department operations and the need for duplicate access points to the buildings and duplicate fire hydrants or department connections. Some large airports have their own firefighting and rescue teams, stationed on the landside portion of the airport with primary responsibility to respond to incidents in and around the terminal in addition to the airport's aircraft rescue and firefighting. Early in the planning and design process, it is advisable to determine how the municipal firefighting and rescue personnel will be interacting with the airport-based firefighting personnel. It is also advisable to consult with the local Fire Marshal on matters relating to the design and adequacy of fire escape facilities, the size and positioning of emergency exits, and procedures to be applied during emergency situations.

II.2.4 Goals and Objectives

As previously mentioned in Section II.2.1.3, at the outset of any terminal planning exercise, it is important to have a clear understanding of the mission of the terminal and to begin formulating a vision for the project. The term vision does not literally translate into what the project will visually look like but rather the purpose and motivation behind the need for the new, expanded, or renovated terminal facility. The vision embraces the underlying reasons why the need for the project has arisen and is typically fueled by the motivation of primary stakeholders such as the mayor of a city or a major hubbing air carrier at the airport.

It is the responsibility of the planner and designers to clearly articulate this vision into a written set of goals and objectives. Goals and objectives provide the first opportunity to distinguish the terminal project from other projects that may appear to be similar on a superficial basis but, in fact, may be quite different. Goals and objectives also provide an early opportunity, perhaps the earliest opportunity, for stakeholders and others to buy into the terminal project by agreeing on the fact that the project is needed in the first place, as well as providing a benchmark against which the options developed for the project may be tested or evaluated. Evaluation criteria should always relate back to, or draw on, the original goals and objectives for the project. Goals and objectives should be initiated in draft form and set forth as a "living document" that may be modified or adjusted as the project is developed, and needs and requirements are more fully understood. Satisfaction of the goals and objectives is one important measure of success for any terminal plan or design.

Early enlistment of support for any terminal plan or design may be enhanced through a meeting that sets forth a set of goals and objectives and then invites input from key stakeholders and agencies.

Once a long list of goals and objectives has been established, a review of the list is recommended to minimize overlaps and consolidate items if possible. Ideally, most lists of goals and objectives should be of manageable length. A list of between 5 and 25 is typical. Each line item should be clearly and succinctly stated with a short definition (one or two sentences maximum). The final draft list should be reviewed with stakeholders and agencies to ensure that all needs and concerns have been addressed before the project moves forward into the initial stages of planning.

In summary, the agreed goals and objectives should address the following:

- Project definition and distinctive character
- Enlistment of stakeholders and agencies participation and buy-in
- Basis for evaluation criteria to narrow down options
- Modalities for testing and measuring success
- Strategy for progressing through future project stages

II.2.5 Demand Forecasts

Long lead times between the commencement of the planning process and final completion of the terminal building (ranging from 2 to 5 years) pose particular challenges to the terminal planner, who is typically charged with planning for demand growth for at least 5 years (and often longer) after the opening of the facility. While traffic forecasts are an essential guide, the presumption must be that they will never be completely accurate; there will inevitably be some discrepancies either in the nature and mix of the traffic or the total traffic volume, or both.

Two major forecasting techniques are available. The first is extrapolation of past trends into the future, i.e., trend analysis. The second involves creating local aviation forecasts through correlation to other independently prepared local or national forecasts of future socioeconomic activity.

The basic flaw with trend analysis is that trends rarely continue indefinitely, and the assumptions underpinning them must be regularly interrogated to ensure they are still valid. Trends in demand growth can change for economic, technological, industrial, or political reasons. The list of reasons why trends do not continue over a reasonable planning period is practically endless. Since deregulation in 1978, development of the aviation industry has been characterized by increasing volatility, airline financial instability (including mergers, acquisitions, and bankruptcies), and changing security requirements. All of these factors can sometimes radically upset trend analyses.

A more sophisticated approach is to tie the forecast of aviation activity to independently created forecasts of the future socioeconomic activity that will affect the airport's business. The underlying assumption with this type of forecast is that aviation activity will be driven chiefly by economic growth which, depending on the size and importance of the airport, could be local, regional, national, or global. This approach is a variation of trend analysis in that it assumes that past economic drivers and relationships will be sustained. While these relationships are generally proven with regression analyses over a long time period, the accuracy of forecasts for particular years is still vulnerable to unexpected shocks that upset direct trend analysis, for example, fluctuations in fuel prices, heightened perceptions of terrorist or health threats, and so forth.

Thus, there is always uncertainty about the levels of different types of future aviation activity at an airport. The terminal planner needs to understand the implications of uncertainty so that s/he can develop a plan that provides the airport as much flexibility as possible to adapt to new circumstances. The following subsections describe some factors that generate uncertainty.

II.2.5.1 Airline Network Planning

In the United States, airlines typically provide connecting services through one or more strategically located hub airports. Airline decisions to open up, expand, contract, or close down a hub location can occur independently of local economic conditions. Planning decisions to support airline hub operations tend to be tied to that airline's long-term business strategy, which may not be driven primarily by the size of the local market.

II.2.5.2 Local Economic Factors

While economic forecasts are generally more reliable than forecasts of future airline plans, airports that serve communities whose economy is dominated by one particular industrial activity, or by a single company's business activities, are inevitably more vulnerable to the effects of decisions to expand or contract the enterprises concerned. Generally, traffic levels at smaller airports are more sensitive to fluctuations in demand of this sort, as compared to airports serving larger, more diverse economic regions, and are likely to face less volatility in demand.

II.2.5.3 Airport Competition for Passengers

Airports have overlapping service areas. While the great majority of originating passengers live within a 1-hour travel time from the airport, some passengers come from up to 3 hours away. The presence of a low-fare carrier will tend to attract passengers from longer distances if no competing service is available from a closer airport. Changes in airline service at competing airports can affect local traffic.

II.2.6 Facilities Programming

Programming of terminal facilities is part art, part science. Not only do a number of different methods exist for developing a program document, the uses to which the document will be put and the expectations of it may also vary widely. Programs used for master planning, conceptual planning, schematic design, and building renovations all offer different levels of detail, synthesize different types of input, and are required to meet the different applications of their users. As the effort to create a terminal program is initiated, it is important to understand both the needs of the end user and achieve a consensus (or lack thereof) on the integrity and availability of the data to be used as the basis of the program. Additionally, an important key to developing a useful and credible terminal program is some prediction of the type, and likely configuration, of the terminal. Concurrence among the programmer, design team, and client on the level of information required and the integrity of existing forecasts and data is crucial to agreeing on the schedule, budget, and participants in the programming process.

Depending on their intended project purpose, terminal facilities programs can vary significantly in their level of detail. A terminal facility's requirements can be generated as part of an FAA-reviewed Airport Master Plan, as an independent study focused solely on the terminal area complex (sometimes referred to as a Terminal Area Master Plan), or in association with the development of a single terminal building. If the terminal facilities programming is part of the Airport Master Plan, or independently addresses the entirety of the terminal complex, then the first step is to consider the number and type of terminals to be developed. Multiple unit terminals create different requirements from a single, consolidated terminal. Multiple terminals duplicate the need for landside access and for internal passenger processing facilities and systems. They also raise issues of connectivity and the potential affect on airline connection times.

No matter how good the planning, multiple terminals cannot split activity evenly at the airport, so each terminal must be capable of responding to its own specific sub-peaks of demand in terms of spatial and systems planning. As a result, the aggregate demand for facilities, staff, and systems throughout the airport is inevitably going to be larger than if a single unit terminal approach were selected. Likewise, small domestic terminals have different needs and characteristics than large international ones. Each of these characteristics should suggest to the programmer how data needs to be collected, organized, and collated to be useful to the design team.

The type of terminal configuration being considered also has a direct bearing on the programmatic needs of the facility. For example, there are two primary organizational approaches to the terminal processor: centralized and decentralized processing of passengers and baggage. In addition, there are four basic overall terminal processor and concourse configurations: linear, pier, satellite, and transporter. These configurations also can be used in various combinations. Each has unique organizational implications and programmatic requirements. The various types of terminal configurations are discussed in more detail in Chapter VI. Key programmatic differences between these types of terminal configurations involve variances in the quantity of space required for circulation and concessions, and variations in their distribution throughout the terminal facility design. Additionally, the quantity of circulation space programmed will be different for concourses that are single-loaded or double-loaded, or that contain moving sidewalks, as well as for buildings with rail transit or bus dock stations.

Tenant development interests also need to be recognized in the program. In some cases the whole terminal development program may be driven by the needs of one or more tenants, usually the principal hubbing airline, but possibly a new airline entrant. In some cases an individual airline may drive the program in order to meet growth or marketing requirements. In other cases an individual airline is the sponsor of the program and may be the sole tenant of the facility. In this case meeting that airline's specific needs will take greater priority than in the case of a multi-airline facility, when the needs of all the tenants must be balanced against their relationship to the airport's competitive objectives.

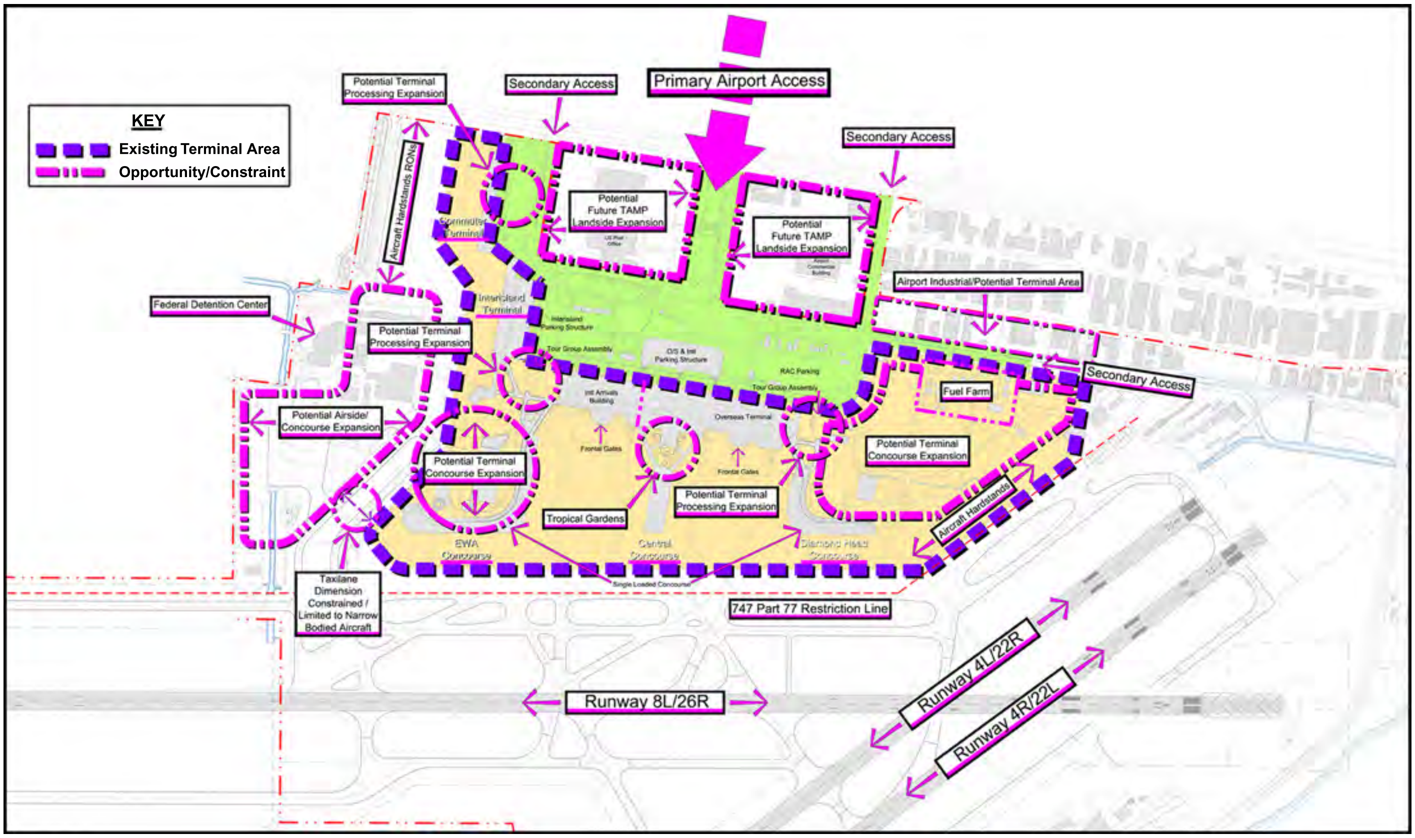
II.2.7 Conceptual Planning

Once the goals and objectives for a terminal project have been agreed on and sufficient terminal facilities programming has been completed, the conceptual planning process may begin. Goals and objectives ideally are refined, along with the planning process, and kept flexible as the project evolves. This is possible primarily because, as additional information is gained along the terminal concept development process, the goals and objectives can be brought into clearer focus as stakeholders and agencies engage in review plans and ideas. A typical terminal planning process consists of several iterations of developing concepts, each iteration serving as a means to receive feedback from the key stakeholders and agencies in the terminal project's outcome, and progressively narrowing the choice of options. For illustrative purposes, a typical terminal planning process may involve the following three main iterative steps.

II.2.7.1 Step One: First Iteration Planning

Definition of Opportunities and Constraints. Opportunities and constraints encompass both physical issues, such as site constraints and boundaries, and also non-physical issues, such as political or policy-driven guidelines. Both are equally important and must not be overlooked during the planning process. Physical opportunities and/or constraints should be clearly represented. This is often done by diagrammatically illustrating opportunities and constraints on a site plan or aerial photograph using color to define issues. Non-physical issues may also be noted on this site plan illustration. Adjustments to the opportunities and constraints diagram may be needed as reviews are carried out. Figure II-3 depicts an example of an opportunities and constraints diagram.

Development of Initial Options. The first opportunity for creative development in any terminal project typically comes as the initial group of conceptual options is being developed. This is the first stage of the planning process in which a relatively long list of concepts may be produced. The process of development will ideally involve input from a variety of resources, which should always be coordinated with, and approved by, the client. Alternatives should be



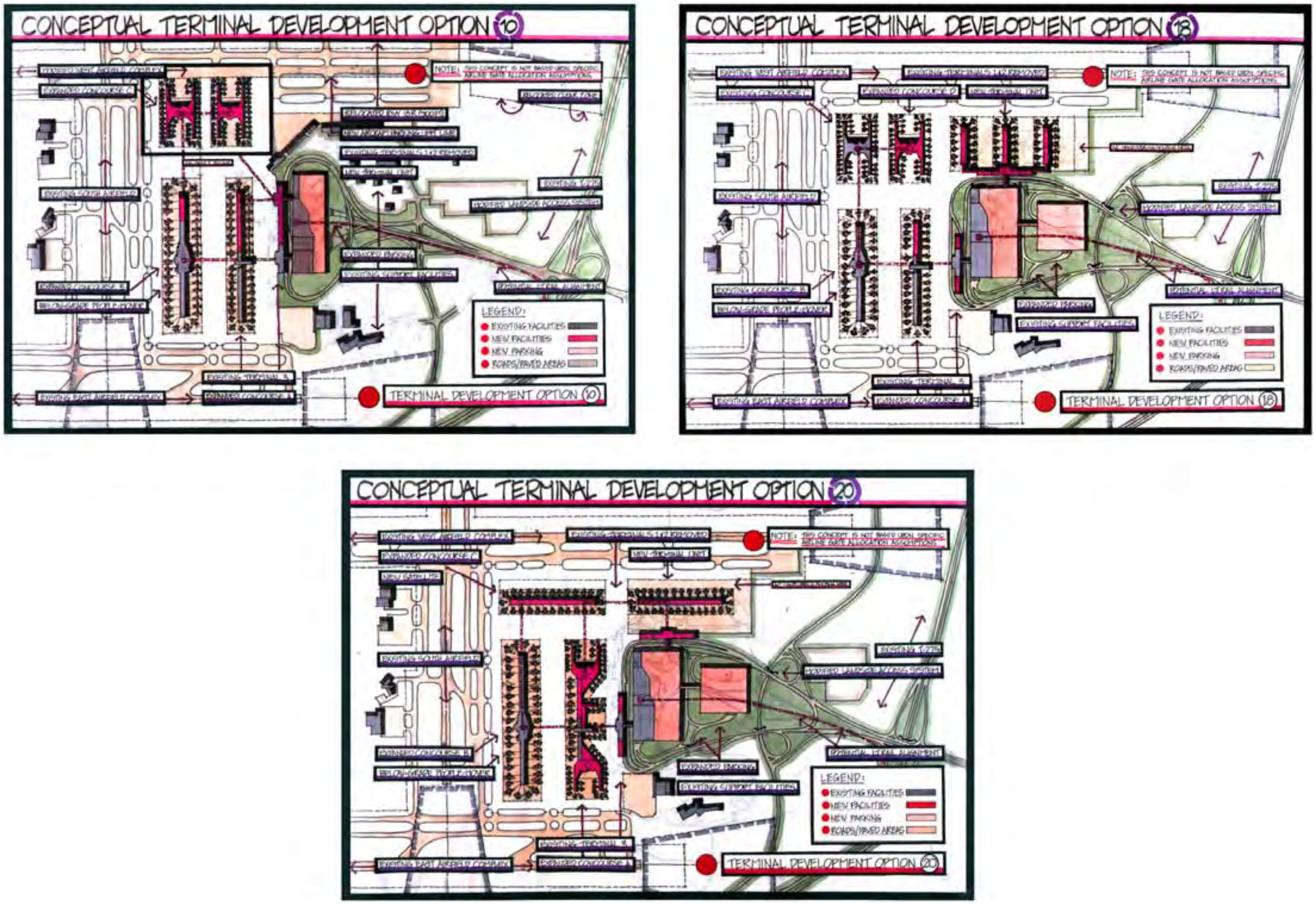
Courtesy of: State of Hawaii, Department of Transportation, Airports Division

Figure II-3. Example of opportunities and constraints diagram.

clearly and consistently defined so that objective comparisons are possible. General programmatic (space program or project brief) requirements should be consistently reflected in each concept so that genuine "apples to apples" comparisons are possible. If the project sponsor is electing to pursue Leadership in Energy and Environmental Design (LEED) certification, which is strongly suggested as a "best practice" approach, then sustainability principles need to be considered even at this early stage of concept development, particularly as it relates to the building's orientation if a greenfield terminal project is envisaged. These initial development concepts may be sketched by hand or prepared with computer-aided design (CAD) as shown in Figure II-4.

Initial Evaluation. After all reasonable options have been developed, an initial evaluation process can be set in motion. Evaluation criteria are best drawn from the original set of goals and objectives for the project and should be simple but clearly defined. To narrow down the potentially large number of initial terminal concepts to a shortlist of three or four, an evaluation process using criteria drawn from the project goals and objectives may be used. Typical criteria may address the following areas:

- Airside
- Terminal
- Landside
- Implementation feasibility
- Flexibility
- Sustainability
- Environmental and community issues



Courtesy of: Cincinnati/Northern Kentucky International Airport

Figure II-4. Example of initial concepts.

- Land use
- Capital costs
- Operating costs

Criteria should be defined and reviewed with the stakeholders and may be weighted depending on the needs of the project or the client/project sponsor. This process will help to gain a better understanding of the performance of each of the facility concepts. Additionally, when an initial option may be underperforming for a particular criterion, refinements may need to be made and, in some cases, new concepts may need to be developed and reviewed before the final selection of the shortlisted concepts begins. A matrix format is often used in the evaluation process to organize and present the ranking of the options against the various evaluation criteria. Criteria are arranged along one side of the matrix while the options may be listed along the intersecting side and identified by a letter or number as shown in Figure II-5.

Evaluation criteria may be grouped according to major concerns; landside, terminal, airside, cost, and site considerations are typical groupings. Initial scoring may be as simple as +1 for positive readings, 0 for no effect, and −1 for negative assessments of criteria considered against each alternative. After the scores are totaled, a short list of the most desirable concepts may be established.

	EVALUATION CRITERIA	1	2	3	4	5	6	7	8	9	10	11	12
AIRSIDE	Aircraft Flow	-	0	-	+	+	+	-	-	+	+	+	0
	Ramp Operations	0	0	0	0	0	0	0	0	0	0	0	0
	Gate Use Flexibility	0	+	+	0	0	0	0	+	0	0	0	0
	Program Implementation/Phasing	+	-	-	+	+	+	0	0	0	+	+	0
	Ability to Expand	0	0	0	+	+	+	0	0	0	+	+	+
	Runway/Gate Taxi Times	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	-1	+3	+3	+3	-1	0	+1	+3	+3	+1
TERMINAL	Program Satisfaction	+	+	0	+	+	+	+	+	+	+	+	+
	Passenger Convenience/Wayfinding	-	-	+	0	0	0	+	+	+	+	+	0
	Connectivity Between Terminals	0	0	+	0	0	0	0	0	0	0	0	0
	Revenue/Concessions Opportunity	0	0	+	0	0	0	0	0	0	0	0	0
	Gateway Opportunities	+	+	-	+	+	+	+	+	+	+	+	+
	Implementation Effectiveness	+	+	-	+	+	+	0	0	0	0	0	+
	Flexibility for Airline Change	0	0	0	0	0	+	+	+	+	+	+	0
	Constructability	0	0	-	0	0	0	0	0	0	0	0	0
	Subtotal	+2	+2	0	+3	+3	+4	+4	+4	+4	+4	+4	+3
LANDSIDE	Program Satisfaction	0	0	-	0	0	0	+	+	+	+	0	0
	Curbfront Interface	0	0	+	0	0	0	+	+	+	+	+	0
	Parking Interface	0	0	-	0	0	0	+	+	+	+	+	0
	Ease of Circulation/Phasing	+	+	-	+	+	+	-	-	-	-	0	+
	Integration of Blue Line	0	0	0	0	0	0	0	0	0	0	0	0
	People Mover Interface	+	+	+	+	+	+	+	+	+	+	+	+
	Subtotal	+2	+2	-1	+2	+2	+2	+3	+3	+3	+3	+3	+2
SITE	Airfield Impacts	0	0	0	0	0	0	0	0	0	0	0	0
	Adjacent Facilities Impacts	+	+	-	+	+	+	+	0	0	+	+	+
	Environmental Assessment	0	0	-	0	0	0	+	+	+	+	0	0
	Economy of Site Utilization	+	+	-	+	+	+	0	0	0	0	0	+
	Subtotal	+2	+2	-3	+2	+2	+2	+2	+1	+1	+2	+1	+2
COST	Construction Cost (Order of Mag.)	0	0	-	+	+	+	0	0	0	0	+	+
	Operation Cost (Assessment)	+	+	+	+	+	+	+	+	+	+	+	+
	Phasing/Timing Cost	0	0	0	+	+	0	+	-	0	+	+	+
	Subtotal	+1	+1	0	+3	+3	+2	+2	0	+1	+2	+3	+3
	Grand Total Score	+7	+7	-5	+13	+13	+13	+10	+8	+10	+14	+14	+11

Scoring System: **+ Positive**, **0 Neutral**, **- Negative**

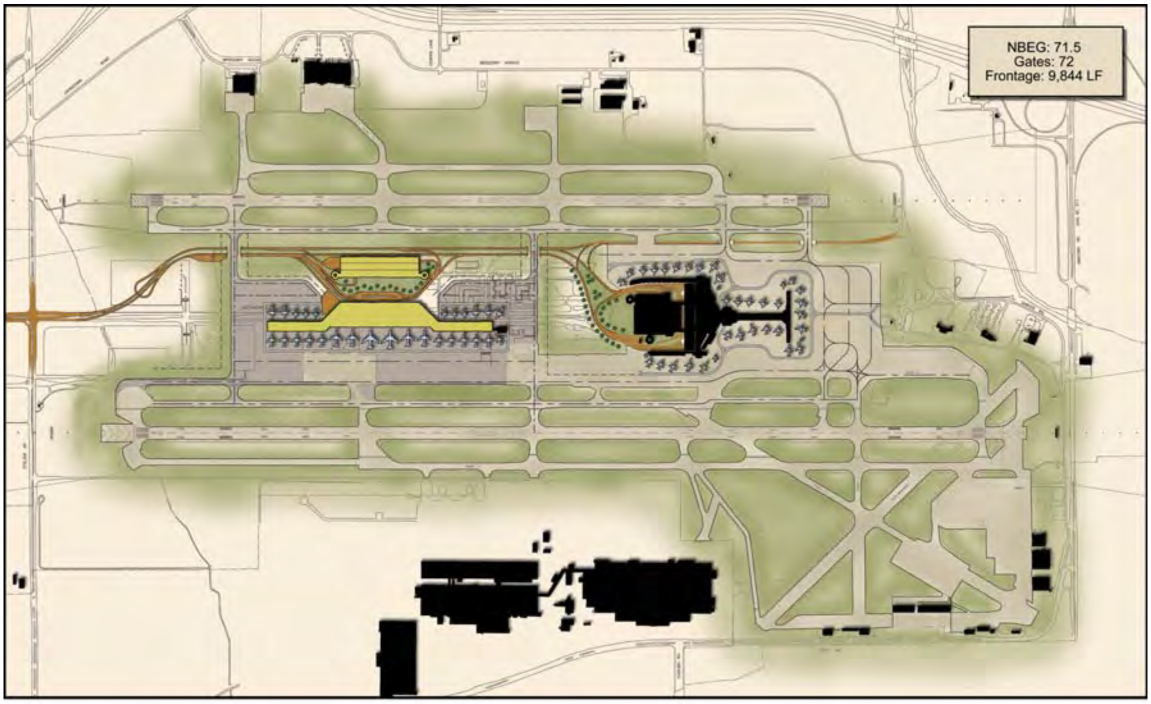
Source: Landrum & Brown

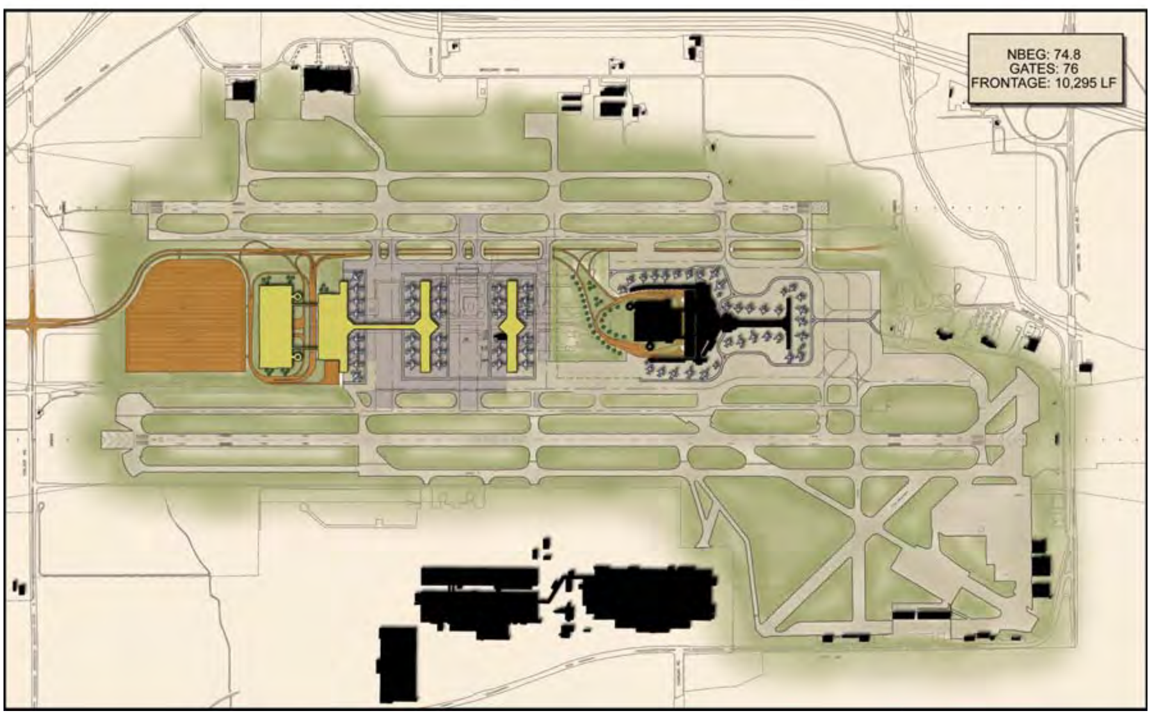
Figure II-5. Example of + and − evaluation scoring.

II.2.7.2 Step Two: Second Iteration Planning

Shortlisted Concepts. The shortlisted options are typically regrouped and redefined so that a more refined evaluation can take place during the second half of the conceptual planning process. Sections, detailed plans, and massing perspectives are some of the methods used to define each concept further. These additional levels of detail for a shorter list of concepts allows for added assessment of capital costs compared to budget targets. At this point, meetings may be held with stakeholders to review the results of the initial planning process. Adjustments and re-combination of some terminal components may also be appropriate at this time. These concepts can be drawn as hand sketches at this point in the process, but the additional accuracy of CAD assisting in more accurately representing the facilities program and the dimensional criteria of the airside, terminal, and landside facilities is also recommended. Figure II-6 depicts an example of shortlisted concepts.

Second Evaluation. After the shortlisted terminal concepts have been refined and redefined, a second evaluation may be carried out. Initial evaluation criteria are usually revisited for validity





Courtesy of: Columbus Regional Airport Authority

Figure II-6. Example of shortlisted concepts.

at this point. A narrowing and recombining of criteria may also be appropriate depending on developments and evolution of views and plans during Step One of the planning process. Weighting of evaluation criteria may also be a useful adjunct to this secondary evaluation of the shortlisted concepts.

Following the conclusion of the refined shortlisted concepts, the evaluation criteria and weightings may need to be revisited and refined for inclusion into a restructured matrix, which should address any additional input from the stakeholders. The evaluation matrix may then be used during a charrette process to facilitate stakeholders input and to assist the consultant with the selection of the best representative preferred concept. The selection of the preferred concept should be a collaborative process between the consultant and stakeholders. Figure II-7 depicts an example of a weighted matrix.

Recommended Terminal Development Concept. Ideally, the output of the second evaluation will be a recommended terminal development concept. Certain components of other concepts may be incorporated into the recommended terminal concept at this juncture in the planning process. The recommended terminal development plan can then be put forward for the review and approval of stakeholders. Figure II-8 depicts an example of a detailed terminal concept drawing.

II.2.7.3 Step Three: Concept Refinement

Concept Plan Refinement. During the third and final step of the conceptual planning process, the stakeholder-approved concept is further refined in order to test and verify performance prior to entering into the more labor-intensive design process. This refined version of the concept, sometimes referred to as "advanced planning," begins to define the terminal building in terms of its internal functional layout in more detail. It is during this step that all of the major functional areas of the terminal building are delineated in CAD corresponding to the space program, and initial passenger and baggage conveyance systems, such as automated people movers, escalators, and elevators, are further identified. At this point in the process, the conceptual length, width, and height of the facilities begin to take initial shape, allowing the preparation of 3D massing perspectives and more accurate cost estimations. Depending on the needs of the project, animated visualizations and scale models may also be produced at this stage. The additional detail in the diagrammatic floor plans of the terminal building also allows for the simulation of passengers based on flight schedules representative of future forecast demand levels. The simulation of the terminal at this stage in the process helps to verify the translation of the space program into a floor plan that meets a satisfactory LOS performance as the basis for architectural design.

Concessions Planning. The concept refinement step is an appropriate time to prepare an initial layout of concession areas with the aim of providing maximum exposure of the various commercial offerings to the main passenger flows through the terminal. This plan should include both the conceptual size and location of areas for retail, and food and beverage outlets, as well as concession delivery routes and storage. Setting the conceptual direction of the concessions planning early in the process helps ensure more productive revenue generation of the terminal project, and anticipate and minimize potential interference caused by the delivery and stocking of goods and waste disposal.

Conceptual Phasing. Step Three is also when conceptual phasing, showing the primary phases of construction corresponding to the trigger points of demand, is prepared. This provides additional information relative to cash draw downs for the project over time.

Program Criteria Document. Often, the final product deliverable of Step Three is a Program Criteria Document (PCD) that carefully describes the refined terminal plan, space program,

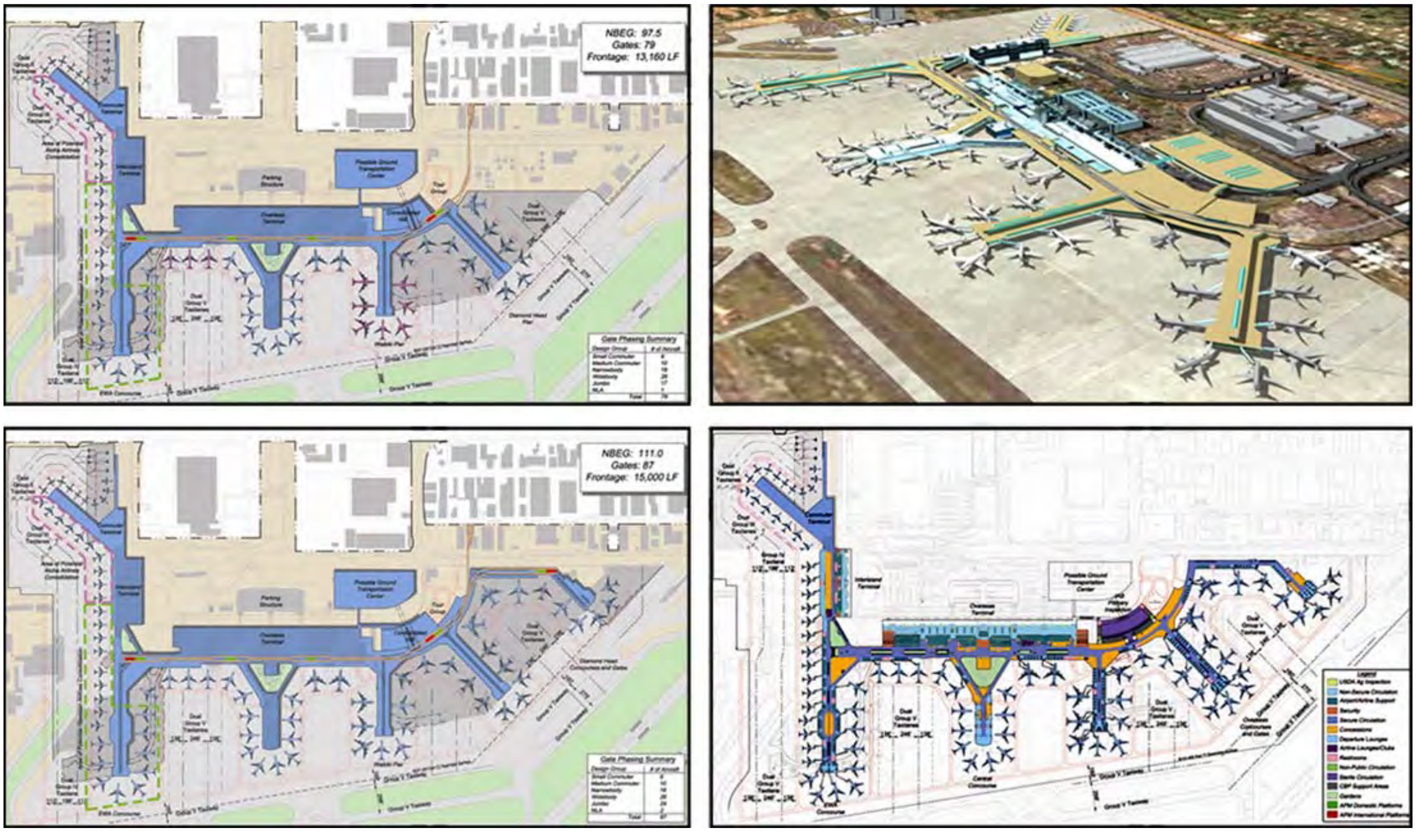
Criteria Categories	Importance: Major Category Weighting	Importance: Secondary Category Weighting	Option 1 Baseline Central Center A RAW	Option 1 WEIGHTED	Option 2 Central West A RAW	Option 2 WEIGHTED	Option 3 West A RAW	Option 3 WEIGHTED	Option 4 South B RAW	Option 4 WEIGHTED	Option 5 South C RAW	Option 5 WEIGHTED
			Airport Master Plan Development Options - Evaluation Matrix									
1 AIRSIDE	20%	100%	2.25	2.20	4.75	4.70	3.00	2.60	4.50	4.40	4.50	4.40
1.1 Meets Required Aircraft Parking Capacity		20%	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00
1.2 Aircraft Gate Use Flexibility		25%	0.00	0.00	5.00	1.25	5.00	1.25	5.00	1.25	5.00	1.25
1.3 Apron/Taxilane Efficiency		25%	0.00	0.00	5.00	1.25	5.00	1.25	5.00	1.25	5.00	1.25
1.4 Taxi Distance to Runway Ends & Exits		30%	4.00	1.20	4.00	1.20	-3.00	-0.90	3.00	0.90	3.00	0.90
2 TERMINAL	25%	100%	2.88	2.70	5.00	5.00	4.13	4.65	4.75	4.90	4.75	4.90
2.1 Meets Required Terminal Capacity		15%	5.00	0.75	5.00	0.75	5.00	0.75	5.00	0.75	5.00	0.75
2.2 Maximizes Flexibility for Potential Operational Changes		5%	5.00	0.25	5.00	0.25	5.00	0.25	5.00	0.25	5.00	0.25
2.3 Ability to Meet Primary Stakeholder Missions (airlines)		20%	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00
2.4 Passenger Convenience & Comfort		30%	0.00	0.00	5.00	1.50	5.00	1.50	5.00	1.50	5.00	1.50
2.4.1 Origin & Destination Traffic		20%	0.00	0.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00
2.4.2 Connecting Traffic		10%	0.00	0.00	5.00	0.50	5.00	0.50	5.00	0.50	5.00	0.50
2.5 Security Efficiency		15%	3.00	0.45	5.00	0.75	5.00	0.75	5.00	0.75	5.00	0.75
2.6 Passenger Orientation to Processing		5%	3.00	0.15	5.00	0.25	5.00	0.25	5.00	0.25	5.00	0.25
2.7 Connectivity to Other Key Facilities		5%	5.00	0.25	5.00	0.25	-2.00	-0.10	3.00	0.15	3.00	0.15
2.8 Concessions Revenue Potential		5%	-3.00	-0.15	5.00	0.25	5.00	0.25	5.00	0.25	5.00	0.25
3 LANDSIDE	10%	100%	2.20	1.20	4.80	4.80	4.80	4.80	5.00	5.00	5.00	5.00
3.1 Meets Required Curb Capacity		20%	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00
3.2 Accommodates Southern Landside Access		30%	-5.00	-1.50	5.00	1.50	5.00	1.50	5.00	1.50	5.00	1.50
3.3 Effectiveness of Access/Egress Roads		20%	3.00	0.60	4.00	0.80	4.00	0.80	5.00	1.00	5.00	1.00
3.4 Ease of Passenger Orientation to Roads		20%	3.00	0.60	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00
3.5 Provides Easy Access to Future Mass Transit		10%	5.00	0.50	5.00	0.50	5.00	0.50	5.00	0.50	5.00	0.50
4 IMPLEMENTATION FEASIBILITY	10%	100%	-5.00	-5.00	0.67	0.20	5.00	5.00	1.67	1.00	5.00	5.00
4.1 Ability to Phase Construction/Modifications		40%	-5.00	-2.00	2.00	0.80	5.00	2.00	3.00	1.20	5.00	2.00
4.2 Operational Effectiveness of Initial Phase		40%	-5.00	-2.00	-3.00	-1.20	5.00	2.00	-3.00	-1.20	5.00	2.00
4.3 Safeguards Future Long-Range Terminal Expansion		20%	-5.00	-1.00	3.00	0.60	5.00	1.00	5.00	1.00	5.00	1.00
5 ENVIRONMENTAL ISSUES	10%	100%	0.00	0.00	1.50	1.50	4.50	4.50	4.00	4.00	4.00	4.00
5.1 Air and Water Quality		50%	0.00	0.00	-2.00	-1.00	4.00	2.00	3.00	1.50	3.00	1.50
5.2 Sustainability (LEED Silver Level)		50%	0.00	0.00	5.00	2.50	5.00	2.50	5.00	2.50	5.00	2.50
6 LAND USE	10%	100%	3.50	3.50	3.50	3.50	0.00	0.00	3.50	3.50	4.50	4.50
6.1 Effective Utilization of Land for Aviation Needs		50%	2.00	1.00	2.00	1.00	-3.00	-1.50	3.00	1.50	5.00	2.50
6.2 Potential Collateral Development Options		50%	5.00	2.50	5.00	2.50	3.00	1.50	4.00	2.00	4.00	2.00
7 CAPITAL COST	15%	100%	-3.00	-3.00	-3.00	-3.00	-3.00	-3.00	-3.00	-3.00	-5.00	-5.00
7.1 Order of Magnitude Costs		100%	-3.00	-3.00	-3.00	-3.00	-3.00	-3.00	-3.00	-3.00	-5.00	-5.00
TOTAL TERMINAL CONCEPT	100%		0.40	0.64	2.46	2.74	2.63	2.66	2.92	3.01	3.25	3.21

Color Scoring Scale:

- 5 to 3 = Good
- 2.99 to -2 = Average
- -2.01 to -5 = Poor

Source: Landrum & Brown

Figure II-7. Example of weighted matrix.



Courtesy of: State of Hawaii, Department of Transportation, Airports Division

Figure II-8. Example of final detailed terminal concept drawings.

phasing, and concessions program, which will serve as guidance to the architectural designers and engineers. The primary purpose of the PCD is to focus the architectural design process on creating a solution that maintains the goals and objectives of the planning process; delivers an architectural design that, once constructed, delivers the desired LOS for passenger and baggage operations; provides flexibility in its phasing; and maximizes revenues from airport concessions programs.

II.2.8 Design Process

Transition to the design process can sometimes be challenging if the team of consultants chosen to design the terminal has not been included in the planning process. The natural inclination of architects and designers is to question plans that have been set out for them to design. This is especially true if they have not achieved the buy-in made possible through an involvement during the conceptual planning process. Consequently, the transition from planning to design stages must be carefully managed to avoid time-wasting and potentially costly attempts to re-plan, re-think, and/or re-shape the recommended concept and to safeguard its functional integrity.

The design process itself traditionally follows three basic stages: schematic design, design/development, and contract documents. In some projects there may be a need for a brief pre-design phase, which may involve confirmation of the designer's understanding of the project. Often the design team may provide a service called "construction administration," which follows the drawing up of the contract documents and provides various oversight responsibilities during construction of the project.

A brief summary of each of the main stages of design follows.

II.2.8.1 Schematic Design

Schematic design takes the conceptual level of planning and begins to translate it into architecture. The space program is validated during this stage and applied to the terminal, which begins to be defined as an architectural statement in volume and structure. Column grids emerge and mechanical systems begin to be defined. This is an appropriate stage to infuse the expertise of a construction manager and engineer to address the realm of constructability and realistic cost estimations. Reviews with stakeholders and applicable building/life-safety groups continue or are initiated during this stage.

II.2.8.2 Design/Development

The schematic design is taken forward into a reality of structure, form, and supporting systems. Compliance with applicable building codes, such as the ADA, Uniform Building Code, National Fire Protection Association, and so forth is verified during this stage in parallel with continuing reviews with stakeholders and pertinent agencies. The design/development stage should result in plans that are sufficiently firm to enable the drawing of contract documents to begin. Only limited changes to plans should be expected after design/development is complete.

II.2.8.3 Contract Documents

This stage of the design process culminates in production of the documents that will be used to construct the new or expanded terminal. Everything necessary to carry out construction should be developed during this stage including plans, specifications, building department reviews, code compliance reviews, and stakeholder updates. Once construction documents have been developed, subsequent design changes become more expensive and problematic.

Recently, new computer software has become available that is greatly enhancing the design process in terms of accuracy and project understanding. This software is referred to as "Building Information Modeling" (BIM) and revolves around a three-dimensional approach to design that was not previously available to designers until much later in the design process. BIM also provides more detailed information regarding quantities of materials (steel, concrete, doors, windows, etc.) that can be used to enhance cost-estimating accuracy.

II.2.9 Value Engineering

Value engineering is an organized review of the proposed airport passenger terminal design, with the goal of identifying possible changes to the proposed project's design that would result in a minimum amount of capital and operating costs to the project sponsor, while still meeting all the project's goals and objectives. This typically occurs toward the end of the schematic design of the terminal facility, although it may be implemented by the project sponsor at another point in the design process.

II.2.10 Construction Process

At many of today's space-constrained airports, staging and implementation are great challenges. More often than not, implementation must be planned and carried out in the midst of ongoing airport operations. Safety and security are always major concerns that must not be compromised; the FAA includes security as a closely related element in the development of Safety Management Systems (SMS).

It is almost always true that a good beginning makes a good end. This axiom is never more true than in an airport setting. A construction management plan that can be implemented in a safe, secure, cost-effective, and timely manner is critical to the success of any terminal development.

Much of the responsibility for the construction management plan falls on the shoulders of airport management and their program and construction management teams. Experience is important, along with attention to detail and quality assurance. Information dispersal and consistent and frequent communication are also critical to the success of any terminal development project. Airlines, the FAA, the TSA, and other stakeholders may also play an important part. The key is to develop the right plan and share that with those who need to be a part of it.

II.2.10.1 Program Management

For airport terminals, program management pertains to the process of effectively managing multiple facets of an overall development program. The role of the program management specialist is to manage and ensure that all aspects of the project are completed on time and within budget. Program management specialists should accurately define the requirements, specifications, and scopes of work of each individual construction project; establish realistic budgets; and develop achievable milestone schedules necessary for the successful completion of the program. The project management team must lead and support the construction and operations activities to ensure all resources are comprehensively managed to meet the program's objectives. In all, program management is the tool with the ability to unify design, scheduling, budgeting, funding, management, and construction processes in one application.

II.2.10.2 Construction Management

The job of construction manager is to deliver projects on time and within budget: inspecting construction, controlling schedules and costs, providing coordination and communication, administering construction contracts, and ensuring compliance with federal and state regulations. The key to the success of the project lies in an ability to cultivate trust and a cooperative relationship between the airport and the project management/construction management team. A construction management plan that can be implemented in a safe, secure, cost-effective, and timely manner is critical to the success of any terminal development.

II.2.10.3 Project Delivery Options

There are three primary means to implement the construction of a new airport terminal project: design–bid–build, design–build, and construction management at-risk. A fourth means, which is being used frequently overseas, infuses investment into the traditional mix of the owner, designer, and builder and is called "build–operate–transfer" (BOT).

Design–Bid–Build. Design–bid–build is the traditional project delivery method in which the agency or owner segregates design and construction responsibilities by awarding them to an independent architect/engineer and a separate private contractor. This method requires two separate contracts. The first contract is between the owner and designer, followed by a second contract between the owner and the building contractor. Using this project delivery method separates the process into three sequential phases: (1) the design phase, (2) the bidding (or tender) phase, and (3) the building phase. The work progresses in a linear sequence where the owner first contracts with an architect for design then uses the design documents to obtain bids from various contractors, with the winning contractor securing the contract. The design–bid–build method typically involves lump-sum contracts that are competitively bid, providing the owner with a lowest responsible bid in the construction market.

Design–Build. Design–build is a procurement or project delivery arrangement for a single entity (a contractor with subconsultants, or a team of contractors and architects/engineers, often with subconsultants) that is entrusted with both design and construction of a project. This arrangement contrasts with the design–bid–build method where one contract is bid for the design phase and then a second contract is bid for the construction phase of the project.

Construction Management At-Risk. Under this approach the owner hires an architect but at the same time also procures the services of a construction manager. The construction manager provides expertise on such matters as value engineering during design, project scheduling, cost tracking, management of construction contracts, and overseeing of construction activities. Under a construction manager at-risk approach, after the design phase, the construction entity provides the owner with a maximum construction cost, which is then negotiated with the owner. Once agreed upon, the construction entity assumes the financial obligation to deliver the project not to exceed the cost agreed upon. If the project goes over budget, the construction entity assumes the risk or overage. This project delivery approach helps to avoid claims and change orders often associated with the low-bid model. While typically the construction price is determined at the end of the design phase, it can occur earlier if mutually agreed upon, which allows the airport sponsor to start the construction process earlier.

Build–Operate–Transfer. BOT is a type of project arrangement in which a private entity receives a concession from a private or public sector entity to finance, design, construct, and commercially operate a facility for a fixed term, typically 20 to 30 years, following which the facility reverts to the granting entity. During the BOT concession period, the franchisee is empowered to charge the users of the facility fees, rentals, and any other charges defined in the concession contract. These charges allow the private entity potentially to recover its original investment, and operating and maintenance expenses, plus a reasonable return. This type of arrangement is used typically in complicated long-term projects, as seen in power plants and water treatment facilities, and has been used in some jurisdictions as a means of privatizing the building of new airport terminals.

II.2.11 Approval and Certification

Building codes and other construction regulations are standards that have been adopted to protect public health and safety. The terminal building project needs to be inspected to ensure that each project meets current standards and complies with local building codes and zoning ordinances. After the project passes a final inspection, the inspecting agency may issue a Building Occupancy Certificate or Certificate of Occupancy. A Certificate of Occupancy provides legal documentation that the building is in a safe and livable condition and can be occupied for its intended purpose. Successful completion of the final inspection and a Certification of Occupancy is required before use or occupancy of a terminal project.

CHAPTER III

Planning Considerations

Airport passenger terminals cannot be planned effectively in isolation. Planners and designers must address and find solutions to an increasingly wide range of technical and operational challenges within the terminal building. At the same time, they must have a thorough understanding of the overall planning context within which the new facility will be developed, both in terms of the airport itself and the region it serves. They must also have a good grasp of wider airport planning considerations and the technical, operational, and regulatory requirements that will have an effect on the terminal planning task.

This chapter provides an overview of the following key contextual issues:

- Airport Master Plan
- Land use compatibility
- Ground access transportation
- Terminal site planning
- Airport security
- Information technology and communications
- Environmental protection
- Sustainability
- Business planning

III.1 Airport Master Plan

According to FAA Advisory Circular (AC) 150/5070-6B, *Airport Master Plans* (*13*), an Airport Master Plan is "a comprehensive study of an airport [that] describes the [airport's] short-, medium-, and long-term development plans to meet future aviation demand." Depending on the airport's size and the complexity desired in developing the master plan, the substance and detail of the document may vary. However, the main elements that are typically considered and contribute to key content in an Airport Master Plan are long-term traffic demand forecasts, airfield configuration, and a land use plan showing the positioning of passenger and cargo terminals and their associated aprons and of other key airport support facilities.

III.1.1 Airport Demand Forecasts

As part of a typical Airport Master Plan, a 20-year forecast of aviation demand must be developed. These projections are used to determine the extent of safeguarding required for future new or expanded facilities (terminal and airfield related). The aviation demand forecast should include aircraft operations and identify the critical aircraft and future fleet mix as well as passenger enplanements. The forecasts of aircraft operations and passenger activity should be developed both on an annual and a peak hour basis so that future facilities are planned to be able to cope

Table III-1. Aircraft approach category.

Category	Approach Speed
A	Less than 91 knots
B	91 knots or more, but less than 121 knots
C	121 knots or more, but less than 141 knots
D	141 knots or more, but less than 166 knots
E	166 knots or more

Source: FAA AC 150/5300-13, *Airport Design*

with demand levels even at the busiest times. This topic is addressed more fully in Chapter IV, Forecasts.

III.1.2 Airfield Configuration

The major elements of airfield configuration involve the positioning of runways and taxiways within the airport property. Some major factors affecting the orientation and dimensions of an airport's runway and taxiway system are based on the type and size of aircraft, air traffic management procedures, natural and man-made constraints on and surrounding the airport, wind and weather conditions, and federal regulations and design standards. The size of the "critical aircraft" that is forecast to utilize the airport will determine the design category by which an airport is classified. According to the FAA, the "critical aircraft" is "the most demanding itinerant aircraft with at least 500 annual operations at the airport" (*14*). This critical aircraft size will also determine the separation dimensions necessary for the runway and taxiway configuration.

III.1.2.1 Airport Reference Code

The airport reference coding (ARC) system, established in FAA AC 150/5300-13, *Airport Design* (*15*), is used to classify airports for design purposes. The ARC is composed of the aircraft approach category (determined by the aircraft approach speed) and the airplane design group (based on the wingspan or tail height, whichever is the most restrictive) of the airport's largest operating aircraft with a minimum of 500 annual operations. The *aircraft approach category* is depicted by a letter, and the *airplane design group* (ADG) by a Roman numeral, as shown in Table III-1 and Table III-2. Appendix D provides a list of commercial aircraft and their associated ADG. The classification of an airport determines the centerline separation and object clearances applicable to the runway and taxiway system.

The airfield configuration depends on many factors other than the ARC including airspace availability, environmental concerns, air navigation obstructions, topography, Air Traffic Control Tower (ATCT) visibility, wildlife hazards, and wind patterns.

III.1.2.2 Airspace Availability

The configuration of the airspace above a particular location has a considerable influence on the positioning, alignment, and length of runways. All existing and planned instrument approach,

Table III-2. Airplane design group.

Group No.	Tail Height		Wingspan	
	Feet	Meters	Feet	Meters
I	<20	<6	<49	<15
II	20-<30	6-<9	49-<79	15-<24
III	30-<45	9-<14	79-<118	24-<36
IV	45-<60	14-<18	118-<171	36-<52
V	60-<66	18-<20	171-<214	52-<65
VI	66-<80	20-<24	214-<262	65-<80

Source: FAA AC 150/5300-13, *Airport Design* missed approach, and departure surfaces must be entirely clear of obstacles. Special use and restricted airspace may alter the air traffic patterns around a particular location and reduce the airspace available for aircraft operations.

III.1.2.3 Environmental Concerns

Environmental impact reviews should be undertaken prior to finalizing the airfield configuration. These studies should consider the environmental effects of the airfield configuration to existing and proposed land use and noise on surrounding residents, air and water quality, wildlife, any historical or archeological features, and other features as identified by the National Environmental Protection Act (NEPA). Generally, an airport's Environmental Assessments and Environmental Impact Statements fulfill the requirements necessary for determining these factors.

III.1.2.4 Air Navigation Obstruction Identification

Identification of obstructions in the airspace around the airport should be conducted when considering airfield layouts. These obstructions may include man-made constraints—such as buildings, towers, and antennas—or natural constraints—such as mountainous terrain. The purpose of obstruction identification is to aid in the placement of runways in an orientation that allows approach and departure areas to be clear of obstacles interfering with air navigation. To identify potential obstructions, it will be necessary to develop and analyze the Federal Aviation Regulations (FAR) Part 77 imaginary surfaces and the TERPS arrival and departure obstacle clearance surfaces. See Section V.1.1, FAR Part 77 and TERPS Requirements, for further discussion of these obstacle clearance surfaces.

III.1.2.5 Runway Safety Areas

The runway safety area (RSA) shall be cleared of all objects, except those needed because of their function. The area shall also be graded to minimize damage to an aircraft and support snow removal and emergency equipment. Any objects that are in excess of 3 inches in height should be constructed on low-impact-resistant support to minimize damage.

III.1.2.6 Topography

The degree of surface elevation change at an airport site serves as an additional factor in determining runway orientation. The elevation differential impacts the degree of grading and drainage work necessary to build a runway in compliance with FAA standards. An airfield configuration requiring minimal grading would thus be considered optimal when determining ultimate placement of the runway and taxiway system.

III.1.2.7 Air Traffic Control Tower Visibility

A clear line-of-sight between the ATCT and all portions of the airfield are a top priority when laying out the runway and taxiway system. The ATCT should have a clear view of air traffic patterns in the immediate vicinity of the airfield, runway thresholds and hold pads, runway structural pavement, and other operational surfaces controlled by Air Traffic Control (ATC). A clear view of all aircraft "movement areas" including runways and taxiways is also essential. Where there is no apron tower present, it is important for the ATCT to have a clear view of all aircraft ramp areas.

III.1.2.8 Runway Visibility Zone

If there are intersecting runways, a clear line-of-sight between the ends of the runways is recommended. Terrain needs to be graded and permanent objects need to be designed or sited so that there will be an unobstructed line-of-sight from any point 5 feet above one runway centerline to any point 5 feet above an intersecting centerline, within the runway visibility zone. See FAA AC 150/5300-13, *Airport Design,* Section 503 (*15*) to determine the runway visibility zone.

III.1.2.9 Wildlife Hazards

The potential for any wildlife hazards, including the risk of bird strikes, should be evaluated when considering runway configurations. The propensity for wildlife hazards increases in areas located near bird sanctuaries, sanitary landfills, bodies of water (i.e., lakes, rivers, reservoirs), and other areas that can attract a significant amount of wildlife. To minimize these hazards, the runways should be positioned as far away as possible from such areas and specific hazard abatement procedures should be implemented as necessary.

III.1.2.10 Wind

Wind patterns, including prevailing velocity and direction, play a major role in runway configurations. So far as possible, the primary runway should be oriented in the direction of the prevailing winds. The most desirable runway orientation based on wind is the one that has the largest wind coverage and minimum crosswind components. Wind coverage is the percentage of time that crosswinds are below an acceptable velocity. The desirable wind coverage for an airport is 95%, based on the total number of weather observations. If the wind coverage is below 95%, the FAA recommends construction of a crosswind runway.

III.1.3 Other Land Use Considerations

III.1.3.1 Positioning of Passenger Terminal Apron and Cargo Facilities

When possible, it is desirable to locate aircraft parking gates for the terminal complex at a location that is approximately at the mid-point of the primary runway and on the side that offers the most convenient ground transportation access. Mid-point positioning will provide an equal taxi distance to the runway ends for departure operations and minimize taxi distance when exiting from the runway. If there is a dual parallel runway system, it is desirable to locate the terminal between the two runways. This will minimize aircraft taxi distance to and from each runway, and will also minimize the number of runway crossings and the potential for runway incursions. Air cargo operations also benefit from being centrally located from runway ends and having a direct connection to ground transportation access.

III.1.3.2 Fuel Farm Facilities

Airport fuel farm facilities primarily exist in centralized locations either near the terminal building or near the perimeter of the airport property boundary. Depending on the airport size, fuel facilities can be a single, self-service station; or for larger operations, it may include a fuel farm with multiple storage tanks. Generally, fuel farms serve as a source for mobile fuel trucks to re-supply aircraft, or connect to an underground apron hydrant fueling system. Fuel farm facilities may also provide storage for ground service equipment (GSE) that operates on the airport.

III.1.3.3 Airport Maintenance Facilities

A wide range of services falls under the umbrella of airport maintenance, and the facilities that support these services generally consist of buildings for the maintenance of equipment and general supply storage. Specifically, these types of buildings include those for GSE storage and maintenance, electrical repair (buildings and visual navigational aids), painting (buildings and airfield markings), and mechanical repair. Airport GSE facilities may house equipment and vehicles such as those used for snow removal, general property maintenance (lawn care), materials storage (sand and salt), and aircraft ground servicing.

III.1.3.4 Aircraft Maintenance Facilities

The space requirements necessary for aircraft maintenance facilities is predicated on the type of aircraft maintenance (checks) that will be conducted at the airport and the type of aircraft to be serviced. Airports handling general aviation and business jet operations generally provide one or more fixed-base operator (FBO) facilities on or adjacent to the property to provide aircraft maintenance. These facilities typically include aircraft maintenance repair hangars with storage space, a building that contains a main office and customer lounge, an apron area for aircraft parking, and vehicle parking adjacent to the main office facility. FBO facilities primarily service regional jets, turboprops, and smaller aircraft. For airports with large commercial and airline operations, maintenance bases for inspection and repair may be established on the airport. No matter what type of aircraft maintenance facilities are provided, consideration must be given to site compatibility with taxiway systems to avoid runway crossings, as well as the noise issues associated with the testing of aircraft engines.

III.1.3.5 Aircraft Rescue and Firefighting Facilities

For all Part 139–certificated airports, adequate Aircraft Rescue and Firefighting (ARFF) facilities must be provided within the airport boundary. The size, location, and number of vehicles are dependent on the largest aircraft using the airport and the airfield geometry. The ARFF stations should be located such that the first responding vehicle can reach the mid-point of any runway within 3 minutes of the alarm (in optimum surface conditions and visibility) and begin application of fire-extinguishing agent. The location of these facilities is crucial when considering that the time to reach an accident area is a key factor in the efficacy of emergency response. Potential structural fires and other duties employed by firefighting personnel should also be considered when planning ARFF facilities. An adequate number of fire stations should be located on the landside portion of the airport to provide firefighting services to all structural buildings and emergency medical services inside the terminal buildings and roadway network. Airports that lack Part 139 certification should coordinate with local municipalities to determine the appropriate emergency response services that can be provided at the airport.

III.1.3.6 Aircraft Deicing Facilities

Aircraft deicing facilities are recommended at airports where icing conditions are expected. For some airports, centralized deicing facilities at or adjacent to the terminal can adequately meet the deicing/anti-icing demands of users and still allow acceptable taxiing times to the departure runways under varying weather conditions. In some cases, remote deicing facilities located near departure runway ends or along taxiways are recommended when taxiing times from terminals or other centralized deicing facilities frequently exceed holdover times. No matter what the location, it will be necessary to provide adequate land area to accommodate such aircraft deicing facilities as the following:

- Aircraft deicing apron
- Bypass taxiway
- Environmental runoff containment system
- Portable nighttime lighting
- Crew shelter (kitchen and toilet)
- Storage tanks for deicing/anti-icing fluid
- Equipment storage area

For additional assistance in determining the optimum location and sizing of the aircraft deicing facilities, refer to FAA AC 150/5300-14B, *Design of Aircraft Deicing Facilities* (*16*).

III.1.3.7 Air Traffic Control Tower

The ATCT is responsible for managing and directing airborne and ground aircraft traffic movements. The site for the ATCT requires a clear unobstructed view of the airport's traffic pattern, runway approach areas, and aircraft movement areas (runway, taxiway, and apron areas). The land area should be large enough to accommodate the ATCT, base building, and auto parking, with adequate land for future expansion needs. The actual land area will be based on the ATC level of activity and should be coordinated with the local FAA Regional Office.

III.1.3.8 In-Flight Catering Services/Flight Kitchens

The preparation and storage of in-flight meals, snacks, and beverages typically requires separate facilities apart from the passenger terminal building. In some cases, each airline or a consortium of airlines will have a third party provide these types of services. It is recommended that the catering facilities (preparation and main stores) should be located to provide quick secure airside access to the aircraft terminal ramp areas. There will also need to be landside access to the catering facilities for the delivery of food products and materials.

III.1.3.9 Airport Administrative Facilities

The airport administrative facilities may house airport management offices, aircraft operator offices, government control authorities [i.e., Transportation Security Administration (TSA)], and airport police and security facilities. Some airports may establish these facilities as a complex separate from the terminal, whereas other airports may integrate these functions into the terminal building. If a separate administration complex is developed, an optimum location for these services is close to public transportation facilities with quick access to secure airport operations areas.

III.2 Land Use Compatibility

One of the primary objectives of the airport master planning process is to assess the compatibility of further airport development with surrounding land uses. While the terminal planner will not normally be involved in addressing this wider issue, it is important that s/he be familiar with the status of local land use planning that may have an important interface with the terminal planning process. Specifically, two levels of land use plans—regional and community—deserve particular attention in order to identify plans and projects that may affect, or be affected by the proposed passenger terminal project.

III.2.1 Regional Land Use Plans

Regional land use plans typically cover several jurisdictions and are usually prepared by the local Metropolitan Planning Organization (MPO). These documents are normally available on an MPO website or in hard copy for a nominal fee. When requesting these documents, it is prudent to ask the status of any revisions because they are updated periodically. It is important to use these plans in the early planning stages of the project to identify any potential incompatibility between the terminal and other planned transportation projects in the region. Conversely, there may be opportunities to coordinate the passenger terminal project with other regional projects. Airport Sponsor Assurances, which are signed when receiving federal funding, mandate that airport projects, including terminal projects, are reasonably consistent with plans of public agencies that are authorized by the state, such as the local MPO (*17*). When reviewing regional land use plans, the areas that have the greatest relationship to passenger terminal projects are typically highway projects; mass transit projects, such as light/commuter rail; and intermodal transportation centers.

III.2.1.1 Highway Projects

As most air passengers in the United States access the airport by car or some other form of road transport, passenger terminal projects may require off-airport highway interchanges to be upgraded or, in some cases, new interchanges to be built. Understanding the planned improvements to nearby highways may provide valuable information when determining the location of a new terminal. Likewise, a regional land use plan may also indicate if there are constraints to upgrading or constructing new interchanges near the airport.

III.2.1.2 Light Rail/Commuter Rail

Many commercial passenger airports are either directly or indirectly linked to regional light rail and commuter rail systems. Because these systems are large public undertakings that may take years to implement, it is critical to determine whether the planned alignments make a direct connection to the airport feasible and, more specifically, whether an airport rail station can be incorporated into the new terminal. Such an undertaking affects not only the physical design of the terminal, but also the ability to provide a right-of-way for the train to enter and exit the airport property. If regional mass transit is a factor in the planning of the passenger terminal facility, it is important to identify the potential benefits of linking the airport to the system and to discuss potential funding sources for the projects. When exploring mass transit at airports, another factor to consider is the potential for collateral development to occur near the train station. This development may include retail opportunities, parking for non-airport passengers, and increased surface transportation due to buses and taxis providing service to the station.

III.2.1.3 Intermodal Transportation Centers

Similar to light/commuter rail, some airports have true intermodal transportation centers that provide seamless connectivity between air, rail, bus/taxi, and automobiles. Regional land use plans will provide information regarding future plans to develop such facilities off-airport. Depending on the geographic relationship of the airport to these facilities, it could be a benefit to the airport and the region to host the facility on the airport in conjunction with an existing or planned passenger terminal facility. Furthermore, airport and terminal planners can recommend this type of facility, when it is appropriate, and coordinate with the MPO to have it included in the future regional plans. Inclusion in the MPO plans may make the project eligible for additional federal funding.

III.2.2 Community Land Use Plans

Similar to regional land use plans, community land use plans should be examined during the early planning stages to identify any constraints or opportunities. These plans are kept at local government offices and typically cover the areas immediately adjacent to the airport. When reviewing community land use plans, the areas that have the greatest relationship to passenger terminal projects are local roadway projects; recreational facilities, such as parks and hiking paths; and secondary/collateral development.

III.2.2.1 Local Roadway Projects

The local roadway system is the key mode of access for residents of airport support communities and neighboring towns. These residents include airport and airline employees, passengers living near the airport, and the multiplicity of service providers making regular truck deliveries. Passenger terminal projects may require local roadways to be upgraded or, in some cases, closed or re-routed. Understanding the planned improvements and the potential effects to nearby roadways is important, especially if there is some flexibility with regards to the precise location and orientation of the new terminal. Increased airport traffic may lead to congestion and/or increased traffic delays and pollution on local roadways. Sensitivity to these issues in the planning phases of a new terminal can be critical to building local support for the project.

III.2.2.2 Recreational Facilities

A number of airports and neighboring communities have developed recreational amenities, such as parks, golf courses, and hiking trails on or adjacent to airport property. These facilities provide opportunities for relaxation, pedestrian connectivity, and healthy exercise for the communities living near the airport. If community land use plans include proposals for new or expanded recreational facilities that may be negatively affected by the terminal development, the issue should be tackled proactively to see if ways can be found to mitigate these effects.

III.2.2.3 Secondary/Collateral Development

The location of an airport passenger terminal has a direct relationship to secondary development, such as hotels, rental car facilities, restaurants, gas stations, and off-airport parking. Therefore, plans for a new or expanded passenger terminal facility should be closely coordinated with the neighboring communities' land use plans to ensure that the secondary development that will occur can be accommodated.

III.2.3 Other Land Use Compatibility Issues

III.2.3.1 Environmental Wetlands

Passenger terminal projects have the potential to include impacts associated with wetlands. Wetlands are defined by the U.S. Environmental Protection Agency (USEPA) as areas that are inundated by surface or groundwater with a frequency to support, and under normal circumstances does or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions. Locating the presence of wetlands is a particularly important element in the compatibility planning step of the process because wetlands have special protection through federal and most state laws. The U.S. Army Corps of Engineers (USACE) will not allow a wetland to be filled unless it can be demonstrated that there is no reasonable or practicable alternative. In addition, Executive Order 11990, Protection of Wetlands, instituted a "no net loss" policy for wetlands, which the FAA implements by requiring airport sponsors to demonstrate attempts to avoid and minimize impacts to wetland before moving to mitigation planning.

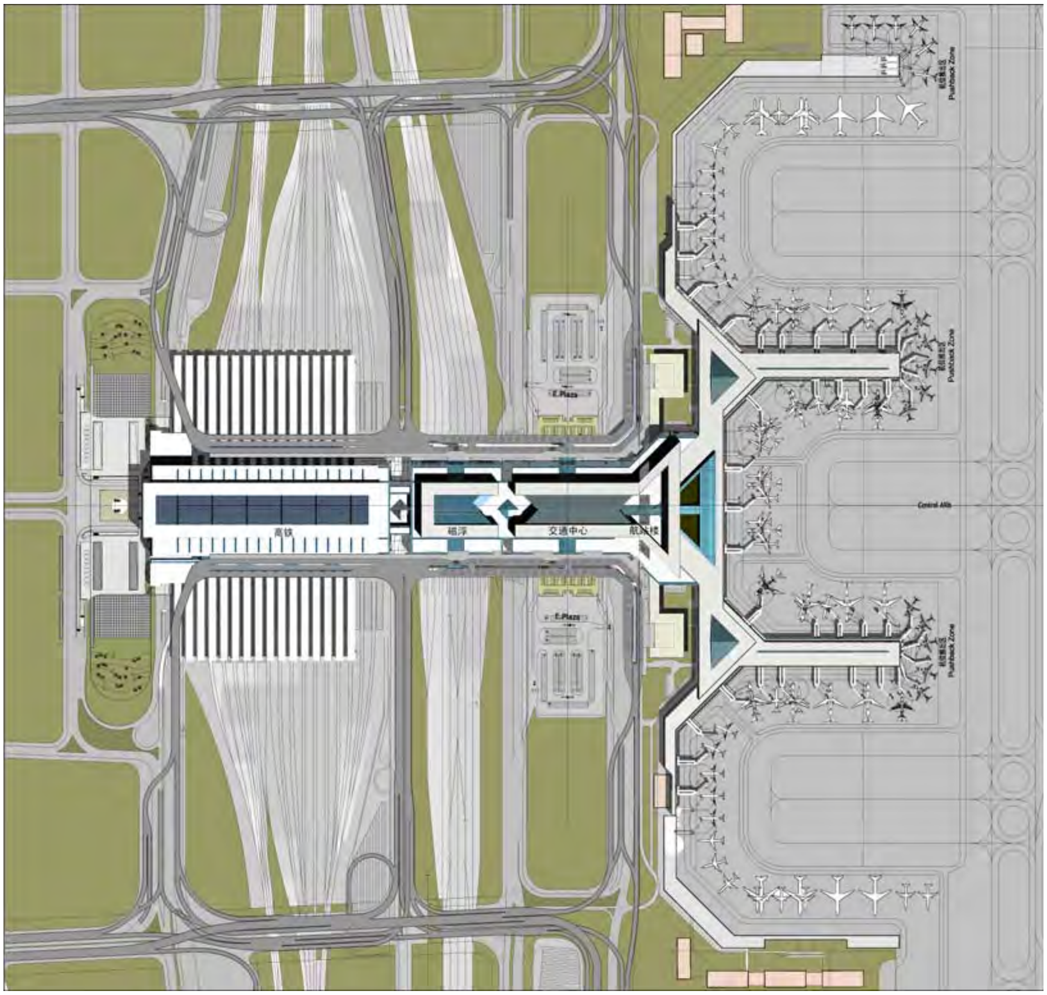
To avoid or minimize a potential effect to wetlands, an inventory of potential wetlands within the project area should be prepared. This inventory should make use of the national wetlands inventory or site-specific wetland delineation. As mentioned above, all wetland areas identified should be avoided if feasible. If impacts to wetlands are unavoidable, then early coordination with the USACE should be conducted to determine ways to minimize or mitigate the impacts to these wetlands.

III.2.3.2 Grading and Drainage

Passenger terminal projects have the potential to increase the amount of impervious surface at an airport, which will increase water runoff resulting in additional pollutants being washed into nearby streams. An airport may use detention/retention ponds to handle the increased water runoff and to treat for water quality. These issues are usually handled at a local level and require permits from the community where the airport is located. Having a complete understanding of these issues early in the process is helpful because if there is a need to create or modify detention basins, there can be secondary impacts.

III.2.3.3 Highest and Best Use Principles

As the privatization of airport ownership and management has not been adopted in the United States in the way it has in Europe, Asia, and Australasia, there has been less pressure on airport management to maximize commercial revenues. However, there is now an evolving trend to adopt the real estate land use principle of highest and best use of the property surrounding terminal facilities. Increased economic pressures to achieve maximum revenues from the passenger activity passing through airport terminals is driving a re-examination of land use priorities in relation to property adjacent to or conveniently connected to airport passenger processing centers.



Courtesy of: Shanghai Airport Authority

Figure III-1. Shanghai Hongqiao Airport.

At large hub airports, particular priority is now being given to realizing the inherent revenue potential of property developed in immediate proximity to terminals that process millions of passengers a year. Generally the closer the property is to these passenger processing activities, the greater the potential for revenue generation from hotel, office, and high-end retail developments, as well as, convention centers and other similar land uses. This highest and best use of land principle is the driving force behind the airport city concepts that have and are currently being developed with varying degrees of success overseas at airports like Hong Kong International Airport, with its adjacent SkyCity and major shopping malls associated with the airport rail in-town check-in facilities on Hong Kong Island and in Kowloon. The integration of a new passenger terminal with a major multi-modal ground transportation center and associated commercial and residential developments at the Shanghai Hongqiao International Airport shown in Figure III-1 is another example. Figure III-1 is from *Graphic Illustration of Hongqiao Integrated Transportation Hub*.

III.3 Ground Access Transportation

Ground access facilities at airports are the interface between the airport terminal(s) and the surrounding region. As such, planning for these facilities cannot exist in a vacuum. Coordination is required on the part of local, state, and federal governments from airport planning and operations representatives; local and state highway and transit officials; and private transportation providers who utilize airport facilities.

Ground access transportation planning at airports occurs on both a regional and a local scale. Regionally, the projected future needs of airport users must be taken into account during long-range planning processes and the strategic aspects will normally be considered in some depth during the Airport Master Plan development process. At a more detailed level, connections between components of the airport facility must be planned and designed to accommodate the expected traffic flows. Components of the ground transportation planning process are described in the following sections.

III.3.1 Regional Airport System Plan

The Regional Airport System Plan addresses air traffic demand and capacity, alternatives to meet future demand, air traffic forecasts, and environmental effects of airports on a regional basis. One of the most important parts of this document is the Ground Transportation Report. This report addresses the effects of increased aviation activity on ground traffic, the ground access improvements needed to support new airfield and terminal developments in the region, and a summary of existing and proposed improvements needed to support airport development.

III.3.2 Regional Transportation Plan

Each metropolitan area in the United States with a population greater than 50,000 has an MPO, which is responsible for coordinating transportation planning processes within its region. Under the requirements of federal transportation laws and regulations (SAFETEA-LU), the MPO has the responsibility to prepare a Regional Transportation Plan (RTP), often called a Long-Range Transportation Plan. The RTP covers a 20-year planning horizon and must be updated every 4 years in areas that have not attained or maintained requisite air quality standards and every 5 years for areas that have.

In development of RTPs, MPOs are encouraged to coordinate with local agencies and planning officials, including airport operators. Improvements to ground access facilities, in order to support airport operations, need to be programmed through the MPO process. Therefore, it is crucial for airports and MPOs to share information to increase the accuracy and efficiency of the planning process.

III.3.3 Airport Ground Access System

III.3.3.1 Roadway

The airport access road system, also known as the airport entrance/exit roadway system, connects the interior airport roads to the local and regional roadway system and is the point of transition between the local and regional roadway system and the airport terminal area. It will need to have the capacity to handle the volume of traffic for now and the future. This facility can vary from arterial roadways with traffic signal control to limited access/freeway type roadways at larger airports.

One of the main considerations to take into account in planning airport access roads is to make sure that they are used only by airport users. Non-airport traffic should be discouraged. Such traffic can best be discouraged by designing a roadway system that does not provide any incentive for other drivers to use the airport roadway, such as travel time advantages for drivers who are searching for a route to another destination. This roadway design needs to be given careful consideration in all types of traffic conditions. For instance, there may not appear to be any advantage during normal conditions, but an advantage may arise when traffic conditions on off-airport roadways are especially congested.

The best way to discourage non-airport traffic is to ensure that the only destination for the airport entrance road is the airport terminals and the other airport facilities. One of the ways that this is typically done is by employing a loop roadway that serves the terminals, parking, and other facilities.

Another important consideration is signage. A lot of information needs to be conveyed to drivers approaching the airport, including which airlines and flights are served by each terminal and which parking areas are open. Many passengers and visitors are infrequent users of the airport, so it is important to minimize the number of decisions to be made at any one point, as well as to provide adequate information sufficiently in advance of the decision points. Wayfinding signage should be simple and concise, with the amount of text on one sign limited to what can reasonably be digested quickly by a driver.

III.3.3.2 Rail

Connection to a regional rail transit system is a very important enhancement to the airport's ground access system. Connection to a regional system provides more flexibility for air travelers. It also provides an alternative means of access for airport, airline, and concession employees.

A main consideration in planning for a facility of this type is to place it as close as possible to the areas with the highest demand. Normally a regional rail system would connect to only one station on the airport. Rail connections, for example, should preferably deliver passengers directly to a dedicated airport station, rather than requiring them to take a bus or taxi to complete the journey. Figure III-2 depicts light rail transit to an airport. This station should ideally be located in the highest areas of passenger demand, such as a high-volume terminal. This location often involves significant design challenges, especially if the terminal is already built. Fitting a rail station in the terminal area can be very difficult. Not only do the station and the platform need space, but there also needs to be a lot of space for passenger circulation, fare collection, and queuing outside of the platform.

Given the space considerations, the airport rail station may need to be in a location away from the terminal, such as at a ground transportation center. From here the passengers and employees can walk to the terminals or connect to an on-airport bus or automated people mover system.

Courtesy of: © Steve Uzzell

Figure III-2. Light rail transit at Minneapolis–St. Paul International Airport.

Another consideration in planning for regional rail stations is flexibility. New station and track locations should be placed so as not to restrict future growth and flexibility of airport facilities. While placing the station close to the major activity centers is desirable, it may restrict the ability to make adjustments to the layout in the future. Location of the station farther away from the terminal may maintain more flexibility for future improvements.

III.3.4 Intermodal Connections

Airports often become a point of convergence for many different modes of transportation including road, rail, and, in some cases, ferry. Increasingly, airport planners worldwide are seeing merit in encouraging the use of public transportation to access airports, in order to reduce road congestion and the amount of land required for the parking of private vehicles, and to facilitate travel for airport employees. Good connectivity between the airport terminal and the various public transportation modes is an essential component of this strategy.

During the planning process, the needs of the various airport user groups must be taken into account. Regular airport users will soon work out the most efficient mode of travel from their perspective, while first time users will place a high priority on assurance of getting to the terminal in good time for their flight. Ease of use and wayfinding are important in ensuring that various transport modes are used to their full potential. The need to make multiple transfers between modes before reaching the destination significantly reduces the likelihood of users selecting that mode.

Intermodal facilities on the airport provide for connections among different providers of ground access services. These facilities bring together access for private vehicles, taxis, limousines, on- and off-airport shuttle buses, local and regional bus service, and possibly on- and off-airport rail service. An intermodal facility located adjacent to the terminal has the advantage of being within convenient walking distance of the terminal. The most common type is the use of the terminal curbfront. In the case of multiple terminals, this curbfront location would require multiple facilities. One of the main planning considerations of this type of facility is signage and wayfinding. This type of facility is typically spread out along a long length of curbfront. It is important to direct passengers correctly into and out of the terminal and from, or to, whichever mode of transport they are using.

An intermodal facility located away from the terminal is often called a “ground transportation center” (GTC) and provides a centralized area for a variety of public transportation modes to pick up and drop off passengers. This option provides greater flexibility for expansion in the future than one located next to the terminal. The major planning consideration for a GTC is access to and from the terminals. Sometimes access can be achieved by positioning the GTC between two terminals and maintaining reasonable moving walkway–assisted walking distances. If distances are too long, however, a supplementary shuttle bus or people mover system becomes necessary. Both systems will require a change of mode for the passenger, which increases travel time. A bus system has a much lower initial capital cost and provides the most flexibility. A rail-based system has a higher initial capital cost but offers a higher quality of service than a bus system. If the demand is especially high, the rail system, such as an automated people mover (APM), should be considered seriously.

III.4 Terminal Site Planning

III.4.1 Airfield Considerations

The design and siting of the terminal complex requires an examination of the existing and future airfield layout requirements. The fundamental airfield-associated components that largely determine the terminal design and location include the Obstacle Clearance Surface requirements, taxiway/taxilane requirements, ATCT sight lines, runway exit locations, and other airfield design standard considerations. Each aspect heavily relies on the type and size (or number) of aircraft operations expected to occur at the airport.

III.4.1.1 Taxiway and Taxilane Requirements

When designing the airfield and terminal complex, it is important to provide an adequate taxiway/taxilane network to provide flexibility in aircraft movements throughout the entire airport. The taxiway and taxilane network will provide for safe, efficient, and expeditious travel between airport facilities (passenger terminal, cargo structures, general aviation facilities, etc.) and the runway system. Specifically, the taxiways function as the airport's paved network for aircraft between the runways and the apron, while the taxilanes provide aircraft routes on the aprons between the taxiways and terminal gate positions. Both taxiways and taxilanes must follow appropriate dimensional criteria based on current FAA and International Civil Aviation Organization (ICAO) design standards. For more information on taxiway and taxilane definition and fundamental design requirements, see Section V.1.2, Aircraft Maneuvering and Separations.

III.4.1.2 Airport Obstacle Clearance Surface Requirements

Navigable airspace in the vicinity of airports is governed by FAR Part 77 standards, which exist to protect the airspace and runway approaches from obstacles and hazards to aircraft in flight. Planning and design of the terminal building must consider any potential effect to these imaginary surfaces. An optimum design configuration avoids or minimizes any significant penetration of the existing and future airport imaginary surfaces. Imaginary surfaces include the primary, approach, transitional, horizontal, and conical surfaces. See Section V.1.1, FAR Part 77 and TERPS Requirements, for further discussion of these imaginary surfaces. If intrusion into these surfaces occurs as a result of terminal development, marking and lighting of the obstruction should take place as described in FAA AC 70/7460-1, *Obstruction Marking and Lighting* (*18*).

The building restriction line (BRL) is used to identify suitable building area locations on airports. The BRL should encompass the runway protection zones, the runway object free area, the runway visibility zone, navaid critical areas, areas required for terminal instrument procedures, and ATCT clear line-of-sight.

III.4.1.3 Runway Visibility Zone

If there are intersecting runways, a clear line-of-sight between the ends of the runways is recommended. Terrain needs to be graded and permanent objects need to be designed or sited so that there will be an unobstructed line-of-sight from any point 5 feet above one runway centerline to any point 5 feet above an intersecting centerline, within the runway visibility zone. See FAA AC 150/5300-13, *Airport Design,* Section 503 (*15*) to determine the runway visibility zone.

III.4.1.4 Air Traffic Control Tower Sight Lines

A clear and unobstructed line-of-sight must exist between the ATCT and all runway approach paths and movement areas (runways and taxiways) on the airfield. This requirement warrants consideration during the terminal siting analysis and design so that interference between ATCT and critical runway, taxiway, and apron areas does not occur. Besides general building structure, aspects of terminal design for consideration include aircraft parking configurations, tail heights, and ramp lighting, because they can result in line-of-sight shadows for the ATCT. The controller must be able to, at a minimum, see the fuselage of all aircraft types operating on the airfield. Section V.1.3 presents additional information relevant to ATCT line-of-sight requirements.

III.4.2 Landside Considerations

The primary landside elements that are important in the design and location of a terminal are intermodal facilities, roadways, pedestrian facilities, and parking facilities. Because each of these elements needs to be located very close to the terminal, they will have a great impact on how the terminal is situated and how it functions.

III.4.2.1 Intermodal Facilities

Intermodal facilities include regional transit links to the airport (such as light rail or heavy rail) and on-airport commercial vehicle staging areas. The primary considerations for regional rail links are the right-of-way needed for the trains, the station layout, and the access links between the station and the terminal. The rail right-of-way and station layout will typically be covered in the design standards for the entire rail system. These can be adapted for the airport environment. Access from the station may be horizontal (sidewalks, moving walkways, overhead walkways) or vertical (escalators, elevators, and stairs). Stations located more than ¼ mile from the station may require a separate transit link to the terminal.

There is more flexibility in the layout and location of commercial vehicle staging areas, because these areas are entirely under the control of the airport design team. They can be dispersed or consolidated. Further discussion of the requirements for intermodal connections is contained in Section VII.2.

III.4.2.2 Roadways

Depending on the size of the airport, many different types of roadways can affect the terminal. However, for most airports, the main ones will be the terminal approach roads, the terminal curbfront roads, and the recirculation roads. The terminal approach roads will widen out as they approach the terminal into the terminal curbfront roadway, which has the widest footprint. The terminal curbfront roadways need to provide for loading and unloading lanes at the terminal and for lanes to accommodate vehicles not stopping at the terminal. For a two-level terminal, the height of the upper level roadway should be a consideration in air flow for the lower level.

Recirculation roads deserve special consideration. They are roadways that allow drivers to leave the terminal and either come back to the same terminal curb or go to another level of the same terminal or to a different terminal. Typically recirculation roads are one-lane roadways, with a wide shoulder to accommodate bypass in case of a vehicle breakdown. The turning radius on these roadways is much tighter than on a typical roadway, and ramp slopes (for two-level terminals) may be steeper than typical roadways. Requirements for roadways are discussed in more detail in Section VII.3 and for terminal curbfronts in Section VII.4.

III.4.2.3 Pedestrian Facilities

Landside pedestrian facilities include sidewalks in front of the terminal and, in many cases, sidewalks in between curbfront lanes. These facilities increase the width of the footprint needed in front of the terminal and, consequently, have an impact on the siting of a terminal. Requirements for pedestrian facilities are contained in Section VII.4.1.

III.4.2.4 Parking Facilities

Typically only passenger parking facilities are located adjacent to the terminal. Other parking facilities (such as employee, rental car, and cell phone lots) are located away from the terminal. Passenger parking can be provided in surface lots, in a parking garage, or in a combination of both. Parking can be placed facing the terminal or on the side of the terminal. For busy airports, the parking lots or garages can take up almost as much land as the terminal itself. Parking facility requirements are presented in Section VII.5.

III.4.3 Utilities Considerations

Utilities can be classified into four main categories: water, sewerage, natural gas, and electric power. Existing terminal expansion or new terminal infrastructure projects should take into consideration each of these utility systems as each can have an effect on the planning and design process. Early in the planning of a new airport terminal or substantial terminal renovation, the site utilities should be assessed to ensure that sufficient capacity is available and that the planner is aware of the location of primary utility alignments. Adequate access considerations should be taken into account when planning the terminal's utility infrastructure in order to provide for proper maintenance and operation of an efficient system. Additionally, careful consideration should be given to incorporating sustainability principles, which are more fully presented in Section III.8.

III.4.3.1 Water

There are two basic patterns of water distribution systems: branching pattern or gridiron or network pattern. Built-up areas, which often require a reliable supply for firefighting capabilities, are more commonly found utilizing a gridiron pattern. Valves installed with valve boxes provide maintenance access from the surface, while larger valves are typically installed in pits or manholes. Pipe diameter and water flow rates are determined by fire protection requirements. Rainwater collection systems are a type of a sustainable building practice that captures rainwater for reuse in landscape irrigation. Another sustainable building practice that contributes to water use reduction is the use of water-conserving fixtures such as urinals, water closets, and metering faucets (infrared).

III.4.3.2 Sewerage

Sewerage systems can consist of either a combined system that collects both wastewater and stormwater runoff from domestic and industrial sources or a waste collection system and separate stormwater system. Separate sanitary and stormwater sewers allow for separate collection and treatment before release. Gravity flow is more typically favored in the design of a sewer system and must be installed with an appropriate downward slope, which may result in varying sewer depths based on the site's topographical features. Pumped or pressurized systems can be installed to address gradient challenges; however, the costs of energy and the possibility of power loss and pump failures reduce the benefits of this type of alternative. Sustainable wastewater building practices can reduce the demand required for a sewer system by utilizing wastewater recovery systems such as the reuse of gray water or on-site wastewater treatment. Gray water is typically defined as wastewater that does not involve human waste or food processing. Typical examples include wastewater from sinks, showers, and washing machines; cooling tower bleed down water; and condensation from air conditioning systems.

Because deicing/anti-icing and glycol fluids are chemical products that have environmental consequences that affect the water quality of local waterways, it will be necessary to provide for the collection and treatment of aircraft deicing and airfield glycol fluids. The recommended structures are those that compose a mitigating alternative that collects and retains runoff for proper disposal or recycling. The deicer runoff must be isolated from the airfield storm sewers or from terminal areas that do not divert seasonal flows of glycols. Deicing facilities enhance the feasibility and economic benefits of recycling glycols by collecting higher concentrations, as compared to drainage systems where glycols are further diluted with other runoff and precipitation.

III.4.3.3 Natural Gas

Natural gas systems typically are supplied via a distribution system fed by a transmission system under reduced pressure. Operation and maintenance are managed by means of access to valves located in vaults or vault boxes.

III.4.3.4 Electric Power

Electric power is either distributed via underground or aerial power cables. It is typically distributed via high voltage transmission lines to substations serving commercial and industrial users such as airports. Typical substations transform from high to low or low to high voltage using transformers. Underground cables can be either buried in the soil or run through ducts or conduits placed underground separately. These duct systems allow for removal and replacement of cable in future applications or the addition of new cable runs without excavation. Transformer space and switching devices are typically installed in underground vaults adjacent to the building or placed in the building's basement. Adequate space for these devices should be taken into consideration early in the planning stages and sized appropriately during the building plan phase. Additional space requirements may be necessary if utilizing certain sustainable building practices that reduce the demand for grid-supplied electric power.

III.4.3.5 Solar Orientation

Solar orientation refers to the use of active or passive systems for capturing the sun's energy. Active systems can capture energy through the use of tilted and/or fixed panels or tracking panels. Passive solar technology is used for harnessing the sun's renewable source of heat during winter months; ventilation during the cooling season; and natural daylighting, which reduces the need for artificial lighting during daylight hours. Elongation of buildings in the east/west axis limits the exposure to the east and west sides, which are more difficult to shade in the morning and afternoon because of the sun's lower angle at these times of day. The more exposed south side can take advantage of the sun's lower angle during the winter months increasing solar heat gain, and shade devices can be implemented to reject the sun's higher direct rays during the summer months, as well as using the prevailing winds for natural ventilation during the cooling season. The long east/west axis also maximizes natural daylight, but glare resulting from direct sunlight should be studied and corrective measures should be taken to diffuse this light. Regardless, the airport's physical location and local climate will ultimately dictate the suitability of other types of this sort of power generation.

III.5 Airport Security

Planning for security of the airport in general, and the terminal in particular, should begin early with a security review of the schematic design efforts of the architects and engineers. A threat and vulnerability assessment should be initiated to identify the strengths and weaknesses of any given elements of design and provide the opportunity to address them in advance on paper, rather than in subsequent expensive and time-consuming change orders to move bricks, steel, and fiber.

Further, terminal security is not limited to anti-terrorism and hijack concerns; the airport operator must also seek to protect the public from theft, physical attack, vandalism and vehicle damage in parking facilities, and all the typical concerns found in a very dynamic and highly transient and stress-filled public environment. These are not trivial matters; they are the daily operational issues around which the rest of the terminal must find a comfortable co-existence.

Over the years, and particularly since September 11, 2001, security issues permeate virtually every aspect of the planning of the terminal complex. This security planning includes not just the TSA passenger and baggage screening operations, but also the federally required access controls to the various levels of security-related operational areas and the closed circuit television surveillance that supplements many of those areas due to dual safety and law enforcement requirements. Terminal complex security issues include the placement of approach roads, parking facilities with adequate standoff, vehicle barriers, blast resistant facades and glazing, limited concealment areas/structures, and a multitude of secure operational pathways, corridors, stairwells, and elevators inside and outside the terminal.

While security concerns for the airport typically begin at the airport's perimeter boundary, this Guidebook will focus on the three primary areas of the terminal complex:

- Airside security
  - Vehicle and pedestrian gates and portals
  - Planning for vehicle checkpoints
  - Apron areas
- Terminal security
  - Terminal lobby issues
  - Employee screening
  - Baggage screening
- Landside security
  - Access roadway and terminal curbside
  - Multi-modal and multi-terminal connections

The topics of airside, terminal, and landside security are discussed in detail in Section V.1.5, Airside Security; Section VI.1.6, Terminal Security; and Section VII.7, Landside Security.

III.6 Information Technology and Communications

From a terminal building systems perspective, the information technology (IT) system is the lifeblood of the entire terminal operation; it is the primary means by which information is transferred to and from airport users, their customers, and business partners. Airport IT systems also underpin key airport management functions including building safety, building services, building maintenance, gate assignments, and airport security and environmental control.

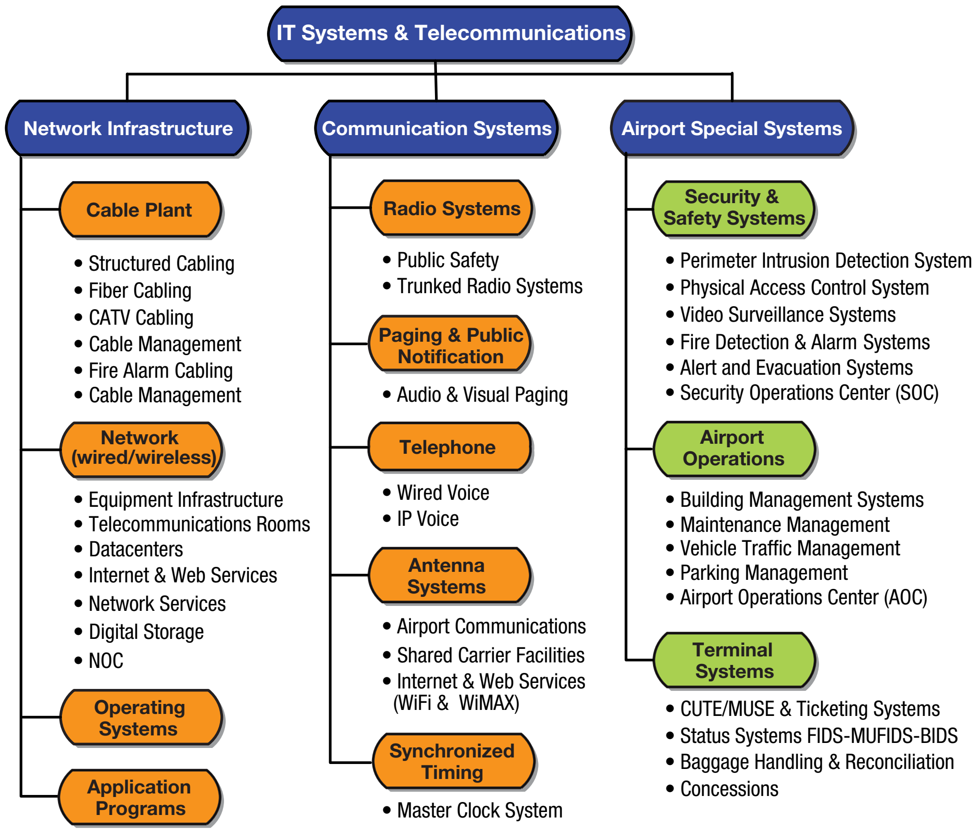
Figure III-3 depicts the range of users and applications that a modern airport IT network should be capable of supporting; each will require attention during terminal design, both as an individual function and part of an overall integrated IT system.

Like physical security and public safety, IT must be a part of the planning process from the very beginning. Issues such as wired vs. wireless, bandwidth availability, network infrastructure and security, Common Use Terminal Equipment, public internet access, and airline and tenant support are all integral parts of IT provisioning for terminal facilities. Without those, and many more, being fully functional and relatively fail-safe, the airport cannot function efficiently.

IT planning for terminal services is not limited to the routing of fiber and copper within the cable plant; it extends to maintaining the availability and functionality of every piece of equipment along the entire network. The IT system must support passenger check-in facilities at curbside and ticket counters, public address systems, baggage handling equipment, internal communications, security and administrative functions of not only the airport and airlines, but also a wide diversity of tenants, public users, and government support agencies, as well as emergency systems and automated systems such as heating, ventilation, and air conditioning (HVAC) power management and lighting controls.

The topic of IT systems is explained more fully in Section VI.4.2, Information Technology Systems, which will discuss the importance of early attention to choices between distributed vs. central design of network architecture; system performance capabilities among the alternative structures; trends in IT networks for common use facilities; scalability to accommodate future demand and some of the more esoteric issues surrounding cabling, system maintenance, and power and network backups; and overall IT systems management, including security of the network itself.

In summary, IT system design is an overriding concern that reaches into virtually every corner of airport planning and operations, from the public's curbside arrival through their airline and



Source: TranSecure

Figure III-3. Airport IT and telecommunications services.

airport processing, visits to services and concessions, safety and security maintenance, and ultimate departure or connections. Terminal planning, from front door to departure gate, determines the essence of the passenger experience, but none of that is possible without an appropriately designed and configured IT network that functions as an integrated whole and can be readily adapted to a very rapidly evolving technology.

III.7 Environmental Protection

A range of environmental issues are relevant to the terminal planning process. In particular, the planner should be fully aware of the implications of the environmental regulatory requirements described in the NEPA, the role of the FAA, compliance requirements of other state and special purpose environmental laws, and the relationship between NEPA and sustainability. Information on techniques used to effectively integrate development planning and environmental activities throughout the airport project development process are available in *ACRP Synthesis 17* (*19*).

III.7.1 National Environmental Policy Act

NEPA of 1970 requires all federal agencies to integrate environmental protection values into their decision-making processes by considering both the environmental impacts of proposed policies and projects and whether reasonable alternatives exist to mitigate those impacts. NEPA created the Council on Environmental Quality as the environmental policy arm of the federal government, and the FAA is required to comply with its rulings.

To comply with the requirement to implement NEPA, the FAA promulgated Order 5050.4B (*20*) and Order 1050.1E (*21*). Any airport development that requires federal involvement or action must comply with NEPA. Examples of federal involvement or action include the following:

- Use of federal funding of any kind
- Approval for a new public use airport
- Approval of a new or amended Airport Layout Plan (ALP)
- Authorization to use Passenger Facility Charges (PFC) funds
- Use or transfer of federally owned land
- Release of federally owned airport land for non-aeronautical use
- Approval of noise compatibility programs
- Approval of the restriction of Stage 3 aircraft
- Issuance of a Part 139 certificate
- Approval of a wildlife hazard management plan

The use of federal funding, PFC funding, and approval of an ALP are the most common federal actions associated with passenger terminal projects.

There are three levels of environmental review that may be required prior to receiving environmental approval from the FAA. These levels, from least to most extensive, include a Categorical Exclusion (Cat-Ex), Environmental Assessment (EA), and Environmental Impact Statement (EIS). The selection of which type of environmental review will be required for a specific project is dependent on the size of the project and the scale of potential impacts of the project on the environment.

III.7.1.1 Categorical Exclusion

According to FAA Order 1050.1E (*21*), Cat-Exs apply in cases when, based on past experience, the FAA has concluded that projects of this nature do not normally require an EA or EIS because they are not likely to cause significant effect on the environment. Many minor passenger terminal projects (such as small additions) can be processed and receive approval under this category.

The preparation of a Cat-Ex for a passenger terminal project can be as simple as completing a checklist or may include some environmental analysis to support the findings that no extraordinary circumstances exist that would require further analysis. As such, most Cat-Ex documents for passenger terminal projects can be prepared in 1 to 2 months. There is no requirement for a public review or hearing with a Cat-Ex, although the FAA may suggest some coordination with regulatory agencies when there is reason to do so.

III.7.1.2 Environmental Assessment

The purpose of an EA is to identify if significant impacts would occur as a result of the proposed action. There are two possible outcomes to an EA. The first is that there would be no significant impacts as a result of the project. In this case, a Finding of No Significant Impact would be prepared and the environmental review is complete. The second outcome would be that significant impacts would occur and an EIS must be prepared as described in Section III.7.1.3.

Passenger terminal projects that are of a substantial nature, or include impacts that may be significant, require an EA to be prepared. This effort involves a more rigorous evaluation of potential environmental impacts than required by the Cat-Ex procedure. As a result, the preparation of an EA may take many months to complete, depending on the issues. Coordination with regulatory agencies is required, and a public hearing may be recommended by the FAA.

III.7.1.3 Environmental Impact Statement

The most intense level of environmental review is an EIS. The main purpose of an EIS is to identify and disclose all impacts that would occur as a result of the proposed action. In cases where an EIS is required, the FAA is responsible for the management of the EIS, including the selection of a consultant if necessary. Most passenger terminal projects alone will not require an EIS, because they are typically constructed in areas on airports where similar activity is already taking place. However, passenger terminal projects are sometimes packaged with other development projects in a consolidated EIS Study.

Because this is the most intense level of review, it can take many years to complete, depending on the size and the impacts that would result from the project. An EIS requires formal coordination with other regulatory agencies throughout the process, and a public hearing is required.

III.7.2 Environmental Considerations in Passenger Terminal Planning—NEPA

When undertaking a passenger terminal project, environmental considerations should be considered during all phases of the planning process as discussed below.

III.7.2.1 Initial Planning Phase

During the initial planning phase of a passenger terminal project, the general criteria for size, number of gates, and potential locations will be determined. It is appropriate at this time to start developing the arguments that explain the purpose and need for the project. As specified in FAA Order 1050.1E (*21*), the proponent must demonstrate both the need for the project and how the proposed project will meet that need (commonly referred to as Purpose and Need); the proposed timeframe for implementing the development should also be indicated. At this point in the process, the focus should be on identifying the major deficiencies in the existing terminal and the demand, operational, or regulatory triggers that are driving the need for new or expanded terminal facilities. Some example needs follow:

- The existing terminal will exceed its current design capacity at a specific number of annual enplaned passengers.
- The existing terminal facility cannot accommodate required security screening.
- The existing terminal cannot be expanded because of age, site constraints, or safety requirements.

When evaluating alternative passenger terminal locations, attempts should be made to avoid or minimize impacting sensitive environmental resources. While all environmental categories need to be considered, the following environmental categories are the most likely to be impacted by a passenger terminal project.

Air Quality. The air quality status of the county in which the airport is located determines the extent of the air quality analysis required under the Clean Air Act conformity regulations. Based on the National Ambient Air Quality Standards for various air pollutants, the USEPA designates the status of counties according to whether the relevant air quality standards have been attained (or not) and, if attained, are being satisfactorily maintained. These designations determine the thresholds against which new project-related emissions are compared to determine the potential for significant air quality impacts.

Air pollutant emissions at an airport result from a combination of aircraft operations: the use of GSE, heating equipment, fuel storage, automobiles, and construction activities. In most cases, the area of greatest concern is the passenger terminal curbfront where cars, taxis, and buses have the potential to be stopped and idling for long periods of time during peak periods of activity. Areas in the vicinity of aircraft parking gates are also of concern due to emissions from taxiing aircraft and GSE and activities such as refueling and the use of auxiliary power units while the aircraft is being serviced. There are a number of ways to minimize pollutant emissions when planning a passenger terminal facility:

- Curbfront initiatives
  - Remote taxi staging areas
  - “Kiss-n-fly” parking areas

  - Consolidated remote rental car facilities
  - Free-flow traffic control at the departure and arrival curb areas—grade-split curbfronts
  - Intermodal connections with public transportation systems
  - Use of "greener" fuels by airside vehicles and public and hotel buses
- Airside gate initiatives
  - Installation of a hydrant fueling system
  - Electrifying of aircraft gates through the use of 400 Hz power systems
- Construction/design initiatives
  - Fuel efficient and low-emission heating units
  - Energy-efficient building methods
  - Use of construction equipment that meets the applicable federal non-road emission standards (tier compliant)
  - Efficient construction phasing

Hazardous Materials and Solid Waste. Passenger terminal projects have the potential to include impacts associated with hazardous materials and solid waste. There are a number of ways to avoid or minimize these potential impacts when planning a passenger terminal facility:

- Hazardous materials: A waste is considered hazardous if it is listed as such by the USEPA or it exhibits characteristics of ignitability, corrosivity, reactivity, or toxicity. Airports routinely use, transport, and store potentially hazardous materials such as aviation fuel, compressed gases, batteries, and deicing fluids. Additionally, should a passenger terminal project include the demolition or modification of existing structures, these structures may contain asbestos and/or lead, depending on their age. To avoid or minimize impacts, an inventory of hazardous materials on the airport or on the sites where the facility may be located must be conducted. This inventory should include reviewing previous environmental documents and potentially conducting field surveys. When feasible, locating terminal and support facilities in these areas should be avoided. When avoiding impacts due to hazardous materials is not possible, then steps should be taken early in the process to determine the extent of the impacts and to develop a mitigation plan that includes monitoring of the site.
- Solid waste: Passenger terminal projects typically include an increase in solid waste. There are temporary increases that occur during the construction phase of the project, and then, when the facility is open, it is not uncommon to have an increase in solid waste from the additional concessions, gates, and airline spaces. Early coordination should occur with the local waste management agency to ensure that increases in solid waste can be accommodated. Airport-wide recycling programs should be instituted and built into the lease agreements with terminal tenants. Solid waste accrued during international travel may constitute a hazard. The waste material must be isolated and dealt with in accordance with government regulations intended to protect the environment and public health.

Natural Resources and Energy Supply. Passenger terminal projects have the potential to include impacts associated with natural resources and energy supply. To avoid or minimize these potential impacts when planning such facilities, it is important to consider the following:

- Natural resources: A majority of passenger terminal projects utilize materials that are readily available and therefore, typically, will not result in impacts to natural resources; however, should the project include materials that are not considered typical in terminal projects, suppliers should be contacted to determine if those materials would be available. The airport should consider implementing projects to reduce use of natural resources such as replacing existing vehicles with vehicles that run on alternative fuels such as electric or hybrid.
- Energy supply: Passenger terminal projects typically result in an increase in the airport's demand for electric and natural gas to power and regulate interior climate. To determine if there would be adequate energy supplies for the project, early coordination with the airport's supplier

should occur. An airport should reduce its use of energy by using energy-efficient products such as compact fluorescent light bulbs, skylights, and other energy-efficient heating and cooling systems.

Water Quality. There are two main areas of potential effect on water quality associated with terminal projects—wastewater management and drainage of surface water:

- Wastewater: It is common for there to be an increase in the amount of water being used as a result of a passenger terminal project. Temporary impacts would result from the construction of the project, but increases also may result from the increase in additional passengers and concessions that are typically included with these projects. Water-saving programs should be considered when developing the project.
- Surface water: Any increase in impervious surface at an airport will have the potential to increase water runoff, which may result in additional pollutants being washed into nearby streams. An airport may use detention/retention ponds to handle the increased water runoff and to improve water quality. These issues are usually handled at a local level and require permits from the community that the airport resides in. Having a complete understanding of these issues early in the process is helpful because the creation or modification of detention basins can cause secondary impacts.

Wetlands. Wetlands are defined by the USEPA as areas that are inundated by surface or groundwater with a frequency that, under normal circumstances, does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions. Wetlands are often important as "stopover" points for migrating birds and can have an ecological significance extending far beyond the neighboring region.

To avoid or minimize a potential effect to wetlands, an inventory of potential wetlands within the project area should be prepared. This inventory should make use of the national wetlands inventory or site-specific wetland delineation. All wetland areas identified should be avoided when feasible. If impacts to wetlands are unavoidable, then early coordination with the USACE should be conducted in order to determine ways to minimize or mitigate the impacts to these wetlands.

III.7.2.2 Design Phase

Recently, the concept of "sustainable design" has received a great deal of attention. These efforts include the incorporation of materials, systems, and procedures that are self-sustaining, require less energy, require less maintenance, and in some cases actually return energy. While these concepts may be studied in the planning phase, it is the design phase when these concepts will be developed and decisions can be made to include them in the project. More information on the use of sustainable methods in the design of terminal facilities can be found in Section III.8.

III.7.2.3 Environmental Review Phase

As discussed above, the implementation of a passenger terminal facility will likely trigger the need for an environmental review in accordance with NEPA and FAA Orders 1050.1E (*21*) and 5050.4B (*20*). Depending on the level of environmental review, the process may take from a month to several years. Understanding this process and the amount of time that may be required is critical to successful implementation planning. In addition, understanding the amount of time it may take to obtain the environmental approval will determine when the environmental review process should begin. To accomplish this phase most efficiently, the following steps should be taken.

Early Coordination. The project should be discussed with the FAA early in the process after the basic plan is developed and potential environmental impacts are known. This discussion may require that a brief environmental overview is initially prepared. The purpose of meeting with the FAA at this point in the process is to accomplish two goals. The first is to inform the FAA of the project, to share the preliminary Purpose and Need and the anticipated timeframe, and to identify any areas of concern. The second is to obtain a decision on the level of environmental review that will be required. The sponsor of the project should come prepared for the meeting with drawings of the project, a project schedule from initiation to planned opening day (with some time shown for environmental review), and a brief summary of the environmental resources in the area and the potential for impacts. Any concerns raised by the FAA and decisions regarding the level of environmental review should be documented and circulated to all parties after the meeting.

Depending on the types of impacts anticipated, the FAA may also request that the sponsor of the project contact other federal, state, or local regulatory agencies to discuss impacts and potential mitigation. For example, impacts to known historic or archaeological sites should be coordinated as early in the process as possible.

Preparation of Environmental Documentation. Once the planning for the project has been completed, the formal environmental review can begin. The specific requirements of each level of environmental review are provided in FAA Orders 1050.1E (*21*) and 5050.4B (*20*). The timing for starting this review is dependent on the timing for the overall project and the level of review that will be required. An environmental approval from the FAA will almost always be required prior to initiating construction; therefore, it is important to understand the amount of time it will take so that the project is not delayed. However, environmental approvals from the FAA have an expiration date of 3 years if substantial activity on the project has not occurred (e.g., grading, demolition of existing structures, land acquisition, etc.).

Environmental Permitting. After preparation and approval of the environmental review document, there may still be additional effort required to obtain environmental permits for the project. The most common of these include a permit for impacts to a wetland, which may require both a federal and a state permit, as well as a National Pollutant Discharge Elimination System (NPDES) permit for the release of pollutants into the water system during construction. These permits can take many months to obtain and should not be ignored in the project schedule. The USACE and/or the state will be the responsible agency for providing wetland impact permits. It is recommended that a pre-application meeting with the USACE should be conducted early in the process if wetland impacts are likely to occur.

III.7.2.4 Construction Phase

Construction activities associated with passenger terminal projects typically create temporary impacts. These impacts are usually associated with air emissions, noise, runoff/erosion, changes in traffic patterns, and the disturbance/release of hazardous materials.

Construction of a terminal complex will cause a temporary deterioration in air quality due to dust and other particulates and emissions from the use of construction vehicles. This temporary increase in pollutants will be measured against the same standards as emissions that result from completion of the terminal. The discharges of these pollutants are typically minimized with the use of Best Management Practices (BMPs).

Temporary impacts to surface water quality could result from erosion and siltation arising from site disturbance activities. This risk of effect to water quality can be minimized through the adoption of BMPs specified in a Construction Erosion and Sedimentation Control Plan.

Activity at airports can generate increased noise for the communities located near the airport. This noise is primarily a function of aircraft overflights, but also includes increased automobile and truck traffic that is typically found near airports. Therefore, construction projects can exacerbate the noise problem and can easily upset airport neighbors. Therefore, when preparing to undertake a terminal project, it should be recognized that noise will increase in the vicinity of vehicles and equipment involved in the construction process. Typically, terminal complexes are located near the center of the airfield and the noise would not be distinguishable from the usual noise being produced at the airport. However, there may be cases where this additional noise will be distinguishable and should be addressed with a thoughtful noise reduction plan. An example of this plan may be limiting particularly offensive noises, such as pile driving and equipment with back up alarms, to daytime hours whenever possible. In addition, it should also be noted that existing and temporary roadways providing access to the site will see a temporary increase in traffic flow thus increasing the level of noise.

Should buildings need to be demolished during the project, there is a possibility that some debris may contain hazardous materials such as asbestos, solvents and lead paints. These materials are typically found in older buildings and measures exist to dispose of them properly. Additionally, the storage of equipment and construction vehicle staging may result in small fuel and oil spills.

III.7.3 Environmental Regulatory Considerations in Terminal Planning—Other Than NEPA

While NEPA and FAA guidance provide the basis for most of the environmental review requirements for airport projects, there are other considerations that must be considered when undertaking a passenger terminal project. These include state-based environmental laws and other federal environmental laws.

III.7.3.1 State Environmental Policies

Most states have environmental laws in place that will apply to airport projects, including passenger terminal projects. A thorough review of the state environmental laws and policies should be conducted at the same time as the NEPA environmental review. It should be noted that, at this time, most state environmental policies are consistent with federal standards and therefore covered in the course of preparation of the NEPA environmental review document. However, there are other states that have different requirements and may be more onerous than federal standards. For those states, a separate environmental review document may be necessary and should be considered when planning the project schedule. Examples of additional analysis that may be required under a state environmental policy include greenhouse gas emissions, forestland/fire hazards, seismology, and mineral resources.

III.7.3.2 Federal Special Purpose Laws

In addition to NEPA and state environmental policies, a number of special purpose laws also may need to be complied with for a passenger terminal project. These laws have their own processes and may require considerable consultation depending on the level of impacts. Therefore, it is important to understand the type and level of impacts a project may have as early in the process as possible. The following paragraphs discuss the most common laws and acts that airport projects have to consider.

Section 106 of the National Historic Preservation Act. This act requires federal agencies to take into account the effects that their federally funded activities and programs have on significant historic properties, those included or eligible for the National Register of Historic Places. If a historic place, typically over 50 years of age, is located at the project site, a Section 106 review must be conducted. This review will determine the significance of the structure and what effect the project will have on the structure. This review is typically coordinated with the state historic preservation office.

Coastal Zone Management Act. The Coastal Zone Management Act was established to preserve, protect, develop, and restore the nation's coastal zones. Should the project be located within a coastal zone, coordination with the state department of environmental protection will need to occur to determine if the project is consistent the state's coastal management program.

Endangered Species Act. The Endangered Species Act protects plants and animals that are listed by the federal government as endangered or threatened. During the environmental review for the project, it must be verified that species on this list do not inhabit or rely on the area to survive. This can be done through coordination with the Department of Fish and Wildlife.

Migratory Bird Treaty Act. This act makes it unlawful to pursue, hunt, capture, kill, or sell birds listed as migratory birds. Similar to the Endangered Species Act it must be verified that species on this list do not inhabit or rely on the area to survive. This can be done through coordination with the Department of Fish and Wildlife.

Farmland Protection Policy Act. The Farmland Protection Policy Act is intended to minimize the effect federal programs have on the unnecessary and irreversible conversion of farmland to non-agricultural uses. If farmlands exist on the site where the project is to be developed, a Farmland Conversion Impact Rating Form must be filled out and submitted to a local office of the Natural Resources Conservation Service or U.S. Department of Agriculture.

Clean Water Act. The Clean Water Act regulates the direct and indirect discharge of pollutants into waters of the United States, including navigable waters and their tributaries, interstate waters, and oceans out to 200 miles. If the project will discharge wastewater or stormwater into the nation's water from a point source such as a pipe, ditch, channel, or tunnel an NPDES permit must be completed prior to initial discharge. This permit may also be required for the construction of the facility.

Executive Order 11988: Floodplain Management. Executive Order 11988 requires federal agencies to avoid, to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development. Direct support results from an encroachment, while indirect support results from an action out of the base floodplain that stimulates growth to occur within a floodplain. If a project significantly encroaches on a floodplain, the following findings must be present:

- There is no practicable alternative.
- The project conforms to applicable state and/or local floodplain protection standards.

III.7.4 Relationship of Environmental Sustainability to NEPA

Environmental sustainability is a concept that has garnered a great deal of attention lately and can sometimes overlap the goals and policies associated with NEPA. There is a relationship between environmental sustainability, but they are not the same thing. As discussed above, NEPA established a national environmental policy and goals for the protection, maintenance, and enhancement of the environment and provides a process by which environmental impacts are disclosed and decisions about proceeding with a project are made. In essence, NEPA is a disclosure of the potential environmental impacts of a project so that decision makers can weigh the relative benefits and costs to the environment before proceeding.

Environmental sustainability is much broader and is concerned with identifying and implementing programs that minimize the effect on the environment, minimizes the consumption of natural resources, and looks for opportunities to replenish natural resources if possible while meeting the needs of the present. There is no federal requirement to ensure that a project includes sustainable initiatives; however, there are significant advantages to including such initiatives into a passenger terminal project.

Sustainability projects can be implemented for many of the areas of concern that fall under NEPA, such as air quality and water quality. As stated above, sustainability initiatives are not required in order to obtain NEPA approval for a passenger terminal project; however, by proactively implementing these initiatives, an airport can demonstrate their willingness to avoid, minimize, and/or mitigate environmental impacts and reduce the consumption of natural resources. This demonstration may lead agencies, such as the Department of Natural Resources or USEPA, to be more willing to approve passenger terminal projects and any required permits, thereby resulting in a quicker NEPA approval process. The implementation of such sustainability projects may also help to build better relationships with environmental regulatory agencies and with the public.

Although environmental sustainability projects would by definition have the reduction of environmental impacts as a goal, elements of proposed plans may themselves be subject to a NEPA review and approval. A NEPA review and approval is required for all federal actions, which for environmental sustainability projects could include federal funding or a sustainability project that results in a change in an ALP. Here again, this highlights just some of the differences between environmental sustainability initiatives and NEPA. More information on sustainability can be found in Section III.8.

III.8 Sustainability

Sustainability is defined as embracing the best possible environmental, social, and fiscally responsible practices in order to meet the needs of the present without compromising the substance or quality of life of future generations. The concept is born out of the growing conviction that mankind cannot continue to deplete the world's natural resources and generate pollution at current levels without seriously compromising the long-term well being of the planet and its inhabitants. Key strategies to promote sustainability include efforts to reduce the environmental impact of the built environment by reducing all types of pollution of the natural environment; to conserve energy and thus the natural resources that generate it; and to minimize the effect of major infrastructure development on the conservation of natural resources, while at the same time creating financial and operational benefits for a project, and social benefits for the community at large.

Within the overall framework of sustainability, the "green building" movement has been growing rapidly in recent years, driven primarily by rising energy costs, the challenge of solid waste disposal, and increased awareness of the environmental effect of building design and operation. At all levels of government and in the private sector, programs have been developed to encourage sustainable design practices; currently, the federal government has mandated that all new buildings constructed by the General Services Administration must meet green standards and many state and local governments and private institutions are following suit.

A "whole building" approach is a proven method for achieving an efficient use of resources, lower operating costs, and improved quality of the interior environment over a building's lifetime. This approach addresses site issues such as stormwater runoff, water conservation, energy efficiency, material resources, indoor air quality, and other measures to ensure the health and well being of the building occupants. These guidelines are grouped into five major categories—each composed of requirements that share a common environmental goal. One of the financial goals of a whole building approach is to minimize the effect on initial costs (construction costs) by offsetting the cost increases from some requirements by decreases in other areas. For example, the cost of improving the insulation of the exterior envelope of the building may be offset by a reduction in the size and subsequent cost of heating or cooling systems. Initial cost is further offset by reduced operating costs over the life of the building.

III.8.1 LEED Certification for Airport Terminals

The information contained in this section follows the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®) Green Building Rating System. LEED certification provides independent, third-party verification that a building project meets the highest green building and performance measures. While LEED certification is a desirable goal for most airport terminal projects, it is a voluntary program administered by the Green Building Certification Institute (GBCI).

LEED is a continuously evolving standard, and project teams interested in pursuing a LEED rating are encouraged to register the project in the early stages of design and review the LEED Credit Interpretation Rulings to learn how other transportation projects have met LEED requirements for these unique building types. The most likely category of the LEED Rating System to be considered for the planning and design of a new or renovated terminal is the LEED Accredited Professional (AP) specialty of Building Design + Construction (BD+C) formerly called LEED for New Construction.

Terminal A at Boston Logan International Airport marks an important precedent as the first LEED-certified airport terminal project in the United States. While it may be difficult for some airport terminal building projects to achieve certification, the majority of new airport terminal projects in the United States are including LEED certification as a major goal.

Building off of LEED, the City of Chicago Department of Aviation has developed the Sustainable Airport Manual (SAM) as an integral part of Chicago's ongoing efforts toward implementing more environmentally sustainable buildings and civil infrastructure, as well as incorporating best practice guidance for planning, operations, and maintenance of all City airport facilities and functions, and those of its tenants. The purpose of the SAM is to integrate *airport-specific* sustainable planning and practices early in the design process, through construction, operations, maintenance and all airport functions with minimal impact to schedule or budget. While certain elements of the SAM are specific to the Chicago Department of Aviation, they can easily be customized and interpreted for any airport's unique environment. The vast majority of SAM's guidance is already applicable to any airport.

III.8.2 Sustainability in the Planning and Design Process

III.8.2.1 Conceptual Planning

During the conceptual planning phase of airport terminal development, the following key factors should be considered to optimize the performance of the building:

- Orientation of the building is important to maximize the use of daylighting and can significantly affect the amount of solar-heat gain of the project. If possible, the building should be oriented on an east-west axis, so that areas that need the most light face north, maximizing the daylighting while minimizing the solar-heat gains. Expanses of glazing on the northern façade can provide ample amounts of indirect light.
- Maximize the use of daylighting to decrease the amount of artificial lighting, as well as minimize the amount of heating and cooling of the area. Automatic daylight dimming controls for the lighting can greatly reduce energy costs, but consideration of glare control is also important to ensure occupant comfort.
- Establish goals for energy and water use within the terminal building.
- Engage airport authorities in pilot programs for the testing of new materials and systems. Develop a program that tries out new products, system technologies, and materials in a nearby existing terminal to establish if it would be a benefit in the newest terminal.

- Research regional, state, and federal funding or incentive programs to increase the payback period of certain technologies and products.
- Develop the potential scope for achievement of "green building" objectives in the initial phase of the planning including commissioning of the systems, daylight modeling, energy modeling, etc.

For LEED projects, check that all prerequisites can be met. For example, projects that will tie into a central distribution plant for chilled water will need to make sure that the plant chillers do not use chlorofluorocarbon-based refrigerants. Register project with the USGBC.

III.8.2.2 Schematic Design

During the schematic design phase of airport terminal development, the following key factors should be considered to optimize the performance of the building:

- Prepare and facilitate an integrated design charrette with all key members of the design team. During the initial design charrette, project sustainability goals should be determined and then act as a guide for the remainder of the project.
- Start modeling the efficiency of the design alternatives for the base building mechanical system. For example, will the base building run off of a central plant or will the most efficient option be a discreet system like ground-source heating and cooling (geo-thermal). Compare first costs and payback costs when determining the best options. Teams should also consider maintenance costs and replacement costs and look at a 20- or 30-year Net Present Value comparison.

For Projects Targeting LEED Certification. Start LEED documentation and continue documentation as the project progresses. Calculations to be documented include the following:

- Stormwater runoff
- Heat island effect reduction
- Water conservation
- Recycling of waste and other materials
- Locally sourced materials
- Daylighting

III.8.2.3 Design/Development

During the design/development phase of airport terminal development, the following key factors should be considered to optimize the performance of the building:

- Begin the building systems commissioning process. Select commissioning authority to lead, review, and administer the commissioning process.
- Begin energy modeling when base building mechanical system has been selected. Model alternative energy efficiency measures to increase performance of systems. Consider strategies such as mechanical system controls, lighting controls, optimization of the building envelope, peak load reduction, and premium efficiencies for all fans, pumps, and motors.
- Review the outline specifications for the project. Evaluate alternative product choices and fixture selections for optimal performance.

For Projects Targeting LEED Certification. Continue LEED documentation and start uploading applicable design phase templates to LEED-Online.

III.8.2.4 Contract Documents

During the preparation of contract documents for an airport terminal project, the following key factors should be considered to optimize the performance of the building:

- When issuing bid-set drawings, include design elements within the drawings. Pertinent design elements include but are not limited to: walk-off mats, bicycle racks, shower facilities, recycling locations.

- Review and edit product specifications, focusing on important environmental standards for the products selected (i.e., volatile organic compound limits, minimum levels of recycled content, prohibited compounds, etc.). Include process specifications for Construction Indoor Air Quality Management and Construction and Demolition Waste Management.

For Projects Targeting LEED Certification. Submit design phase credits to LEED-Online for review.

III.8.2.5 Construction Administration

During the construction administration of airport terminal development, the following key factors should be considered to optimize the performance of the building:

- Monitor and photo-document progress throughout the construction phase.
- Review all contractor submittals relevant to the project's sustainability goals. Products that fall into this category include products from Division 2-10 in most industry-accepted formats of the Construction Specifications Institute.

For Projects Targeting LEED Certification. Submit remaining targeted LEED credits for final review at or around substantial completion.

III.8.3 Major Elements of Sustainability for Terminal Planning and Design

III.8.3.1 Site Development

Site development affects biodiversity, water quality, urban climate, energy consumption, and light pollution. This section addresses issues associated with the selection of new sites for terminals and the site design of existing terminals.

Designing and constructing a sustainable airport terminal begins with appropriate building orientation. The orientation of the airport terminal allows the building to take advantage of lighting and heating from the sun, as well as natural ventilation. Future additions or expansions should also be considered in the orientation of the building encouraging smart growth.

Minimize development of open space or greenfields by selecting previously developed land, brownfields, or building retrofits. Restore the health of degraded sites by improving habitat for indigenous species through native and adaptive plants. Avoiding development of sensitive areas, like wetlands and areas with endangered species, decreases the likelihood of distressing surrounding ecosystems further and minimizes habitat disturbances. Taking such a strategic sustainable approach also assists in reducing the potential for public objections to the airport terminal project.

Adopt landscaping methods to control erosion and stormwater runoff from the site. Techniques include grading, bioswales, bioretention, constructed wetlands, and pervious pavement to decrease stormwater runoff. Pervious paving material can be incorporated on both landside and airside paving applications, but maintenance costs should be considered. Pervious paving may not be suitable for all climates.

Constructed stormwater containment basins in conjunction with on-site treatment facilities can help curb significant amounts of pollutants from contaminating adjacent watersheds and water bodies. Activities that possibly contribute to the pollution of the surrounding environments are deicing of aircrafts, transportation of fuels, and landside and airside transportation vehicles.

Reduce heat island effects using landscaping, building design methods, and high-albedo materials. Use trees and other shading vegetation around walkways and parking areas to reduce the amount of heat absorption of constructed surfaces, yet also keep in mind that landscaping should be of types that are not wildlife attractants.

High-albedo and vegetated roofs reduce the heat island effect, as well as maximize energy savings. When specifying high-albedo roofing material, the slope of the roof is important to note because of the possibility of glare to ATCTs. When specifying vegetated roof plantings, consider sedum and other species that are not known to be wildlife attractants and not known as species that can attract or create harborages for birds not desired in proximity to airside activities.

Transportation solutions that can reduce the volume of single-occupancy vehicles should be considered when feasible. These may include provision of secure bicycle parking for terminal staff, carpool staging, preferred parking for low-emitting vehicles, and improved access to mass transit. Consider employing strategies to encourage car rental companies to consolidate rental areas, which greatly decreases the need for passenger buses shuttling customers to and from the rental site.

III.8.3.2 Water Conservation

Water consumption in airport terminals is affected by landscape irrigation demand; demand from commercial/retail facilities, restrooms, and kitchen spaces; as well as cooling towers and maintenance uses. Decreasing the demand for large volumes of water can decrease overall maintenance costs and life-cycle costs, as well as reduce costs through lower water usage and lower sewage charges. There are many techniques and resources to help reduce the demand for water at airport terminals.

Specifying low-flow fixtures for restroom lavatories, toilets, and urinals can significantly reduce the amount of water used on site, without large up-front costs and a relatively short payback period. Specifying 0.5 gallon per minute (GPM) flow rates on bathroom lavatory faucets and employing automatic shut-off sensors can reduce the amount of water used from these fixtures by more than 80% when compared to the maximum allowable flow rate of 2.5 GPM established by the Energy Policy Act of 1992.

Dual-flush valves are available with two different flushing options for optimum water savings. There is a full flush 1.6 gallons per flush (gpf) for solid waste and a 1.1 gpf option for liquid waste. Installing signage to explain how the flush valves work in each stall helps ensure the toilets will be used correctly and water efficiency will be maximized. Because airport terminals are hubs for international visitors, the dual-flush instructional signage should be in several different languages.

Low-flow urinals and fuzzy logic urinals are big contributors to water savings in men's rooms. Fuzzy logic flushing systems conserve water by measuring the length and frequency of use, and flush an appropriate amount (0.5 to 1.0 gpf). Low-flow urinals are any urinal that uses 0.5 gpf or less. There are low-flow urinals on the market that currently use only 0.125 of a gallon of water per flush compared to the maximum allowable 1 gallon per flush.

Dry urinals or waterless urinals also contribute to water and sewage savings in men's rooms. These urinals eliminate the use of water for flushing except for maintenance. Specialized sealant liquids and innovative urinal traps are used to prevent odor. High-traffic airport terminals like Boston Logan International Airport Terminal A and Austin-Bergstrom International Airport in Austin, Texas, have employed waterless urinals in back-of-house areas. Both airport terminals have conserved a great deal of water while lowering their sewage cost using the waterless urinals. When considering this technology, make sure to research local codes as a variance may be required in some jurisdictions.

Capturing stormwater on site and using it on the project can reduce both the amount of runoff and reduce the overall water consumption. Catchment basins or cisterns can be constructed to store stormwater on site allowing it to be used for irrigation, maintenance, toilet flushing, and cooling tower make-up.

Decrease or eliminate the need for permanent irrigation by incorporating xeriscaping and drought-tolerant species, as well as low- to no-mow grass species. The use of native and adaptive species also has significantly lower life-cycle costs when compared to conventional planting and landscaping because they require less fertilization and irrigation.

III.8.3.3 Energy Conservation and Ozone Protection

Energy conservation can be achieved by a combination of good building design and judicious building management and operational practices. Terminals that can reduce energy consumption help to lower energy-related carbon emissions and achieve significant cost savings.

Energy modeling has a key role to play in the design of an energy-efficient building as it enables the project sponsor and the design team to analyze a variety of energy efficiency measures and make decisions on which to include in the design based on savings in energy and energy costs. At a minimum, energy modeling needs to be performed soon after the base building HVAC system has been selected. However, energy modeling can also be a useful tool to compare base building HVAC systems.

During the conceptual design phase of the project, determine if the project will be required to tie into a central plant for heating and/or cooling. If the project is required to draw from a central plant, the efforts to reduce energy consumption in the building should be focused on lighting, the building envelope, and ventilation/air exchange.

A variety of energy modeling software programs can be employed on a given project. The software used should be rigorous enough that it can model how much energy the building uses on an hourly basis over an entire year. In addition to the architectural, mechanical, and electrical aspects of the design, the modeling should also factor in local weather data, the operational schedule, and the building and use of the HVAC system.

The following should be considered when evaluating energy efficiency measures.

Lighting. Reduce the light power density for the project by selecting efficient fixtures and ballasts and by increasing the surface reflectivity of walls, floors, and ceilings. Lighting controls can also have an effect. Consider occupancy sensors when appropriate and employ automatic daylight dimming controls.

Daylighting. Daylighting can reduce the energy used in some climates when daylight-responsive dimming controls are employed. Use of such controls helps reduce the energy needed for lighting and, because artificial lighting can generate unwanted heat gain inside the building, it can also reduce the energy needed for cooling. The resulting savings in energy costs due to daylight dimming systems can be significant. Energy modeling for Delta's Terminal A at Boston Logan International Airport demonstrated an annual savings in energy costs of over $100,000 annually. Other advantages of daylighting include increased occupant satisfaction and productivity along with a decrease in accidents.

Ventilation. In large-volume spaces like ticketing areas and holdrooms, employ ventilation strategies that do not waste energy by cooling air in spaces (such as roof vaultings) that are never occupied. Employ demand control ventilation in all multi-occupant spaces so that the supply of conditioned outside air can be provided based on the constant variation in occupancy. This will allow, for example, the project to cycle down fans and motors when holdrooms are not occupied, but ensure that ample amounts of conditioned outside air will be provided automatically via carbon dioxide monitors when these and similar spaces are at peak occupancy.

Central plants that provide chilled water, hot water, and/or steam can be cost-effective and energy-efficient ways to power airport passenger terminals. Upgrading a central chiller/steam plant can increase efficiency and decrease harmful emissions. When upgrading or adding to the central chiller plant, combined heat and power (CHP) (or cogeneration) should be considered. CHP can utilize less-expensive fuel sources like natural gas to generate electricity via micro turbines. Recovered waste heat from these systems can then be used for domestic hot water.

Also consider the effect of refrigerants used in a central chiller plant. Choosing refrigerants with low global warming potential and low ozone depletion potential minimizes the emission of harmful compounds into the environment. The inefficiencies of aging central chiller plants, as well as heating, ventilation, air conditioning, and refrigeration equipment can further contribute to global climate change. Selecting and upgrading building equipment reduces the possibility of unnecessary compounds being released into the atmosphere. At a minimum, the use of CFC-based refrigerants should be eliminated or phased out on all existing central plants.

III.8.3.4 Material Procurement

The construction and operation of buildings consumes over 40% of all mined resources. The building materials used for the construction of airport terminals are a major contributor to its life-cycle environmental effect. Sustainable building materials offer benefits to the owners and occupants including lower energy and maintenance costs and improved health of building occupants. Selection of building materials should optimally aim for the following:

- Use of high amounts of recycled content whenever possible
- Wood materials sourced from sustainably managed forests
- Limitation or elimination of the use of materials that pollute or are toxic during manufacturing
- Preference given to locally harvested, processed, and manufactured materials
- Reused or salvaged materials substituted for virgin materials
- Use of rapidly renewable materials

The cement portion of the concrete design mix used in the construction of the terminal building and surrounding hardscapes should contain at least 20% fly ash or other alternative pozzolans. Higher percentages are common and preferred. The production of 1 ton of portland cement emits approximately 0.5 ton of carbon dioxide and requires about 6 million British Thermal Units in energy to produce. Supplementing portland cement with fly ash exchanges a highly energy-intensive product with a by-product of coal-fired power plants, thus decreasing demand for cement and electricity, and finding a use for material that otherwise ends up in a landfill.

The use of synthetic gypsum over virgin gypsum board is preferred when feasible.

III.8.3.5 Indoor Environmental Quality

Indoor environmental quality principally addresses issues associated with indoor air quality, in particular good air circulation; suppression of dust, mold and other contaminants; and good temperature and humidity control—all of which benefit the health and well being of building occupants. This section identifies opportunities to prevent indoor air contaminants, increase daylighting, and maximize occupant comfort.

The quality of the indoor environment of airport terminals is important for the people working in the terminal, as well as the passengers passing through. Airport terminals are unique in that there will be times of very low occupancy and times of peak occupancy which can happen several times a day. Bad weather also affects the occupancy numbers and duration of transient use. Bad weather, locally or at other airports, can delay departing flights, which can quickly increase the terminal's occupant loads.

Volatile organic compounds (VOCs) are substances found in many conventional paints, coatings, primers, glues and adhesives, building materials and furnishings, as well as thousands of other products. VOCs are at the very least respiratory irritants; some have been found to cause cancer and VOC levels have been shown to be two to five times higher indoors than outdoors. Specifying materials and products that have significantly reduced, or have no VOCs should be a priority.

The South Coast Air Quality Management District (SCAQMD) Rule 1118 provides limits for VOC content for adhesives, sealants, and sealant primers. SCAQMD Rule 1113 provides limits for architectural adhesives. Green Seal Standard GS-11 provides VOC limits for paints and coatings.

III.8.3.6 Construction Practices

Construction Waste Management Plan. Implement practices and procedures to meet the project's environmental goals within the project specifications. Specific project goals that affect this area of work include the implementation of construction waste management (CWM) practices that do the following:

1. Reduce waste generation
2. Reuse, salvage, or recycle waste materials
3. Minimize waste disposal in landfills

As part of measures to ensure that these goals are implemented to the fullest extent, the CWM Plan should outline the provisions to be implemented to recycle and salvage demolition and construction waste generated during a project. The end-of-project recycling rate should equal, at minimum, 75% (by weight) of the total waste from construction, demolition, and land-clearing activities.

The CWM Plan should be implemented throughout the duration of the project. As an initial step, develop a list of the waste materials from the project that are targeted for reuse, salvage, or recycling. The following materials are examples of the types of materials that can be recycled:

- Cardboard, paper, and packaging
- Clean dimensional wood and palette wood
- Beverage containers
- Land-clearing debris
- Soil
- Concrete
- Bricks
- Concrete masonry units
- Asphalt
- Metals from banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze
- Drywall
- Carpet and pad
- Paint
- Asphalt roofing shingles if applicable for any existing building demolition
- Rigid foam
- Glass
- Plastics

The CWM Plan typically also includes information on landfills, sorting method, packaging waste, field conditions, recycling facilities, as well as any additional information deemed relevant to describe the scope and intent of the CWM Plan to the owner, architects, and subcontractors. The CWM and recycling requirements should be incorporated into all subcontractors' contracts to ensure effective implementation.

Construction Indoor Air Quality Management Plan. The development of a Construction Indoor Air Quality Management Plan establishes that the project goals should include minimizing the detrimental impacts of construction activities on indoor air quality (IAQ). Factors that contaminate indoor air, such as dust entering HVAC systems and ductwork, improper storage of materials on site, and poor housekeeping, should all be closely monitored and kept to a minimum.

The IAQ Plan should specify that construction activities shall be planned to meet or exceed the minimum requirements of the Sheet Metal and Air Conditioning National Contractors' Association (SMACNA) *IAQ Guidelines for Occupied Buildings under Construction* (*22*). The SMACNA guidelines include measures such as the following:

- HVAC protection: describe the filtration media and replacement criteria for the following equipment and processes
  - Return side
  - Central filtration
  - Supply side
  - Duct cleaning
- Source control
  - Product substitution
  - Modifying equipment operation
  - Changing work practices
  - Local exhaust
  - Air cleaning
  - Cover or seal
- Pathway interruption
  - Depressurize work area
  - Pressurize occupied space
  - Erect barriers to contain construction areas
  - Relocate pollutant sources
  - Temporarily seal the building
- Housekeeping

Protect vulnerable materials from moisture damage when stored on site and after installation.

If air handlers are to be used during construction, filtration media with a minimum efficiency reporting value (MERV) of eight should be used at each return air grill, as determined by American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 52.2-1999.

Replace filtration media immediately prior to occupancy. Filtration media shall have a MERV of 13 as determined by ASHRAE 52.2-1999.

Low-Emission Equipment. Vehicles that transport passengers to, from, and within airport grounds emit pollutants such as carbon dioxide (CO_2), nitrogen oxide (NOX), sulfur oxide (SOX), and carbon monoxide (CO).

Terminal planning should include goals to reduce and/or limit the amount of airport-generated emissions caused by airside and landside equipment. Achieving and maintaining air quality is critical for the well being of building occupants and the economic vitality of the community.

Determining the amount of global-warming and ozone-depleting pollutants that will be emitted by equipment within the terminal allows for the terminal authority to quantify reductions and possibly engage in emissions or carbon credits purchasing. The Voluntary Airport Low Emissions (VALE) Program, created in 2004, provides financial assistance for airports seeking to reduce airport ground emissions in areas that fail to meet or maintain USEPA's ambient air quality standards.

Pollution-reducing practices also help reduce the amount of global-warming and ozone-depleting compounds being released by airport terminal vehicles. Using low-emission/fuel-efficient, as well as alternative-fuel GSE will reduce emissions and save on fuel costs.

Vehicles transporting passengers on the landside also contribute to increased air pollution. Incentivizing the use of hybrid taxis and car rental shuttles increases awareness and decreases pollution. Most airports have a taxi access fee in place; decreasing the price that hybrid taxis pay incentivizes taxi companies to purchase more hybrids if only to use at airports.

Also, consideration should be given to alternative fuels for construction vehicles and equipment, as well as everyday shuttle service between terminals to and from on-site parking areas, and to and from off-site parking areas.

As part of the City of Boston's continuing commitment to sustainable transportation, the CleanAir CABS Program was launched on April 1, 2007. Through the CleanAir CABS initiative, taxi owners will have the opportunity to replace ordinary taxis with cleaner vehicle technology. There are benefits for taxi owners to make the switch to hybrids. Hybrids burn much less gasoline than ordinary vehicles (from 50% to 70% less in the city) and compressed natural gas (CNG) generally costs less per gasoline gallon equivalent than gasoline. Drivers of CNG vehicles may qualify for a rebate from a natural gas company and a federal tax credit.

III.9 Business Planning

III.9.1 Business Considerations

The construction of a new airport terminal, like any major capital investment, should be supported by a clear business case. In addition to focusing on the need to meet forecast traffic demand, it is also important that, from the outset, the planning process integrate key business considerations to guide planning and inform analyses of inevitable tradeoffs among project features.

Strategic positioning of the airport, adaptability to respond to uncertain future conditions, and affordability are three important considerations when developing a business case for a new terminal project.

III.9.1.1 Strategic Positioning

Suffice to say, a challenging responsibility falls on those charged with management of the business enterprise to balance operational enthusiasm to design to the "upside" against the preservation of financial integrity of the organization, particularly in the event of less favorable future conditions.

This responsibility calls for foresight and expertise beyond managing the current business of the airport. A careful analysis of the business case for a new terminal must build on a solid understanding of the service and business philosophy of the airport, as well as the service standards and performance of airport management, airlines, and service providers. The analysis must also draw on a thorough understanding of the aviation market being served by the airport, the potential for growth, and the downside risks including future competitive factors and market fluctuations. An airport's "business leader" would typically develop the business case for the planning team and provide guidance on various business issues.

As an example of the application of business considerations in the terminal planning process, an airport's business leader will have very good information about concession space demand, as well as future trends. During programming and planning, the business leader can provide helpful validation of assumptions about concession locations, facility sizing, desired adjacencies, and ancillary needs based on the specific market served by concessionaires serving the airport.

As another example, an airport's business leader will have an understanding of the risks associated with tailoring terminal facilities to a specific new entrant. The business leader undoubtedly will be called on to help balance goals for the project with risks such as those posed by responding to a new entrant. Later in programming and planning, the business leader should vigilantly monitor for opportunities to further mitigate risk through adaptable, rather than rigid, structures and systems.

While a broad-based strategic background will provide a sound basis for evaluation, there remain some fundamentals that set the envelope of options and choices the terminal planner will face. These fundamentals include whether the terminal is being built to accommodate the following:

- Origin and destination (O&D) traffic or airline hubbing
- Low-cost carriers or network (legacy) carriers (or a combination of both)
- Domestic or international traffic (or a combination of both) (*23*)
- Specialized visitor requirements

The physical parameters of the facility (including the amount of space, number of gates, space functionality, walk and wait times, peaking characteristics, general levels of service, types of concessions to be offered, etc.) will differ markedly depending on those factors. Some examples of these differences include the following:

- A terminal that is used primarily for hubbing activities would need much less ticket counter and security checkpoint space and curbside than one used primarily for O&D activity—even if the traffic throughput of the terminal is exactly the same in both cases.
- A terminal that is used to process international passenger arrivals would need significant amounts of space dedicated to the Federal Inspection Services, i.e., customs and immigration.
- A terminal that is used for low-cost carrier operations could have fewer gates than one used for international departures and would also have a different concession profile (e.g., no duty-free shop, fewer "high-end" offerings).

Each of these factors will have a dramatic effect on the type of building that is developed—the cost of the building, the subsequent cost of operating and maintaining the building, the revenue profile of the facility, and the overall ability of the facility to generate enough cash to repay debt issued to build it (with an appropriate debt service cushion).

Consequently, it is very important when planning the terminal to be clear about what type of facility it is intended to be, i.e., the type of airline tenant it intends to cater to, the profile of the travelers that are expected to use the facility, and the structure of business relationships with the airlines.

A tool to align the airport business leader's views and those of the planning team is use of a strengths/weaknesses/opportunities/threats (SWOT) analysis. Results of a SWOT analysis will strengthen the business case by establishing mutually understood perspectives with which to critically evaluate proposals and, when necessary, engage in course corrections or confirmations throughout the programming and planning processes.

III.9.1.2 Adaptability

With strategic positioning as a background, the airport's business leader will be well informed to engage in discussions about the range of future demands that may confront the airport (e.g., types of passenger traffic, industry trends, and consumer demands). These discussions, in turn, should provide a basis to assess questions related to adaptability of the terminal, such as the appropriate design life for the shell and internal elements of the terminal (*24*).

Also, the airport's business leader should bring value to evaluation of tradeoffs inherent in selection of current technological, security, environmental, and other solutions versus provision of broadly adaptable core systems. Similarly, the business leader should help assure that reasonable balances are reached between competing factors like the following (*25*)

- Practical requirements of service providers versus other planning criteria such as passenger flow, customer service, cost, and aesthetics.
- Modularity or flexibility of plan versus layouts focused on cost-efficient design-day considerations.

III.9.1.3 Affordability

A critical step at the earliest stages of a terminal development project is to determine if a project is affordable given the resources available to the airport. While some development projects may have very straightforward funding plans, airport development projects typically are funded from sources that are nested in fairly complex financial structures. This is particularly true when regulatory regimes influence rate-making methodologies, as is the case with airports in the United States.

The key to understanding affordability and anticipating sensitivity to changing conditions is long-term financial planning supported by models calibrated to the unique financial and regulatory structure of the airport. A selection of financial metrics, such as airline costs and concessions sales per enplaned passenger, can provide helpful summary statistics for effectively communicating results of alternative actions. Users of this guidebook are cautioned against using industry averages of metrics like airline cost per enplaned passenger as litmus tests of affordability and instead are encouraged to be aware of such averages and the reasons circumstances at their airport warrant uniquely higher or lower standards. Continuous updates to reflect the passage of forecasts into history (including comparison of actual results with forecasts) and revisions to forecasts (including estimated costs and time to complete the terminal project) should be elements of the ongoing management process.

Engaging airline and other key tenant management representatives in program consultations early and throughout the planning process through well-established means is important to assure that rules are followed to gain "official" positions and to address cost increases due to delays and scope change requests. Otherwise, changes of a strictly proprietary nature that should be funded by the requestor may incorrectly become project costs. Airport tenants are a diverse group whose interests will not always be consistent. The programming, planning, and eventual design processes involve many parties. This dynamic of multiple parties with their own sets of preferences and priorities sets up ample opportunities for mixed signals and unsatisfactory results. Careful management of these interactions can help preserve affordability objectives.

Affordability from the airport business leader's perspective will reflect reasonable life-cycle evaluations. Such evaluations track an asset's life-cycle costs beginning with initial planning, design, development, and commissioning costs; continuing with operational and maintenance costs throughout the useful operational life of the asset; and ending with asset refurbishment and ultimately decommissioning and disposal costs (as applicable). Results are assessed using techniques such as net present value or internal rate of return to facilitate comparisons of alternatives in today's dollars, thereby ensuring a consistent "apples to apples" comparison is employed in cases where alternative terminal development plans are being evaluated. These very real cost tradeoffs between capital costs now and future operations and maintenance costs plus replacement costs will be considerations of financial planning and may lead to terminal planning actions that otherwise might be overlooked. Use of more durable and expensive flooring materials allowing lower maintenance expense and longer replacement cycles is an example (*26*).

A further consideration is that any given airport sponsor will likely have a range of capital needs for its airport beyond the terminal—most notably capital improvements that relate to airfield operations, automobile parking, rental car activities, and landside development. The affordability of the terminal project needs to be determined in the context of the overall affordability of the capital program for the airport.

III.9.2 Funding Options

III.9.2.1 Types of Funding

In the United States, the vast majority of terminal developments are controlled by the governmental body owning the airport. In a few cases in the United States, and much more commonly in other countries, private entities (including, sometimes, airlines) are granted rights to develop and operate terminals.

Governmental owner developers in the United States typically use a mix of funding sources, which include the following:

- Bond proceeds supported by general airport revenues
- Bonds repaid from a PFC
- PFC revenues on a “pay-as-you-go” basis
- Airport Improvement Program (AIP) grants, which encompass both “entitlement” grants and “discretionary” grants
- Unrestricted airport cash balances (net free cash flow generated from airport operations)

Short-term liquidity requirements can be addressed through commercial paper programs or internal borrowing.

Several of these funding sources can be used to fund only certain types of capital spending, and under certain conditions:

- PFCs (whether leveraged or pay-as-you-go) can be spent on projects only if those expenditures have first been approved by the FAA, following airline and public consultation (*23*).
- PFCs cannot be used to fund terminal concession space, or most categories of non-public terminal space (*23*).
- Typically, terminal projects are about 70% eligible for PFC funding.
- For large, medium, and small hub airports, AIP discretionary grants cannot be expended on the terminal building itself—only on terminal apron and roadway access to the terminal (and even then, roadways are low on the FAA’s priority list for AIP discretionary funding, so are unlikely to actually receive such funding, even though they are eligible). Non-public spaces, or concession areas, are generally not eligible for entitlement or discretionary AIP funds. Advance review of grant eligibility with regional FAA officials is advisable.
- Airport cash (equity) is typically used sparingly by airport sponsors for terminal development projects, but a good use of such monies would be to fund preliminary planning, conceptual design, and environmental analysis of a potential terminal development project.

Further, it should be noted that among government-sponsored airports in the United States, general airport revenue bonds used for terminal development often are legally secured by all airport revenues (including, but not confined to, revenue generated from the terminal).

Bonds repaid from PFCs are not (except for a few large airports) legally secured solely by the PFC revenue stream. Rather, they are secured more often by general airport revenues, but the source of payment for interest and principal payments is PFC revenues.

Non-governmental terminal developers may rely on loans secured by the developer’s business, as a whole, rather than the specific revenues associated with the proposed terminal. However, it is more common for project revenues to provide repayment security; for example, the terminal development financing by a private entity for the International Air Terminal (Terminal 4) at JFK International Airport was arranged through debt secured solely by revenues anticipated from the completed terminal, net of operating and maintenance expenses, which included rent payable to the airport owner, the Port Authority of New York and New Jersey (*24*).

There are some other instances of special facility bonds being used to develop airport terminals in the United States. In addition to the JFK International Air Terminal noted previously, the Massachusetts Port Authority redeveloped its Terminal A at Boston Logan International Airport using Special Facility Bonds originally secured by Delta Air Lines (*25*).

The airport business leader's role includes understanding the project funding requirements and anticipated cash flows of the development. This understanding should allow a plan of finance to be developed so that appropriate funding sources and funding availability can match requirements. Of course, financial resources are limited in both magnitude and timing, either or both of which may serve as a governor on the project.

In summary, the business plan for a terminal development project should include the following:

- A capital funding plan that considers the myriad of available funding sources and the various rules and regulations about using those funds, determines the optimal funding strategy for the project, considers the timing of receipt of the funds, and also considers the impact of the terminal project on overall airport finances (including plans for financing the rest of the airport's capital program)
- Airline user charges that are appropriate for the specific situation, reasonable in terms of industry averages and norms, and calculated taking into consideration applicable rules such as FAA's prohibition of including in the airline rate base capital costs funded with AIP grants (*26*)
- A healthy stream of non-airline revenues from the facility
- Reasonable operating cost levels that consider all aspects of terminal operations (staffing, janitorial, utilities, materials and supplies, security, maintenance, contracted services, etc.)
- Sufficient levels of debt service coverage that includes a cushion in the event that passenger traffic is lower than anticipated
- Provision for ongoing maintenance of the facility (reflecting the manufacturers' warranties that the major categories of equipment in the new facility will be under for a period of time)
- Provision for replacement of worn-out equipment and major rehabilitation of the facility at intervals during its life cycle
- Provision for modular build-out of the facility to accommodate increasing passenger demand over time

III.9.2.2 Timing of Funding

The terminal planning team and airport business leader must maintain close collaboration beginning at the earliest programming phases to assure that financial feasibility, inclusive of timing of funding, is achievable within the schedule constraints for the project.

A plan of finance will be developed by the business leader. A range of factors particular to each airport's circumstances will influence the shape of the financing plan. This high degree of customization precludes any but the broadest generalizations regarding timing of funding. The plan, as likely to be developed, will be structured in conformity with federal, state, and local laws, as well as U.S. Department of Transportation rate policies, the airport's financial framework (including bond ordinances, debt policies, etc.), and possibly airline and other tenant lease agreements. The plan will identify sources, uses, and timing of funding. Together with a team of professionals, which may include financial consultants, financial advisors, and bond counsel, the business leader will establish an optimized plan of finance that seeks the most efficient timing to secure funds to meet local contracting regulations and project cash flow requirements. To a certain extent, short-term funding mechanisms, such as commercial paper, grant anticipation notes, or bond anticipation notes, can be used to "match up" funding availability with funding need.

III.9.3 Concessions Planning

The development of a culture of strong in-terminal concessions planning in the United States has lagged behind the development of very strong non-aeronautical revenue streams from commercial concessions in Europe, Asia, Australasia, and, more recently, the Middle East. In these markets, the focus has been on the marketing of high-end duty-free products—with a strong emphasis on "boutique" designer–branded goods combined with local specialty retail, souvenir, and gift items.

This formula has evolved largely because of the predominantly international nature of air travel in these markets, as well as high local taxes and duties that help make items purchased on-airport less expensive than those purchased off-airport. In the predominantly domestically driven U.S. market, the increasing interest in airport concessions by airport operators is the result of the following:

- Increased expectation levels of passengers and airport/airline employees for the airport to offer a wide variety of products and services
- Reductions in complimentary food and beverage and other services provided in-flight by most air carriers
- Increased airport dwell times, especially in airside areas of the terminal
- Increased pressure on airport operators to maximize non-aeronautical revenue streams
- Increased interest in providing a relaxing and pleasurable airport experience to passengers

III.9.3.1 Impact on Passenger Satisfaction

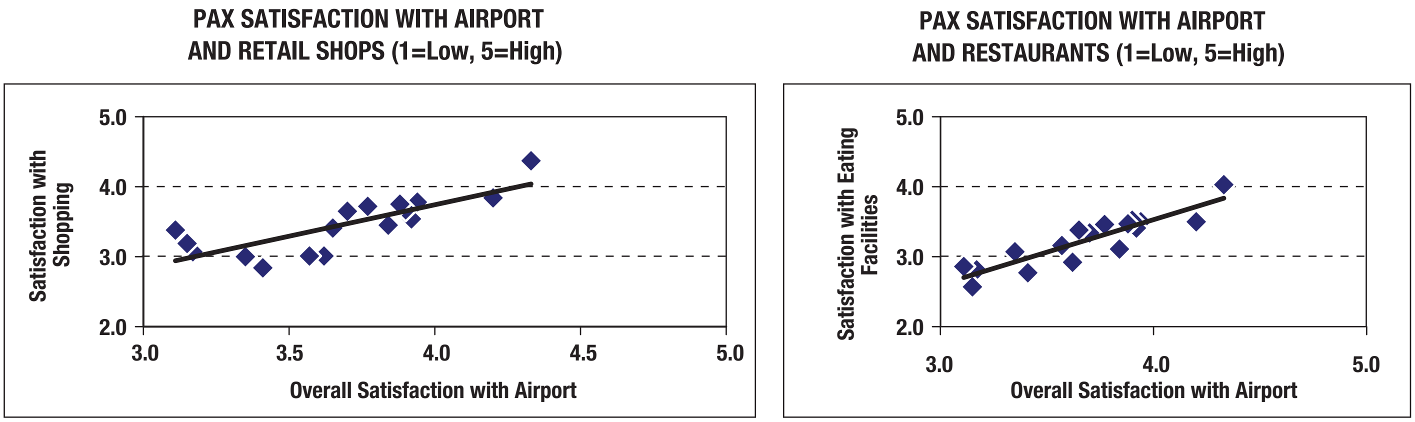
The world's highest-rated airports all provide an extensive range of retail and food and beverage offerings for passengers and airport employees. These airports, however, have achieved the appropriate balance between maximizing concessions revenues (e.g., they all provide large shopping areas that are easy to find and close to the primary passenger flows) and maximizing passenger service levels (e.g., the shops do not hinder these passenger flows and do not create confusion for passengers who want to go directly to their gate).

In fact, the quality of an airport's concessions program can serve as a key contributor to the overall satisfaction level of the airport to its passengers. As depicted in Figure III-4, passenger surveys performed on behalf of IATA reveal the close relationship between passengers' satisfaction with airport shopping and restaurant facilities and passengers' overall satisfaction with the airport.

III.9.3.2 Impact on Airport Revenues

Major in-terminal concessions—comprising news/gift, food/beverage, and specialty retail activities—at the 50 busiest U.S. airports in 2007 generated more than $5 billion in gross sales and provided in excess of $750 million in net revenues to airport operators (*27*). Considering that the average U.S. airport in 2007 generated an average of $170 per square foot of leased terminal shop space in concession fee income to the airport operator, providing additional space for these income-generating activities can be quite beneficial to an airport's financial position.

- In 1997, news/gift, food/beverage, and specialty retail at the country's 20 busiest airports generated an average of $4.80 in gross sales per passenger.



Source: *IATA Global Airport Monitor,* IATA, 2002.

Figure III-4. Passenger satisfaction survey results.

- By 2007, average sales per passenger enplanement at the country's 20 busiest airports had increased to $8.50 for these same product categories.

III.9.3.3 Importance of Early Commercial Planning

The planning of commercial concessions should begin at the very early stages of the terminal planning process for the following reasons:

- Over a 20-year period, an airport that currently serves 10 million enplanements and has current sales of $9.00 per enplanement in news/gift, specialty retail, food/beverage, and duty-free activities may generate nearly $3 billion in total sales, and more than $390 million in concessionaire royalty payments to the airport operator. These calculations are based on 2.5% per annum inflation, 2.5% per annum enplanement growth, and assumed average concession fee payments of 13% of sales. Even a 1% improvement in these amounts is significant to tenants and landlord alike.
- The quality of retail and food and beverage outlets is particularly important at airports with high levels of non-local and/or leisure travelers and/or higher-than-average airside dwell times as they provide passengers with options for amusement and whiling away the time before flight departure.
- Ensuring that commercial activities are prominently located and a feature of newly designed terminal facilities are usually important to both the airport and shop operators.
- Being able to assess the financial impacts of alternative terminal layout configurations on commercial sales and associated concessionaire payments to the airport operator—while planning is being performed, instead of afterwards—serves to optimize the financial feasibility of the airport's redevelopment project.

Ensuring that construction and development of the new terminal facilities has minimal effect on existing commercial activities is important to all airport stakeholders.

III.9.3.4 Case Study Example: Airport Commercial Planning Assessment at a Major International Airport

A good example of how airport operators can benefit from commercial planning can be found in a case study example of analysis performed by a leading Asia–Pacific airport. This airport, in 2007, generated the world's highest levels of duty-free sales per enplanement and had the second highest level of total airport duty-free sales (greater than US$1 billion in 2007).

As part of the development of a new, midfield satellite concourse, airport planners had provided for three lower-level gate holdrooms:

- The gate holdrooms were to be located immediately below a large commercial cluster at the center of the concourse.
- In an effort to reduce concourse development costs, each holdroom was to be served by a single (down) escalator so, if passengers wanted to return to the commercial facilities above, they would be required to climb stairs, as no return (up) escalator was planned to be provided.

As part of cost–benefit analysis and other commercial planning tasks, the airport operator determined that the financial effect to the airport operator of the lost commercial sales at these three gate holdrooms (if no up escalators were provided) would total US$84.3 million over a 20-year period. (These estimates incorporated conservative assumptions for the financial affect that not providing return escalators at these holdrooms would have on commercial sales and concessionaire payments to the airport operator). Thus, the opportunity cost to the airport operator of not providing each return (up) escalator would be US$28.1 million, far exceeding the cost of its development.

III.9.3.5 Types of Concessions

Typical in-terminal concessions at U.S. airports often include the following six categories of offerings for passengers and other customers, including airport meeters/greeters, well wishers, and airline/airport employees:

- News/gift
  - Newspapers and magazines
  - Convenience items and sundries
- Specialty retail
  - Apparel
  - Souvenirs
  - Gifts
  - Sunglasses
  - Jewelry
  - Personal care/health products
  - Entertainment products (movies, music, others)
  - Prepackaged food and wines
- Food and beverage
  - Food courts and other self-service units
  - Full-service restaurants
  - Cocktail lounges and bars
  - Coffee stand
  - Vending machines
- Duty-free shops
- Services
  - Massage, spa
  - Entertainment (arcades, movie rentals, others)
  - Pay-per-use passenger lounges, business centers
  - Currency exchange
  - Luggage storage and wrapping
  - Hair salon, barber
  - Medical services
  - Shoe shine
  - Post office
- Advertising

III.9.3.6 Trends in Terminal Concessions

General and Retail Trends. Airport concession programs continue to mature and gain increasing importance as a source of revenues for airports large and small. The following general trends are affecting airport concessions programs around the world:

- Increased security concerns are affecting commercial sales directly and indirectly:
  - Additional immigration and security inspection requirements are affecting some airport programs by limiting the time available for duty-free shopping and negatively impacting per-passenger duty-free sales.
  - Restrictions on liquids, aerosols, and gels (LAG) and continued passenger uncertainty about LAG regulations could continue to constrain sales of certain products, while increasing others, such as the purchase of beverages at post-security locations.
- Specialty retail, including fragrance and cosmetics, candy, fashion items and accessories, and luxury goods, have shown the largest growth rates over the past several years.
- Some concessionaires are shifting focus from customer sales as commodity-based transactions to an interest in triggering desire. Operator marketing strategies include increased emphasis on the following:
  - Gifting: Duty-free products as gifts for non-traveling family and friends.
  - Aspirational demand: Products that convey the buyer's socioeconomic status.
  - Uniqueness/difference: Products and/or packaging that can be found only at this location (either this particular airport or this city/region).
  - Service/comfort/happiness: Customer service associated with the transaction increases traveler comfort and helps to reduce the stresses that can be associated with travel.
- Increased focus on customer service and personal interaction with the customer that serves as a key method for differentiating airport duty-free shops with Internet and other mail order–based operations.
- Some concessionaires are increasing the entertainment value of the shopping experience by means of the following:
  - In-store promotions.
  - Entertainment, to encourage customers to remain in the shops.
  - Blurring the boundaries between shop and public circulation and waiting areas.
- The preference for unique or customized (non-generic) products and the desire of suppliers to differentiate and promote their brands has led to increased segmentation of airport offerings. For example, large, multi-purpose retail shops will still exist, but the space within these shops will increasingly be divided by merchandise brands and differentiated visually.

Food and Beverage Trends. Food and beverage concessions generate a significant share of airport revenues. Food and beverage activities help to (1) draw passengers to commercial clusters at which passengers and other customers pass by retail shops and services and (2) create high passenger satisfaction levels. The following general trends are affecting airport food and beverage concessions around the world:

- Passengers expect availability of internationally recognized brands, which do particularly well because of the instant recognition and positive associations they have for potential customers.
- However, passengers also want to experience successful local brands as part of their travel experience.
  - The use of local brands also allows the airport operator to reinforce the passenger's positive impression of the destination.
  - Local brands usually enable the food and beverage operator to provide some flexibility in the types of products offered—global products (such as McDonald's) do not allow that same amount of flexibility in facility design and menu offering.

- Including a mix of recognized international brands and local brands allows the airport to maximize passenger satisfaction levels and to promote local operators and cuisine.
  - Being part of an airport's food and beverage concessions program (with international brands) increases the awareness and positive associations of local food operators and cuisines.
  - The value of this positive association should not be undervalued.

Duty-Free Trends. Duty-free product categories with high growth rates per passenger (sales per passenger are increasing) include the following:

- Perfume and cosmetics
- Fashion and luxury goods
- Candy and other luxury packaged food

Product categories with *low or negative* growth rates per passenger (sales per passenger are *flat or decreasing*) include the following:

- Liquor and wine
- Tobacco

Increased governmental efforts to restrict general tobacco consumption could have competing impacts on demand for tobacco products at airport duty-free shops:

- Increased taxes and duties imposed on non–duty-free sellers could increase demand for products sold without these costs as the disparity between duty-free (airport) and duty-paid (Main Street) prices widens.
- This effect may be more than offset by general efforts to reduce public consumption, by means of increased restrictions on tobacco advertising, marketing, and shop display of products.
- Therefore, overall demand per passenger for tobacco products at duty-free shops may continue to decline.

Many on-airport duty-free operators face increased competition from off-airport operators, including Internet operators and sellers of "gray market" goods:

- Customer recognition of the airport duty-free operator/brand, especially by travelers from countries in which gray market and counterfeit goods are prevalent, will become increasingly important.
- On-airport duty-free operators will need to provide "added value" services to retain their competitive advantages over non-airport, Internet sellers.
- Duty-free concessionaires will need to increase their efforts to generate "impulse" purchases and rely less on demand for bulk goods (such as tobacco and liquor), which are driven primarily by pricing advantages.

The success of duty-free activities at a U.S. airport depends substantially on (1) a critical mass of international passengers and (2) the characteristics of these passengers. High demand for duty-free products is typically the result of the following:

- High duty tax rates at the country of destination and/or in the traveler's home country
- Cultural norms, which may include significant levels of gift giving to friends and relatives upon return from a trip
- High personal income levels of travelers
- Large number of products available for sale at the airport
- Competitive duty-free prices
- Low amounts of competition from "gray market" or counterfeit products sold locally
- Unavailability of arrivals duty-free shops at the traveler's final destination
- High share of passengers that are traveling non-stop to/from their final destination (i.e., traveling to/from the airport on an O&D basis).

Duty-free sales per international enplanement can, at select Asia–Pacific and Middle East airports, reach $50.00. Duty-free sales at U.S. airports average approximately $8.00 per international enplanement based on analysis prepared by The S-A-P Group in 2008 (*28*).

III.9.3.7 Planning of Terminal Concessions

A concessions plan should optimize the airport's revenues and levels of customer service. Summarized below is a typical approach for developing a comprehensive airport concessions master plan:

- Calculate optimal concession space amounts for near- and long-term periods using supportable space analysis, space profitability analysis, and benchmarking.
  - The analysis and benchmarking include assessments of space per enplanement (square feet per enplanement), sales per enplanement ($ sales amounts per enplanement), and sales per amount of space ($ sales amounts per square foot).
  - Supportable space analysis incorporates assumptions for the amounts of space that can be supported by anticipated sales volumes, as calculated on a "per square foot of shop space" basis.
  - Shops with low sales volumes per square foot of shop space may be "under-trading" and generating low levels of profit for the shop operator, as well as constraining monies available to pay the airport landlord.
  - Conversely, shops with high sales volumes per square foot of shop space may be "over-trading," an indication that additional shop space is needed to serve potential demand.
- Prepare detailed financial analyses (to assess the potential profitability of new commercial activities and space), which should include ad hoc cost–benefit analyses to assist other terminal planners with identifying the implications of alternative terminal/concourse layouts on airport income. The airport case study presented previously provides an example of ad hoc cost–benefit analysis that assisted planners with the development of optimal terminal facilities.
- Identify the optimal terminal and concessions layout configurations, which should be dependent on aeronautical operating considerations, concession and financial considerations, and passenger satisfaction.
  - Consolidated passenger flows, consolidation of commercial activities into clusters, and visibility between gate seating areas and centrally located commercial areas are all essential components of a world-class concessions program.
  - Integrate the concession clusters with primary passenger flows and in-terminal transport nodes (such as vertical circulation points, access to APM, and passenger convenience facilities, such as toilets and airline lounges).
  - Aircraft gate locations (by aircraft size and daily utilization) affect concession space requirements, the ability to provide centrally located concession clusters, and concession spending and shop operator costs.
  - Providing good shop visibility, while still providing intuitive wayfinding and minimal walking distances to gate holdrooms, will help to maximize overall retail sales and passenger satisfaction levels.
- Ensure that walking distances are minimized and post-security (airside) dwell times are maximized—these factors affect both passenger satisfaction levels and airport operator income amounts.
  - Passengers departing from gate holdrooms distant from main commercial clusters at an airport spend, on average, 20% less than passengers that depart from gates located immediately adjacent to commercial areas. The ability to see commercial facilities from gate seating areas helps to minimize passenger anxiety and also develop impulse purchasing.

  - As such, terminal layout configurations that maximize the number of gate holdrooms close to commercial clusters will generate higher overall sales than will decentralized layouts.
  - Airside dwell times significantly affect commercial sales. One extra minute of airside dwell time at an airport may increase commercial sales per passenger by approximately 1%.
- Assess the financial and other implications of development phasing on airport operator income levels. For example, accelerated development of certain terminal facilities could generate incremental revenues that exceed the incremental development and operating costs of providing the facilities in advance of passenger-driven demand.
- Determine appropriate shop locations and sizes by concessions activity (retail, food and beverage, services).
- Ensure flexibility in the terminal design.
  - The concessions layout plan should provide flexibility for the future, in order to ensure that changes in passenger flows and customer demand can be accommodated with minimal financial burdens to the airport and concessionaires.
  - Until demand warrants its use, planned retail space could be used on a near-term basis for storage or for temporary passenger services, such as corporate exhibit space.
- Provide for development phasing that minimizes construction impacts. The optimal concessions master plan should attempt to minimize affects on shop operators (financial and operational), the airport (financial), and customers/passengers (quality of service levels).
- Assess the successful attributes of the world's leading airport commercial programs, including those inside and outside of the United States.

CHAPTER IV

Forecasts

Forecasts are informed predictions of future aviation activity that are supported by careful assessment and analysis of historical trends in traffic demand, projected economic growth, and any other relevant factors that may affect growth in the local aviation market. The more robust the analysis, the more reliable the predictions will turn out to be, particularly for the short term. For the medium to longer term, forecasts provide an important guide to airport planners as to when additional airport infrastructure may be required, but they must have regular review and adjustments, as necessary, to reflect any unexpected changes in market conditions.

Forecasts of future levels of aviation activity serve as the basis for effective decisions about the terminal plan. Planners use forecasts to determine the need for new or expanded facilities. In general, forecasts should be based on the latest available data and provide justification for the proposed development.

The level of effort required to produce a planning forecast will vary significantly from airport to airport. Considerable effort, including the use of elaborate forecasting tools and techniques, may be warranted in the case of more complex projects. A more cursory update of an existing forecast, on the other hand, may be all that is required for simpler projects. Planners should determine the appropriate level of forecasting effort in the course of pre-planning and scoping the study.

A number of forecasts are readily available for use in developing and evaluating the master plan forecast. These include the FAA Terminal Area Forecast (TAF), state aviation system plans, and other planning efforts. Most of these forecasts lack the detail about peak period activity required for terminal planning, and thus, at a minimum, the terminal planner must extend the forecast to include this needed detail.

"Planners preparing forecasts of demand or updating existing forecasts should consider socio-economic data, demographics, disposable income, geographic attributes, and external factors such as fuel costs and local attitudes toward aviation" (*13*). FAA AC 150/5070-6B provides a good general overview of the forecasting process and the information that a planner should consider in preparing a forecast:

- Economic characteristics: The economic characteristics of a community will affect the demand for air traffic. In addition to national and regional economic activity, these characteristics include specific, identifiable, local activities that distinguish the geographic area served by the airport. The type of industry in an airport's service area also will affect aviation demand, with manufacturing and service industries tending to generate more aviation activity than resource industries such as mining.
- Demographic characteristics: The demographic characteristics of an area's population also affect the demand for aviation services. Demographic characteristics influence the level,

composition, and growth of both local and long-distance traffic. Factors such as average disposable income, leisure time, and recreational pursuits are also important in estimating activity, but can be difficult to measure. These factors are a good indicator of the propensity to travel and may also be significant for demand of general/business aviation aircraft purchases and use.

- Geographic attributes: The geographic distances between populations and centers of commerce within the airport's service area may have a direct bearing on the type and level of transportation demand. The existence of populations and centers of commerce beyond an airport's service area may indicate the need for additional airports that serve transportation demand. The physical characteristics of the area and the local climate may also be important, because they may stimulate holiday traffic and tourism. The role of the airport within the airport system and its relationship to other airports may also have an effect on the services that are demanded at the airport as well as the availability of alternative modes, particularly high-speed rail.
- Aviation-related factors: Business activity, changes in the aviation industry, and local aviation actions can markedly affect the demand for airport services. Business developments in the airline industry, such as consolidations, mergers, and new marketing agreements, can affect airline operations at a particular airport. Wider industry trends, such as the introduction of low-fare service, new classes of aircraft, and the growth or curtailment of an airline hub may also alter the level and pattern of demand. Actions taken by local airport authorities, such as changes in user charges, ground access policies, or support services, can also stimulate or hinder the demand for airport services. Investment decisions made as a result of the planning process itself can also produce change by removing physical constraints to airport growth, which should be reflected in the forecasts.
- Other factors: External factors that may also influence the demand for airport services include fluctuations in fuel price and the availability of aviation fuels, currency restrictions, and changes in the level and type of aviation taxes. Political developments, including rising international tensions, changes in the regulatory environment, and shifting attitudes toward the environmental impacts of aviation, may also affect future demand and should be considered in developing or updating airport forecasts.

IV.1 Methodology

Long-term forecasts of annual traffic demand are usually created using one of three techniques: by computing an airport's share of a larger system forecast, by extrapolating past activity trends into the future, or by relating the forecast of future activity to other forecasts of socioeconomic factors through regression analysis. A brief description of these techniques is described in the following sections. The technique of choice will depend on the resources available to the forecaster and the complexity of analysis required, but, either way, the forecaster will be expected to support his predictions on a firm foundation of facts, historical trends, and socioeconomic analysis. Deployment of more than one methodology and/or multiple analyses will strengthen confidence in the recommended outcome of the forecast study.

IV.1.1 Share Analysis

An airport's traffic can usually be assessed as being a share of a larger traffic volume, such as that of a statewide or regional aviation system. A relatively simple forecasting technique is to examine the percentage relationship of the airport in question to the larger system. One can determine whether this relationship grows or shrinks over time, and then extend this trend into the future. This technique is useful when an independently prepared forecast for the larger area is available.

Share-based forecasts can be prepared with relatively minimal effort and can be a useful tool to benchmark forecasts prepared by other methods. They work best in stable aviation markets when any changes in airline service strategies and economic trends are expected to be few or relatively uniform across the larger forecast area. They perform less well in more dynamic aviation markets or at times of market or economic uncertainty. Accordingly, the forecaster needs to review carefully the overall characteristics of the aviation market concerned in order to determine whether share analysis is an appropriate tool.

IV.1.2 Trend Analysis

One method of creating a forecast is to examine historical data to determine the trend in activity and then extend this trend into the future. Generally, at least 20 years or more of data should be examined so that periods of both economic growth and recession are captured. The forecaster can then determine whether recent performance is above or below the longer term trend line and begin to analyze the reasons why.

Trend analysis is adequate when no changes to the status quo of airline service and economic activity are expected. Trends, however, tend to be upset when airlines make a radical change to their service models, declare bankruptcy, or enter/leave an airport market. Trends also tend to be upset by unexpected changes to the economic health of a region. Trend analyses tend to work best for short-range forecasts because the risks of these changes occurring are less.

IV.1.3 Regression Analysis and Econometric Modeling

Regression analysis derives forecasts of passenger and/or cargo activity at an airport from independently prepared forecasts of factors such as population size and profile, disposable income, breakdown between business and leisure travel, and cost of air fares. This sort of analysis compares historical data on passenger and/or cargo activity with comparable data relating to one or more independent factors, to create an equation that relates the passenger or cargo activity to the independent factors. The forecaster then uses this equation to refine forecasts of future passenger and/or cargo activity in the light of the modifying affect of the independent factors. Various statistical tests are used to evaluate the quality of the correlation of historical passenger or cargo volumes to the independent variables. Forecasters typically try to correlate the historical passenger data to multiple variables in an effort to improve the accuracy of the final result. Normally, forecasters use personal income, population, and air fares as the independent factors, because personal income and fares are factors in passenger decisions on whether to travel and whether to use air transportation. Population can be a predictor of the total volume of a market, once the propensity to travel is determined by personal income and fares.

Regression analysis improves on trend analysis by relating passenger volumes to predictive factors that have independently prepared forecasts. These independent forecasts will likely capture demographic characteristics, migration trends, and employment profiles. More sophisticated independent forecasts may reflect local infrastructure improvements, industry changes, population densities, and land use controls. The use of regression analysis enables the assumptions that have informed the independent forecasts to be incorporated into the dependent forecasts of aviation activity.

Thus, there is always uncertainty about the levels of types of future aviation activity at an airport. The terminal planner needs to understand the reasons behind uncertainty and then develop a plan that provides the airport flexibility to adapt to new circumstances.

Airport terminal facilities are sized to accommodate the peak hour passenger volumes of a selected design day. Annual enplanements are an indicator of overall airport size; however, peak hour volumes more accurately determine the demand for airport facilities based on the specific user patterns of a given airport. Peak hour passengers are typically defined as the number of passengers in the peak hour of an average day in the peak month (PHADPM) and are also often referred to as "design hour passengers." The design hour measures the number of enplaned and deplaned passengers departing or arriving, on aircraft in an elapsed hour of a typically busy (design) day. The design hour typically does not correspond exactly to a "clock hour" such as 7:00–7:59 but usually overlaps two "clock hours," for example, 7:20–8:19 reflecting airline scheduling patterns.

Each airport or terminal also has its own distinct peaking characteristics due to differences in airline schedules, business or leisure travel, long- or short-haul flights, the mix of mainline jets and regional aircraft, originating/terminating passenger activity or transfer passenger activity, and the balance of international and domestic passenger services. These peaking characteristics determine the size and type of terminal facilities. Thus, two airports with similar numbers of annual passengers may have different terminal requirements, even if the design hour passenger volumes are similar.

The following sections will discuss how the user can proceed from annual forecasts (typically from an Airport Master Plan or the FAA TAFs) to the necessary design hour forecasts for terminal facility planning. These sections will also cover the similar process to convert annual aircraft operations to data needed to develop gate forecasts.

IV.2 Data Sources

Regardless of the forecasting method used, the forecasting process examines past aviation activity patterns, as well as other information, and attempts to predict what future activity will be based on the patterns of past activity. Thus, all forecasting efforts begin with gathering data about past aviation activity at the airport, as well as other information about the airport's market that the forecaster may find useful in predicting future aviation activity. The following data sources are often tapped to prepare forecast information:

- Airport records
- Socioeconomic data
- Flight activity data
- Airline surveys
- Passenger surveys
- Other sources

These data sources are described in the following sections.

IV.2.1 Airport Records

Virtually all commercial service U.S. airports keep monthly records of aircraft operations, passenger numbers, mail, and cargo by each airline. This information is used to invoice airlines for landing fees; therefore, these records are kept by the airport finance department. Historic information on monthly and annual traffic counts of passengers and aircraft operations should be obtained for as long a period as available, preferably long enough to cover a couple of boom economic times and a couple of economic recessions (airport activity tends to vary with population and economic activity). Traffic activity by specific airlines should be examined to identify when different carriers started and ended service, as this type of information can explain changes (either up or down) in total activity.

Airport-generated traffic counts should be compared with FAA air traffic counts as a control measure. FAA records will capture total activity, of which traffic activity reported to the airport by the individual carriers will make up a significant portion. The airport usually reports the difference between its records and FAA records as "miscellaneous" or "unknown" activity. Usually this activity is by general aviation aircraft that do not use the passenger terminal. However, the planner should validate this with locally knowledgeable personnel at the airport. Some of this activity can include non-scheduled air charters that use the passenger terminal. In addition, this activity can qualify an airport for AIP assistance.

Local airports report their information either on a calendar year or on a local fiscal year, while the FAA tends to report its annual information on a federal fiscal year basis. The terminal planner needs to be cognizant of the annual periods being used to report information by each agency and prepared to reconcile between data sources using monthly information from each agency.

IV.2.2 Socioeconomic Data

Aviation activity tends to vary with an airport's service area (catchment area) population and per capita personal income. In addition, the number of flight destinations available and the price of air fares may increase the size of an airport's service area, because customers tend to drive from further away to use low-fare or nonstop air service.

The local census bureau or equivalent regional agency will likely have historic socioeconomic data. The forecaster should obtain a history of local socioeconomic data that at least covers the period of time that local airport traffic data has been available. Because historic aviation activity usually correlates fairly closely to past socioeconomic information, the forecaster should also obtain county-level forecasts of future socioeconomic trends for the airport's service area. These forecasts are often available from a regional agency or from private data services that provide data nationally by county.

IV.2.3 Flight Activity Data

In addition to airport data, flight activity data is available from a wide range of sources, depending on the budget available and the level of detail desired. The FAA provides a substantial volume of aircraft activity data through its various web portals. Some of the more common data sources are described below.

IV.2.3.1 Federal Aviation Administration

The FAA provides data on aviation system operational performance, including airport utilization statistics, via its Aviation System Performance Metrics website (aspm.faa.gov). Some sections of this site require a user name and password (available from the FAA) for access. The site also provides access to the FAA TAFs. Not all types of data are available for all airports, because the FAA data focuses on airports that have FAA facilities such as air traffic control towers or terminal radar approach control facilities.

IV.2.3.2 Bureau of Transportation Statistics

The U.S. Department of Transportation (U.S.DOT) has centralized the processing and disseminating of various statistics on transportation usage within the Bureau of Transportation Statistics (BTS) (www.bts.gov). The BTS is home to several useful databases that describe airline and airport activity including the following:

- Form 41 databases, which provide airline-reported financial statements, aircraft operations, and passenger statistics.
- OD1A databases, which provide a 10% sample of passenger itineraries based on ticket information, passenger profiles, fares, city-pair travel, and revenues.
- T-100 databases, which provide information on load factors (passengers carried versus seats offered) by city-pair market.

The BTS website (www.bts.gov/programs/airline_information/sources/) provides a list of various vendors who preprocess and analyze the various BTS databases. These services may make analysis of these large data sets more efficient.

IV.2.3.3 Official Airline Guide

The Official Airline Guide (OAG) (*29*) provides flight-by-flight listings of scheduled airline activity (arriving and departing aircraft) with various data about each flight including aircraft type, number of seats, arrival and departure times, flight numbers, fares, and full flight itineraries (cities served by each flight). This data is compiled and sold by Official Airline Guide, Inc. as a manual, as data files available on CD, and as data files available for download.

IV.2.4 Airline Surveys

Sometimes demand for a terminal project is prompted by a change in a particular airline's business plan at the airport. In this case, it is very helpful to get information directly from the airline about future plans. Even when there is no specific announced plan, interviews of airline station management or property management personnel will give insights about future airline plans at the airport. However, the forecaster needs to treat forward-looking information (such as future flight schedules) from the airline company with some skepticism, because business plans do not always occur as expected and are subject to change. Ultimately, forecasters must apply their judgment about the viability of future airline changes. For example, two airlines may enter a single market simultaneously, each expecting to win the competition. The forecaster must judge whether the market is big enough to support both competitors beyond the short-term future.

IV.2.5 Passenger Surveys

Some forecasting information about air service is available only by asking the passenger:

- Trip purpose (business/government or leisure/discretionary/tourism)
- Visitor versus local passenger
- Whether the passenger considered using another airport when booking the trip

Answers to these types of questions help the terminal planner understand the level of uncertainty and risk in the forecast.

Surveys are usually sponsored by local airport operators to understand passenger attitudes about customer service, how long before flight departures do passengers arrive, ground transportation modes that passengers use, passenger demographics, spending at the airport (concession usage), or spending in the local economy (economic impact analyses). The information about trip purpose, type of passenger, and whether passengers considered using another airport may have been asked in past surveys, but these answers may not have been published. However, the survey sponsor will likely have a database with these survey results.

Surveys reflect the conditions when questions were asked and may not reflect future conditions when underlying factors affect the mix of passenger types within the sample. A survey taken in winter will miss passenger profiles on summer vacations. Surveys taken before 2001 do not reflect security procedures put into effect after 2001. The analyst needs to understand the temporal context for the survey and how more recent changes in activity affect the relevance of the survey.

For additional insights on correcting statistical information on passenger-related processing rates from passenger surveys, please reference *ACRP Report 23: Airport Passenger-Related Processing Rates Guidebook* (*30*).

IV.2.6 Other Sources

Every local airport service or catchment area has its own unique characteristics that will define its travel market. The forecaster should consider the use of any data source that will accomplish one of two goals in the forecasting process:

- Describe the future trends in air passenger demand
- Reduce the uncertainty in the forecast

The forecast accomplishes these two goals by improving information quality and/or providing new/additional information.

IV.2.6.1 Forecasting Basics and Sources of Forecast Information

Most initial forecasting efforts provide only annual estimates of future enplaning or total passengers and aircraft operations. These forecasts come from one or more of the following sources:

- FAA TAFs (www.aspm.faa.gov)
- State and/or regional aviation system plans
- Airport Master Plan forecasts
- Airline forecasts
- Other forecasts (such as a regional agency airport analysis or an environmental study)

It is up to the terminal planner to extend the analyses provided in these forecasts to estimate the peak hour flows of passengers and aircraft that will be required to develop the terminal plan.

As described in the overview, forecasting future demand has inherent uncertainties based on external factors that tend to upset the continuation of past economic trends. The terminal planner needs to understand the reasons behind uncertainty and then develop a plan that provides the airport flexibility to adapt to new circumstances. Some critical factors that create uncertainty are discussed in the following list:

- **Airline network planning:** Many U.S. airlines structure their route networks around one or more strategically located "hubs" that have passenger flows from less heavily trafficked feeder routes consolidated before transfer to and from longer haul sectors with higher load factors. While the advent of more low-fare carriers and regional jets is increasing the proportion of point-to-point services, business at many airports is still heavily dominated by the main local hub carrier. Thus, airline decisions to open, expand, contract, or close down a hub location can radically affect the volume of traffic passing through a particular airport. Airline strategic business decisions of this sort can occur for reasons that are largely independent of local factors.
- **Local economic factors:** While local economic forecasts are generally more reliable than the forecasts of future airline plans, the more dependent a community is on a single industry or corporate activity, the more susceptible are local airport traffic levels to factors affecting that industry or activity. For obvious reasons, smaller airport traffic levels are more vulnerable in this respect than airports serving a larger, more diverse economy.
- **Airports' competition for passengers:** Airports have overlapping service areas. While the great majority of passengers originate within a 1 hour travel time of the airport, some passengers come from up to 3 hours away. The presence of a low-fare carrier will tend to attract passengers from longer distances if no competing service is available from a closer airport. Changes in airline service at competing airports can affect local traffic.

The best response to uncertainty is to build alternative forecasts that have scenarios that are sensitive to one or more of the factors described above. Most airports now keep statistics on historic traffic activity. The planner can assess how this traffic rose and fell in response to external factors. Study of this history in the context of airline actions, local economic events, and activity at other airports enables the development of low and high case scenarios, in addition to the main expected case, including scenarios that have different mixes of connecting versus origin/destination traffic. The purpose of having a range of forecast scenarios is to have an understanding of the magnitude of development risk associated with investing in expanded airport facilities. This helps the planner and stakeholders evaluate the various terminal expansion options and select the most prudent and cost-effective planning solution.

IV.3 Typically Forecasted Information and Forecast Validation Issues

While forecasts usually focus on future passenger activity, terminal plans also need estimates of belly cargo or mail and aircraft arrivals and departures (operations). Once forecasts are prepared, then there are several activities that the forecaster can conduct to gain stakeholder acceptance of forecasting results.

IV.3.1 Passengers

Usually, forecasters spend the most time and effort on forecasting passenger volumes, using the techniques described above, because passenger volumes form the basis for many of the analyses that the planner will use in evaluating the functional requirements of the terminal. While passenger growth can be forecast in totality, it is often more beneficial to forecast specific categories of passengers independently. Numbers of domestic origin and destination passengers tend to vary with local economic factors and local air fares. International passenger traffic will be driven more by global economic and business considerations and the relative importance of business and tourism links with the overseas regions concerned.

The numbers of transfer passengers will vary depending on the size and role of the hub airport and the airline route development and network strategy. The forecaster may need to get information about connecting passenger volumes from the hub airline if there is substantial connecting activity at the airport.

IV.3.2 Belly Cargo and Mail

Larger aircraft, especially widebody aircraft on international flights, will also carry cargo and mail in addition to baggage in the lower compartments of the aircraft. Similar to passengers, the volume of this activity will also vary with local economic conditions and the price of air cargo. Small changes in price may divert domestic air cargo to truck, as long as the truck will get the cargo to the destination in sufficient time. The time required and the expense of cargo security may also determine whether air cargo and mail goes in the belly of a passenger aircraft, by a dedicated cargo aircraft, or by truck (if domestic).

The planner should be sure to evaluate the qualities of the air cargo data they receive. Some "air cargo" does not go by air at all, but is still recorded as air cargo. Some data is based on estimates and not actual tonnage reports. If possible, the planner should cross check various data sources to determine reasonableness.

IV.3.3 Aircraft Operations

Aircraft operations by commercial airlines are normally derived by determining the average number of passengers on board each aircraft, determining the expected percentage of seats filled (load factor), and then dividing the volume of boarding passengers by these two numbers to determine the total number of aircraft operations. Forecasting growth in aircraft operations also involves evaluating whether the airlines will introduce new or different aircraft types in order to tailor their services more closely to the demand profile. This element of the forecast also involves assessing the airlines' fleets and determining what types of aircraft are available for substitution. The aircraft manufacturers publish the aircraft they have on order from each airline.

The forecaster also needs to be aware that growth in aircraft operations may be limited by airfield constraints that cannot be resolved through additional construction. In this case, average aircraft size may increase to absorb demand growth unless the relevant airlines have no plans to order larger aircraft. Without growth in the size of aircraft, airfield delays will likely grow to an unacceptable level, at which point the FAA may step in and limit the number of hourly aircraft operations when delays increase beyond an average of 20 to 25 minutes per aircraft.

IV.3.4 Benchmarking and Stakeholder Buy-in

Because many assumptions about future terminal size and configuration depend on long-term demand forecasts, obtaining stakeholder buy-in is an essential step in the planning process. Four steps help improve the acceptability of forecasts to stakeholders and increase the likelihood of obtaining a broader consensus.

IV.3.4.1 Consider and Use Stakeholder Data in the Forecast Whenever Possible

Forecasters need to consider a wide range of data sources in order to identify as many cause and effect relationships between basic information and passenger volumes. Airlines have some of the most detailed information about passenger profiles available. In addition, they may be willing to share their opinions about future market conditions at an airport, or within a regional airport system, providing they do not perceive such disclosure as a breach of commercial confidentiality. While these opinions might not be included in the final documentation, the simple statement, that stakeholder data and opinions were considered in the creation of the forecasts, improves the chance for obtaining a stakeholder consensus that the forecasts are reasonable.

IV.3.4.2 Examine the Sensitivity of the Forecast to Variations in the Independent Variables or Changes in Major Assumptions

The selection of independent variables and the forecast assumptions underpinning them can be attacked as being somewhat subjective. The forecaster should present a discussion on how changing independent variables and assumptions will affect the forecasts. This could include a complete forecast using alternative assumptions, or it could include a simpler discussion on whether a changed assumption will depress or stimulate traffic levels. Presenting alternatives, along with a narrative that describes the rationale for choosing a particularity of assumptions should improve the chances for acceptance of the final forecast among stakeholders. Discussing this analysis with stakeholders before completing and accepting the forecasts should further increase stakeholder acceptance of the final forecast.

IV.3.4.3 Evaluate Alternative Methodologies and Compare Results

While forecasters may have their favorite methodologies, not all methods work in all places. A technique that produced an acceptable outcome at one airport may be ill suited at another. Further, a methodology that worked in a previous study may no longer work in a new or repeat study. Finding the methodology that best represents the current conditions involves testing alternatives and finding a method that provides the best explanation and support for the prediction of future conditions. Explaining the choice of methodology to stakeholders should improve their acceptance of the final forecasts.

IV.3.4.4 Benchmark (Compare) the Local Forecast to Other Forecasts, as well as Regional and National Forecasts

Comparing forecasts to other relevant forecasts demonstrates that other parties share a similar opinion about the future growth of aviation activity at the airport. If the results are not broadly similar, the comparison should include an analysis of the factors which cause the forecast to differ. The benchmark forecasts could include previous forecasts at the same airport, system plan forecasts prepared by a state or regional agency, and the FAA TAF. If the forecasts will be used to support FAA Airport Improvement Program funding decisions, then the FAA expects the local forecast to be within 10% of the TAF after 5 years and within 15% after 10 years. If the forecasts do not agree with the TAF, the FAA will require compelling documentation that describes why the local forecast should be used in lieu of the TAF for funding decisions. If the planner elects to use the TAF and expects to use the forecast for a larger master planning effort, the FAA will expect the planner to prepare an analysis that validates the TAF.

IV.3.5 Planning Activity Levels

Because forecasts typically project demand over a particular time frame, such as 20 years, removing the time frame from the analysis and focusing on an activity level may increase the shelf-life of a future plan, because the plan still provides the appropriate response to a future level of demand even if the forecast of when future demand occurs is incorrect. Use of a planning activity level instead of a time-based forecast will focus planning decisions on the size and configuration of a terminal instead of whether it is advisable to proceed with any development at all. Use of planning activity levels is especially useful for long-range planning when major design and construction will not occur for some period of time after the terminal planning occurs. Use of planning activity levels also allows the planner to round activity levels to representative levels rather than focus on serving a specific demand level.

IV.4 Peak Hour Demand Analysis

IV.4.1 Defining the Design Hour

As already discussed, the terminal planner must have, as a basic planning tool, forecasts of peak hourly passenger loadings that the terminal and its various systems may have to cope with. These loadings are also referred to as “design hour passengers,” a term which the Guidebook will use for consistency. The design hour is not the absolute peak level of activity, nor is it equal to the number of persons occupying the terminal at a given time. It is, however, a level of enplaning and deplaning activity that the industry has traditionally used to size many terminal facilities. The number of persons in the terminal during peak periods, including visitors and employees, is also typically related to design hour passengers. There are a number of methods for determining design hour passengers.

One approach is to define the design hour as the 90th (or 95th) percentile busiest hour of the year. This approach requires keeping track of all enplaning and deplaning passengers for every flight during the year, and then ranking these by hour (usually a clock hour) to find the level of activity that accounts for 90% of the annual traffic. While used by some non-U.S. airports, it is a very data-intensive approach for which data is not available for the vast majority of U.S. airports.

In the United States, the design hour is typically defined as the peak hour of an average day of the peak month. The design hour measures the number of enplaned or deplaned passengers departing or arriving on aircraft in an elapsed hour of a typically busy (design) day. The design hour typically does not correspond exactly to a “clock hour” such as 7:00–7:59, but usually overlaps two “clock hours," that is 7:20–8:19 reflecting airline scheduling patterns. More information about selecting the design hour is presented in the following section.

IV.4.2 Estimating Design Hour Passenger Activity

Estimating design hour passengers is typically a three-step process:

- Determine the peak month
- Determine the design day to be used
- Estimate the amount of daily activity that occurs in the design hour.

This process is applied to both existing (base year) conditions as well as activity in future years.

IV.4.2.1 Peak Month

The peak month is based on historic patterns of passenger activity. It is recommended that 3 to 5 years of data should be collected to determine if the peak month is a constant or changing percentage of annual activity. The peak month may be different for enplaned and deplaned passengers, domestic and international, and so forth.

Table IV-1 is an example of monthly enplanement data used in the Spreadsheet Models to determine the peak month percentage. For this airport, the peak month for enplanements was consistently August, but the percentage varied over the 5-year period.

The peak month percentage may be modified for the future based on local trends and/or anticipated changes in service patterns.

IV.4.2.2 Design Day

For most airports, an average day of the peak month is used for the design day; the peak month is simply divided by the number of days in that month.

An alternative to using the average day of the month is to use an average weekday. This alternative is often used at airports that have domestic service as the predominant activity and weekend activity is less than weekday activity. Airport records on monthly and daily passenger volumes (as recorded by the airlines) are the best source for determining whether an average day or an average weekday is the appropriate (design) day for the design hour.

Table IV-1. Example of peak month percentage of annual enplanements.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2004	339,212	335,431	380,372	383,986	384,009	412,229	433,519	438,881	359,801	392,988	389,683	390,748
2005	351,751	343,331	410,799	410,089	417,314	431,319	448,310	453,798	381,840	396,737	390,193	386,018
2006	346,250	345,682	406,676	412,639	410,434	430,066	437,895	446,311	373,111	401,655	395,973	407,416
2007	371,721	365,513	432,975	433,370	438,341	452,244	456,592	478,329	388,735	414,229	390,115	366,854
2008	350,450	350,533	408,656	392,136	385,109	398,749	411,909	419,764	342,455	362,867	325,972	344,026

Year	Total	Monthly Average	Maximum Value	Peak Month	PM % of Year
2004	4,640,859	386,738	438,881	August	9.5%
2005	4,821,499	401,792	453,798	August	9.4%
2006	4,814,108	401,176	446,311	August	9.3%
2007	4,989,018	415,752	478,329	August	9.6%
2008	4,492,626	374,386	419,764	August	9.3%
		Average Peak Month		AUGUST	9.4%

Average Peak Month Percentage of Annual

Source: Landrum & Brown

At a small number of airports with highly variable activity from day to day, a specific day of the week may be chosen as the design day. For example, a vacation destination airport may have significantly more activity with larger aircraft on Saturdays than during the week. The concentration of larger aircraft would affect both the daily and peak hour activity.

IV.4.2.3 Design Hour Passengers

The design hour can be computed by one of two approaches: using a design day flight schedule (DDFS) or applying percentage factors against a design day passenger volume.

The most frequently used source of data for assembling a DDFS is the OAG. Data from OAG needs adjusting to account for non-scheduled activity such as charters. Choosing the correct day for a flight schedule should take into account monthly activity statistics from the airport operator and daily flight activity from either the FAA or OAG. The chosen day should be representative of activity for the design day as discussed above. Because the primary use of the design hour is to estimate passenger activity, the day chosen for the OAG schedule should reflect a day with a representative number of scheduled seats.

DDFSs should have, at a minimum, the following information:

- Airline name (usually listed as a two-letter code)
- Aircraft type (usually listed as a three-letter code)
- Number of seats on the aircraft (usually derived from the airline name and aircraft type information)
- Time of flight arrival or departure
- Destination or origin of the flight (used to determine whether a flight is using international or domestic terminal facilities)
- Flight number

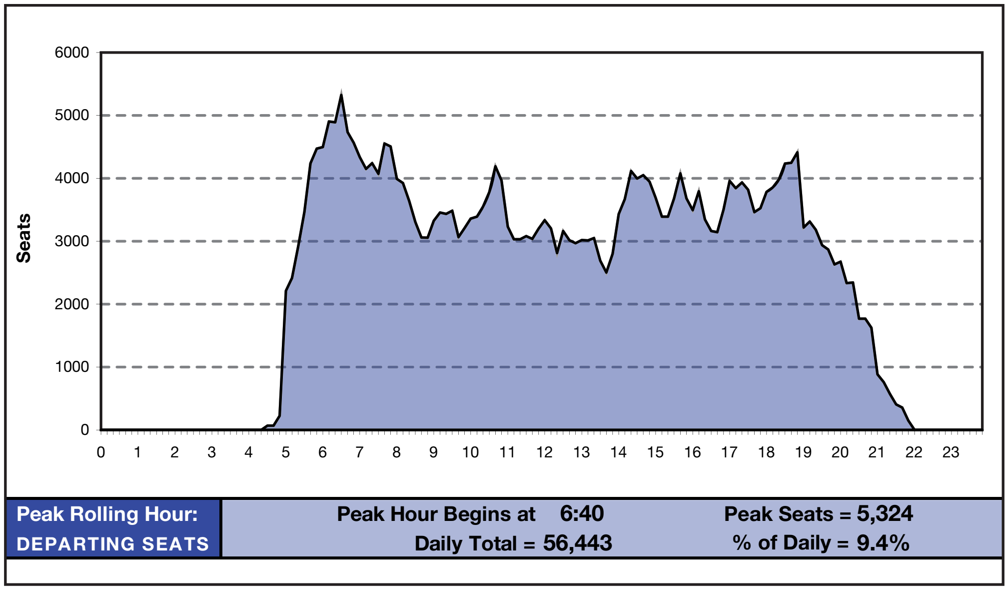
In addition to these six fields, flight schedules can contain several other pieces of information about each flight, such as operating airline (versus the marketing carrier), the time the aircraft left the originating airport or arrived at the destination airport, and the days of week the flight operates. Days of operation are especially important for airports with flights that may not operate daily.

If an airfield simulation study is being done, a usable DDFS and fleet mix could be available directly from that study. However, the planner should validate that a DDFS chosen for the airfield analysis also has representative information for a design day for passenger terminal planning.

Regardless of the source of the DDFS, the terminal analyst should consider that a DDFS presents a very detailed description of a single day. The analyst should evaluate whether the flight activity schedules are truly representative (through examination of other historical schedules for the same airport) or whether it represents a unique case. See Section IV.4.4 for a discussion of the factors involved in developing a DDFS.

The rolling peak hour seats can be determined from a flight schedule using a spreadsheet analysis. As shown in Figure IV-1, the peak hour (design hour) usually does not occur in a clock hour, but across two hours. This type of analysis can be done using scheduled seats (as in Figure IV-1) or flight-by-flight actual passenger loads.

The advantage of using a DDFS is the great level of detail it provides. The disadvantage is that small variations in the schedule can vary results in ways that may be difficult to explain. For example, the shift in a flight by a few minutes can determine whether or not it falls within the busiest hour and thus affect the percentage of daily activity in that peak hour. Some analysis that compares percentage of activity in the design day and design hour should be used to ensure that the schedule provides representative information.



Note: This chart was created in the Design Hour Determination model, which is part of the Spreadsheet Models provided in *Volume 2* and was developed to work with the material in this volume.

Figure IV-1. Design hour for departing seats.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Design Hour Determination model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model takes the user through the steps to determine the peak hour planning factors that can be used when a DDFS is not available.

If flight-by-flight data is not available, the design hour is estimated as a percentage of daily activity. These percentages (enplaned and deplaned) should be based on actual passenger activity data collected from the airlines for a typical week. Actual passengers per flight data is preferable to scheduled seats because it is more accurate. For example, to position aircraft for the next morning's departures, an airport may have a late night arrivals peak in terms of seats. However, the actual deplaning peak may be in late afternoon or early evening when load factors are higher.

IV.4.2.4 Sample Design Hour Calculations

Table IV-2 illustrates a typical approach to estimating future design hour activity as contained in the Spreadsheet Models. In this example, the peak month factor has been held constant based on an average of the last 5 years, although it could be varied. An average day has been used as the design day, so the future peak month is divided by 31 days.

The percentage of daily activity represented by the design hour is currently estimated to be 15.4% for enplaned and 12.5% for deplaned. This estimate is based on actual flight-by-flight activity, scheduled seats, or a combination of assumptions including scheduled seats and peak hour and average daily load factors.

Most planners will assume some variation in the design hour percentage of daily activity for the future based on local trends and/or anticipated changes in service patterns. If there are many "valleys" in the current schedule, adding off-peak flights or assuming increasing loads in off-peak

Table IV-2. Design hour calculation example.

Calendar Year		Total Enplanements		
	ANNUAL			
Base				
2008		4,492,626		
Forecast				
2010		4,168,100		
2015		4,732,800		
2020		5,381,300		
2025		6,104,700		
2030		6,925,300		
	PEAK MONTH			
Base		9.4%	Peak Month Factor	
2008		419,764	~from Peak Month Tab	
Forecast	Peak Month Factor			
2010	9.4%	391,800		
2015	9.4%	444,900		
2020	9.4%	505,800		
2025	9.4%	573,800		
2030	9.4%	651,000		
	PEAK MONTH AVERAGE DAY			
Base		31	# of Days in Peak Month	
2008		13,540		
Forecast				
2010		12,640		
2015		14,350		
2020		16,320		
2025		18,510		
2030		21,000		
	DESIGN HOUR			
Base	% of Average Day	Enplaned	% of Average Day	Deplaned
2008	15.4%	2,080	12.6%	1,700
Forecast				
2010	15.4%	1,950	12.6%	1,590
2015	15.0%	2,150	12.2%	1,750
2020	14.7%	2,400	12.0%	1,960
2025	14.0%	2,590	11.7%	2,170
2030	13.5%	2,840	11.5%	2,420

Source: Landrum & Brown.

times may reduce the design hour as a percentage of daily activity over time. This is the type of assumption typically used and is reflected in the example. In contrast, there may be an increase in the peak hour percentage (especially in the short term) if forecasts indicate that new service would be provided in the current peaks without a concurrent increase in off-peak activity.

Regardless of the analysis method used to derive the design hour volumes of passenger and aircraft activity, the method used to create the analysis must be calibrated against data or observations that reflect actual operations at the airport.

IV.4.2.5 Other Design Hour Considerations

O&D vs. Connecting Passengers. After determining the total number of design hour passengers, it is usually appropriate to divide this volume into O&D passengers and connecting passengers. Connecting passengers usually stay on the airside area of the terminal while the O&D passengers make use of both the airside and the landside areas of the terminal. The only time connecting passengers make use of the landside facilities is when they change airlines and the onward airline's gates are located in a different concourse or terminal with no airside connector.

Connecting passenger volumes tend to vary considerably from airline to airline. In general, the larger the volume of flight activity that an airline has at an airport, the greater is the likelihood that connecting passengers will be a part of that airline's total passenger volume. Information on connecting passenger volumes should be collected from the airlines if possible. Analysis of U.S.DOT databases on O&D travel (10% ticket survey) and connecting travel can also be used to derive factors that calculate connecting versus O&D traffic flows.

Visitor Ratios. In addition to passengers, other populations are present in the terminal building and use its various facilities. Frequently, the largest volumes of non-passengers (besides airport, concession, and airline employees) are visitors who usually are present to send off or greet passengers. The best method for determining the number of visitors to the terminal is through a passenger survey. The survey information is then used to determine the number of visitors per arriving or departing passenger. Care should be taken to identify those visitors who actually enter the building as opposed to those who just drive the passenger to or from the airport and never actually leave their cars.

IV.4.3 Determining Design Hour Aircraft Operations

Three types of analyses are appropriate for aircraft operations: determining the number of arrivals; the number of departures; and the number of aircraft on the ground, either parked at contact gates or remote stands. The first two numbers are useful to evaluate the capacity of taxiways and taxilanes, while the third is useful for determining the number of contact gates and remote stands required for each aircraft type.

If a DDFS is not used for future design levels, then the forecaster should evaluate the number of passengers and seats per flight operation, airline aircraft orders, and other forecast information to judge how the mix of aircraft in the design hour will change in future years.

It is possible and sometimes necessary to match arriving flights to departing flights to prepare detailed analyses of gate usage. Flight numbers and aircraft operator codes can provide useful information in the matching process. However, the best information on which arriving flights become the next departures will be obtained from actual records of gate usage. More detailed information on gate analysis is presented in Chapter V.

The forecaster should also examine the fleet mix across several representative hours of the day to identify other hours of the day that have critical aircraft that do not arrive or depart in the design hour. For example, an international flight may use a widebody aircraft, but this flight may not occur in the design hour. In addition, the fleet of aircraft that Remain Overnight (RON) should also be examined to determine whether overnight parking needs are different from the design hour.

IV.4.4 Developing Design Day Flight Schedules

DDFSs present a level of detail that can enhance the planning effort and sometimes aid in gaining stakeholder acceptance of planned improvements. The schedules contain detailed flight-by-flight information that can be time consuming to prepare, evaluate, and manipulate, depending on the reliability of the sources of information available and the software tools available to manipulate, summarize, and present the information they contain.

The most usual starting point for creating an existing design day schedule is using data available from the OAG. The planner still must go through the process of estimating the design day and design hour demand levels, and then select an OAG for a day that most nearly matches the selected design day and design hours. In addition to the OAG, the planner should also use airport and FAA records to identify non-scheduled activity that the OAG does not contain.

The flight schedule initially will contain two parts: a listing of arrivals and a listing of departures. The planner may choose to link arriving flights to subsequent departing flights. Linking flights allows the planner to create Gantt charts of gate usage. More information on creating gate charts and the analysis of gate usage is described in Chapter V.

DDFSs for forecast years are usually created by adding flights to the existing schedule and by editing existing flights to show new aircraft types, or changed times of arrival or departure. The following points should be considered when creating forecast schedules:

- Forecast design day and design hour values should be estimated prior to creating forecast schedules. Because a DDFS usually has a whole day's activity, hourly target values should be set.
- Design day aircraft fleet and airline mixes should be estimated prior to creating forecast schedules.
- Flight schedules should be edited one airline and one market at a time.
- Adding an additional flight by an airline to a market usually requires retiming the remaining flights in that market to provide a realistic frequency of flights to that market.
- The future ability of an airline to increase the size of an aircraft on a flight versus adding frequency of service should be considered. The planner should consult published information about an airline's fleet and aircraft orders or ask the airline about future fleet plans.
- Shorter haul markets tend to have more frequent service versus longer haul markets, although many exceptions occur.
- The inbound and outbound fleet mix to each market is usually the same.
- Airline orders for aircraft and network routing strategies should be considered when adding or changing flights for a future demand level.
- Long-haul and international markets have times of day when operations are not viable because of time zone constraints, especially eastbound flights. Generally, both ends of a domestic flight should arrive or depart between 6:00 a.m. and midnight. For example, a transcontinental flight that leaves Los Angeles at 6:00 a.m. (Pacific Time) will not arrive in New York until 2:30 p.m. (Eastern Time). Thus, a future DDFS for a New York airport should not show transcontinental flights arriving before 2:30 p.m. These time zone constraints often define peak hours, especially in international terminals.

DDFSs developed from an OAG reflect the constraints of existing terminal facilities, runway lengths and widths, and specific airline leaseholds. If the goals of future planning include removing these constraints, the development of future flight schedules should reflect a less constrained or unconstrained future facility environment.

A DDFS provides estimates of seats and aircraft operations available at the terminal. However, the planner needs to create reasonable estimates of passenger load factors to convert the seat counts into passenger volumes. These load factors will likely vary from airline to airline and by time of day. Design hour load factors usually range between 80% and 95% of seats filled.

A DDFS contains a very specific sequence of flights, which will generate a very specific volume of aircraft activity at the gates, and flows of passengers and bags through the terminal building. The planner should spend some time understanding whether an analysis based on a DDFS is truly representative of a range of future activity or reflects a unique condition resulting from the specific sequence of flights in the schedule.

CHAPTER V

Terminal Airside Facilities

The interface between the passenger terminal building and the airside facilities of an airport is crucial to the achievement of safe and efficient aircraft operations. Accordingly, the terminal planner must be fully aware of and conform to specific airside planning regulations and requirements. Specifically, the terminal planner needs to consider:

- Airside planning requirements
- Terminal apron planning
- Aircraft gate requirements

V.1 Airside Planning Requirements

The following airside constraints and functions must be considered in the site planning of the airport terminal complex:

- FAR Part 77 and TERPS requirements
- Aircraft maneuvering and separations
- Air traffic control tower line-of-sight
- Emergency equipment access roads
- Airside security
- Aircraft apron/gate access points
- Aircraft deicing
- Electronic interference

Each of these planning considerations are applicable in principle to all airports but may be adjusted in relation to the actual complexity of aviation operations. Each of these items must focus on the specific needs of the airport for which a terminal plan is being prepared, and the scope of the study must be tailored to the individual airport. Therefore, in any given study, certain aspects of these airside functional areas may be emphasized, while others may not be considered at all. Each of these terminal airside planning considerations is presented in more detail in the following subsections.

V.1.1 FAR Part 77 and TERPS Requirements

The navigable airspace located around an airport constitutes a sizable area requiring optimum consideration and evaluation when determining the runway system. All airspace in proximity to airports is governed by FAR Part 77 (*9*). In addition, airports utilizing aircraft instrument approach and departure procedures may also fall under TERPS (*10*). Each of these two airspace planning criteria is discussed in more detail below. At the anticipated publication date of this Guidebook, the FAA intends to revise the FAR Part 77 standards to better incorporate TERPS requirements.

V.1.1.1 FAR Part 77 Imaginary Surfaces

The purpose of FAR Part 77 is to protect the airspace and approaches to each runway from hazards that could affect the safe and efficient operation of aircraft. These standards can also be used by local jurisdictions in controlling the height of objects in the vicinity of airports. For example, the FAR Part 77 surfaces can be utilized in zoning and land use ordinances adjacent to an airport to protect the navigable airspace from encroachment by hazards that would potentially affect the safety of airport operations.

The FAR Part 77 imaginary surfaces are established relative to the airport and runway system. The Part 77 imaginary surfaces include the primary, approach, transitional, horizontal, and conical surfaces as shown in Figure V-1. The dimensions of each imaginary surface are based on the runway approach capability (visual, non-precision, or precision) and are depicted in the data table in Figure V-1.

Primary Surface. The primary surface is located closest to the runway environment. It is a rectangular area symmetrically located about the runway centerline and extending a distance of 200 feet beyond each runway end and varies in width from 250 feet for utility runways to 1,000 feet for precision instrument runways. Its elevation is the same as the runway centerline at a point perpendicular to the runway centerline. The width of the primary surface depends on the runway approach capability (visual, non-precision, or precision).

The primary surface must remain clear of most objects in order to allow unobstructed passage of aircraft. Objects are only permitted if they are no taller than 2 feet above the ground and if they are constructed on frangible mounts. The only exception to this rule is for objects whose location is "fixed by function" such as navigational and visual aid facilities (glide slope, precision approach path indicator, windsock, etc.).

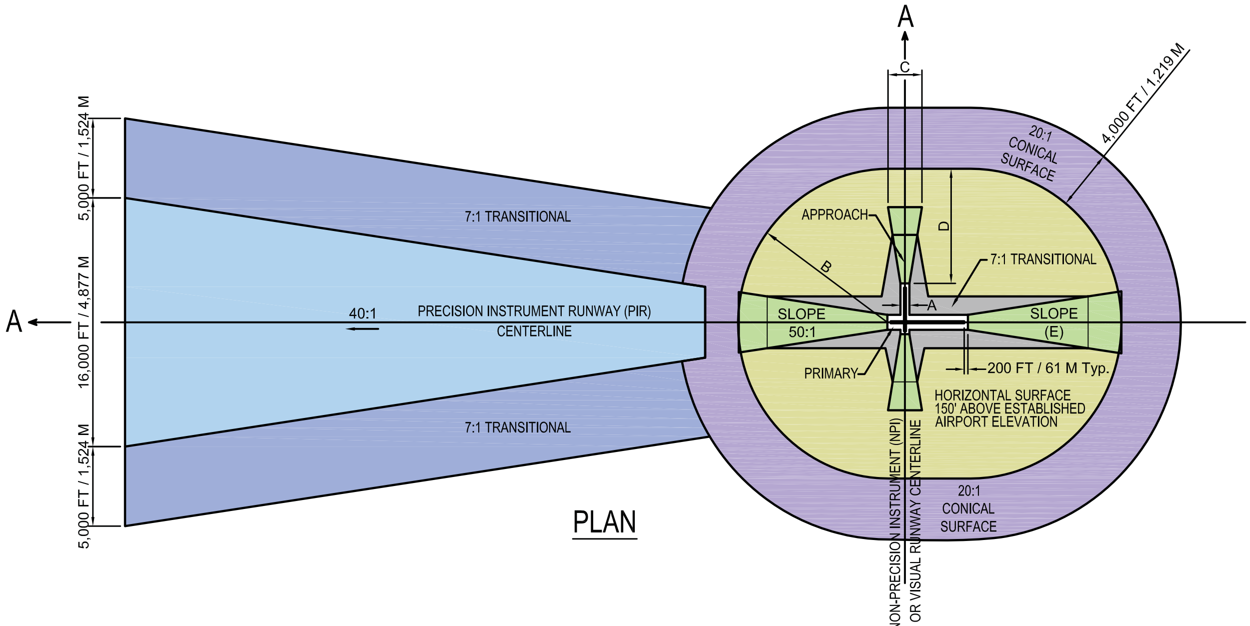
Approach Surface. An approach surface is also established for each runway end. The approach surface has the same inner width as the primary surface and then flares out (gets wider) as it rises upward and outward along the extended runway centerline. The approach surface starts 200 feet beyond the runway ends. The slope of the rise and the length of the approach surface are dictated by the type of approach available to the runway (20:1 approach slope for visual, 34:1 approach slope for non-precision, or 50:1 approach slope for precision). The length of each approach surface is depicted in the data table shown in Figure V-1.

Transitional Surface. Each runway has a transitional surface that begins at the outside edge of the primary surface and at the same elevation as the runway centerline. There are three transitional surfaces. The first is off the sides of the primary surface; the second is off the sides of the approach surface; and the third is outside the conical surface and pertains to precision runways only. The transitional surface rises at a slope of 1 foot vertically for each 7 feet of horizontal distance (7:1) up to a height that is 150 feet above the published airport elevation.

Horizontal Surface. The horizontal surface is established at 150 feet above the published airport elevation (mean sea level). This surface is composed of swinging arcs of radii (5,000 feet in length for utility/visual runway and 10,000 feet in length for all other runways), beginning at the edge of the primary surface.

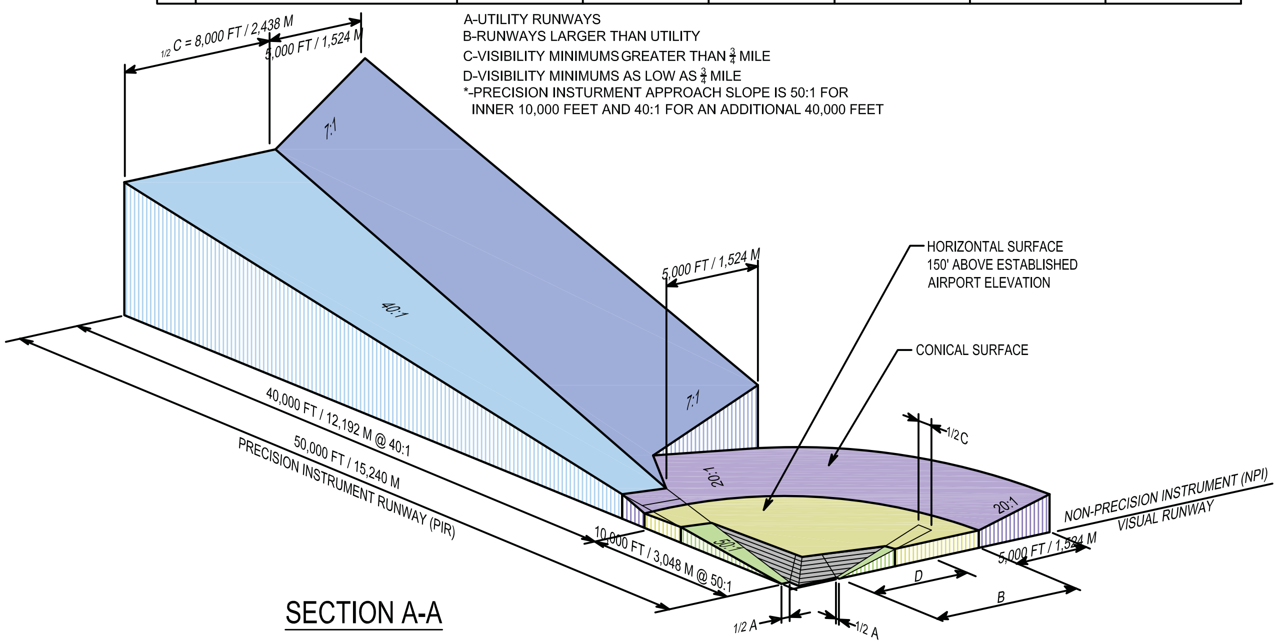
Conical Surface. The conical surface begins at the outer edge of the horizontal surface. The conical surface continues for a distance of 4,000 feet horizontally at a slope of 1 foot vertically for each 20 feet of horizontal distance (20:1).

All obstructions to the Part 77 imaginary surfaces should be identified and should be either removed or lowered so that obstruction height is below these surfaces. In some cases, it may be



DIM	ITEM	DIMENSIONAL STANDARDS					
		VISUAL RUNWAY		NON-PRECISION INSTRUMENT RUNWAY			PRECISION INSTRUMENT RUNWAY
		A	B	A	B		
					C	D	
A	WIDTH OF PRIMARY SURFACE AND APPROACH SURFACE WIDTH AT INNER END	250 FT / 76 M	500 FT / 152 M	500 FT / 152 M	500 FT / 152 M	1,000 FT / 305 M	1,000 FT / 305 M
B	RADIUS OF HORIZONTAL SURFACE	5,000 FT / 1,524 M	5,000 FT / 1,524 M	5,000 FT / 1,524 M	10,000 FT / 3,048 M	10,000 FT / 3,048 M	10,000 FT / 3,048 M
		VISUAL APPROACH		NON-PRECISION INSTRUMENT APPROACH			PRECISION INSTRUMENT RUNWAY
		A	B	A	B		
					C	D	
C	APPROACH SURFACE WIDTH AT END	1,250 FT / 381 M	1,500 FT / 457 M	2,000 FT / 610 M	3,500 FT / 1,067 M	4,000 FT / 1,219 M	16,000 FT / 4,877 M
D	APPROACH SURFACE LENGTH	5,000 FT / 1,524 M	5,000 FT / 1,524 M	5,000 FT / 1,524 M	10,000 FT / 3,048 M	10,000 FT / 3,048 M	*
E	APPROACH SLOPE	20:1	20:1	20:1	34:1	34:1	*

A-UTILITY RUNWAYS
B-RUNWAYS LARGER THAN UTILITY
C-VISIBILITY MINIMUMS GREATER THAN $\frac{3}{4}$ MILE
D-VISIBILITY MINIMUMS AS LOW AS $\frac{3}{4}$ MILE
*-PRECISION INSTURMENT APPROACH SLOPE IS 50:1 FOR INNER 10,000 FEET AND 40:1 FOR AN ADDITIONAL 40,000 FEET



Source: CFR, Title 14, Part 77 – Objects Affecting Navigable Airspace.

Figure V-1. FAR Part 77 imaginary surfaces.

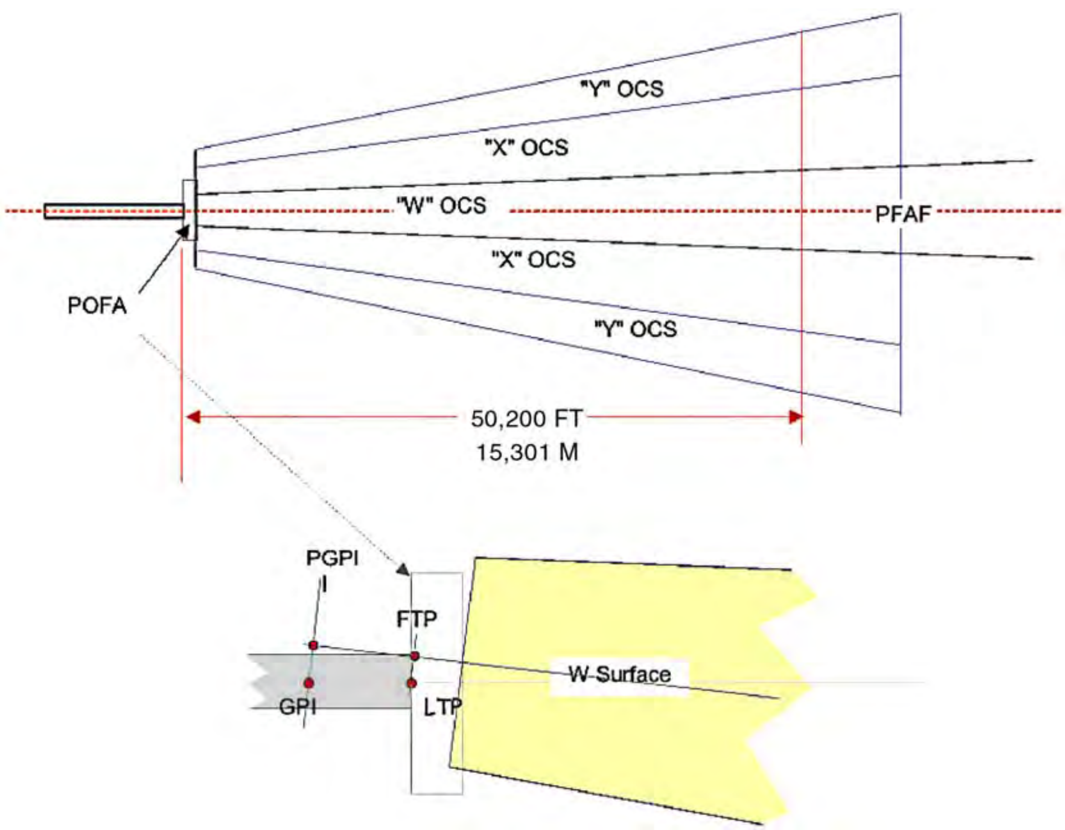
appropriate to mark and light the obstruction in accordance with FAA AC 70/7460-1 (*18*). This form can be downloaded and submitted electronically to the appropriate FAA Regional Office. Each obstruction must be reviewed by the FAA to determine if it constitutes a potential hazard to air navigation and, if so, to identify which course of action is appropriate. If removal, relocation, or lowering the height of an obstruction is not feasible, runway thresholds may need to be displaced or adjustments to the glidepath angle and threshold crossing height may be necessary. The guidelines for altering the latter, and the maximum and minimum values that are relevant, are located in FAA Order 8260.3B (*10*).

V.1.1.2 TERPS Surfaces

The U.S. Standard for TERPS criteria formulate, review, approve, and publish procedures for instrument flight operations at airports. For the purposes of this chapter, only the precision final approach and departure segment surfaces for obstacle identification purposes will be discussed.

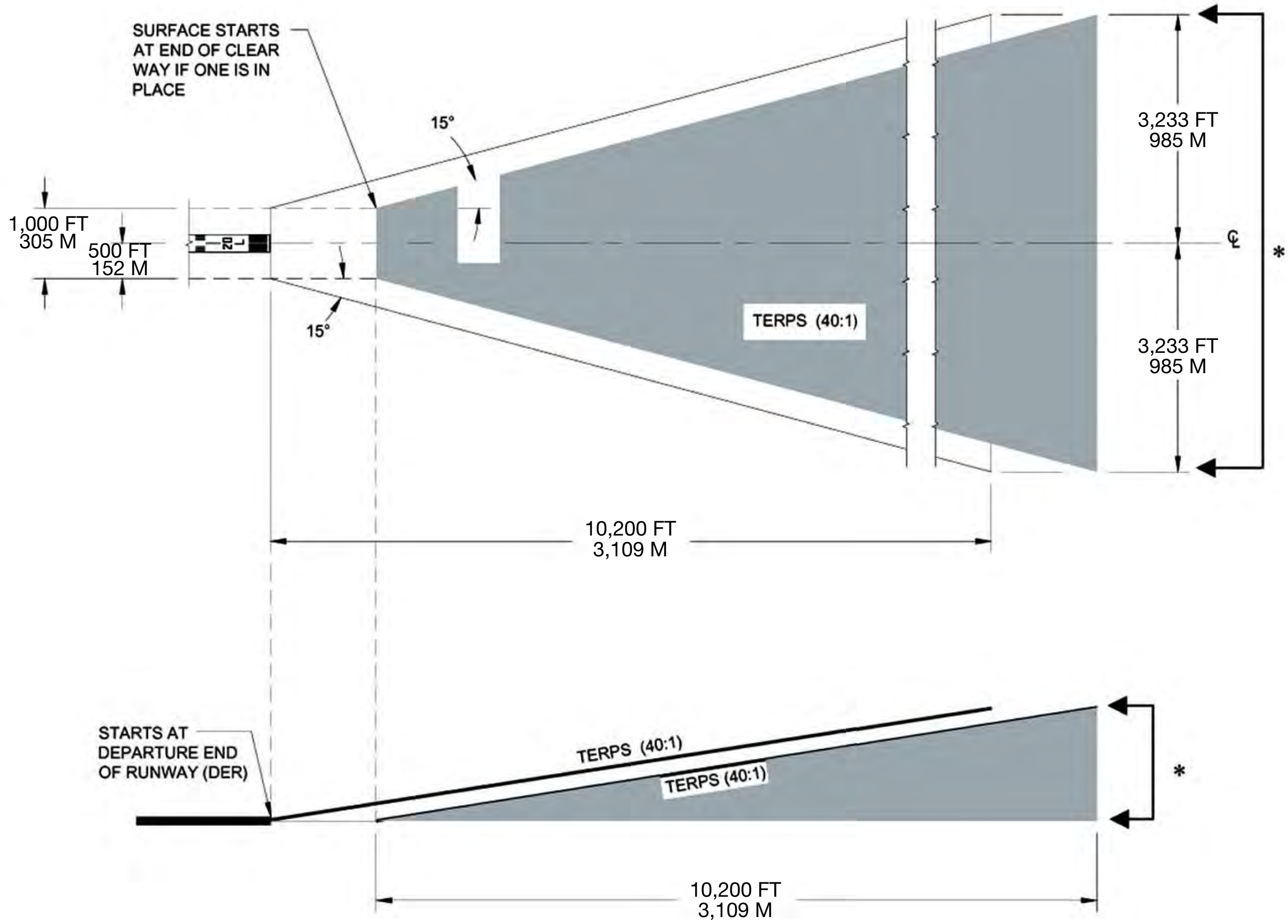
The TERPS final approach surface is divided into two areas: primary and secondary. For precision instrument approaches, the primary area consists of the "W" and "X" obstacle clearance surfaces (OCS), and the secondary area contains the "Y" OCS, as shown in Figure V-2. In addition, there are primary and secondary TERPS departure surfaces for the evaluation of obstacles during takeoff operations as shown in Figure V-3.

Final Approach Surfaces. The TERPS final approach surface begins at 200 feet from the landing threshold point (LTP) or fictitious threshold point (FTP) and ends at the precision final approach fix. The "W," "X," and "Y" surfaces cohesively define the total approach surface, with the "W" OCS running down the extended runway centerline, the "X" OCS flanking the "W" OCS,



Source: FAA Order 8260.3B, U.S. Standard for Terminal Instrument Procedures (TERPS)

Figure V-2. TERPS approach surfaces.



Source: FAA Order 8260.3B, U.S. Standard for Terminal Instrument Procedures (TERPS)

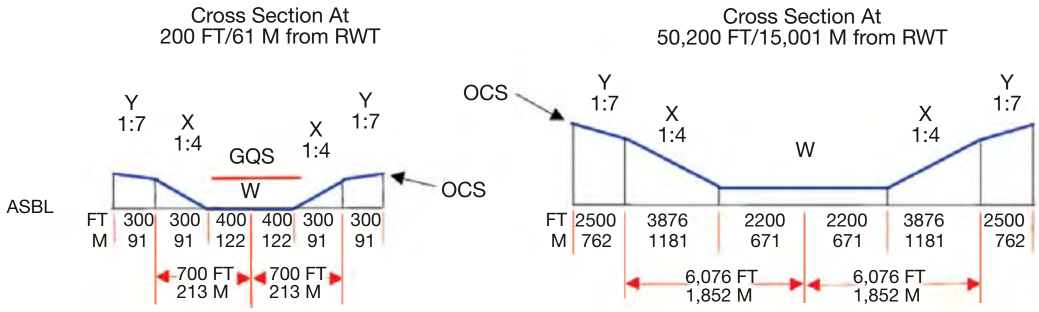
Figure V-3. TERPS departure surfaces.

and the "Y" OCS occurring on the sides of the "X" OCS and making up the exterior of the TERPS approach surface. A cross section of these surfaces is shown in Figure V-4.

Primary Area ("W" and "X" OCS). The "W" OCS maintains a 34:1 slope and has a width of 400 feet (200 feet on each side of the runway centerline) at the beginning of the TERPS approach surface. The surface expands until it reaches a width of 2,200 feet at a distance of 50,200 feet from the LTP or FTP. The "X" OCS runs along both sides of the "W" OCS and has a width of 300 feet on each side. It extends out 50,200 feet at a slope of 4:1 and perpendicular to the final approach course where the dimensions eventually equate to 3,876 feet on each side of the surface.

Secondary Area ("Y" OCS). The secondary area of the TERPS approach surface occurs on each side of the "X" OCS and exists as the outer OCS for the TERPS approach surface. Each side of the "Y" OCS starts as 300 feet wide and extends out 50,200 feet at a slope of 7:1 in a direction perpendicular to the final approach path where the OCS ends at 2,500 feet at both sides.

Departure Surfaces. The departure surfaces for TERPS begin at the departure end of the runway, or the end of the runway opposite the landing threshold. It has an inner width of 1,000 feet and splays outward at a rate of 10° relative to the departure course for a distance of two nautical



Source: FAA Order 8260.3B, U.S. Standard for Terminal Instrument Procedures (TERPS)

Figure V-4. Cross section of TERPS surfaces.

miles. The primary area OCS slope occurs at 40:1, and the secondary area (only applicable when positive course guidance systems are identified) has a 12:1 slope.

V.1.2 Aircraft Maneuvering and Separations

When planning passenger terminal configurations and their adjacent aprons, it is important to consider the maneuvering patterns and paths of the aircraft that the facility will serve. These considerations are based mainly on the role the airport intends to play. For example, aircraft type, terminal configuration, number of gates, and configuration of the runways all greatly affect the way aircraft maneuver and operate on and around the terminal apron area.

V.1.2.1 Dual vs. Single Apron Taxiways/Taxilanes

A major concern for airports with a large number of gates is maintaining an uninterrupted taxi flow both to and from the aircraft gates. This flow can be accomplished through the use of two or more parallel taxiways/taxilanes. Dual parallel taxiways/taxilanes enable one or more aircraft to be pushed back or taxi in one direction, while aircraft are moving in the opposite direction on the parallel taxiway/taxilane. Dual parallel taxiways/taxilanes provide for increased flexibility in accessing the terminal gates during peak operating periods.

V.1.2.2 Taxiway and Taxilane Separations

A taxiway is a defined path established for the taxiing of aircraft from one part of an airport to another. A taxilane is a portion of the aircraft parking area used for access between taxiways and aircraft parking positions. Aircraft taxi speeds on a taxilane are less than that on a taxiway. Taxiways are part of the airport's movement area controlled by the FAA ATCT while taxilanes are considered non-movement areas and generally not controlled by the ATCT.

When planning for parallel taxiways/taxilanes, it is important to ensure that there is adequate separation between centerlines to accommodate the appropriate design aircraft based on the aviation demand forecast. The airfield components should be designed using either the FAA or ICAO current guidelines as shown in Table V-1 and Table V-2 for the specific airplane design groups. The use of these planning standards will provide for adequate aircraft wingtip and obstacle clearance.

V.1.3 Air Traffic Control Tower Line-of-Sight

For the safety of aircraft operations, the ATCT must have a clear line-of-sight to all movement areas (runways, taxiways, and ramps) on the airfield. This requirement will need to be considered during the terminal site analysis and design. The aircraft parking configuration and tail heights

Table V-1. FAA airplane design groups.

FAA Airplane Design Group	Maximum Wingspan Feet	Maximum Wingspan Meters	Typical Aircraft
I. Small Regional	49	15	Metro
II. Medium Regional	79	24	SF340/CRJ
III. Narrowbody/Lrg. Regional	118	36	A320/B737/DHC8/E175
IIIa. B757(winglets)	135	41	B757
IV. Widebody	171	52	B767/MD11
V. Jumbo	214	65	B747,777,787/A330,340
VI. Super Jumbo	262	80	A380/B747-8

Note: The FAA considers all B757 aircraft as part of ADG IV. However, for gate and holdroom planning purposes, the B757 has more characteristics in common with AGD III aircraft than the rest of the widebody aircraft in ADG IV.
Source: FAA AC 150/5300, Change 12, ICAO Annex 14

will also need to be considered because they can result in line-of-sight shadows from the ATCT. The controller must be able, at a minimum, to see the fuselage of all aircraft operating on the airfield.

In addition, it is desirable to have a clear line-of-sight from the ramp tower(s) to view the aircraft entering the terminal apron area and progressing to their gate position. The ramp controller should at least be able to maintain visual contact with the tail of the aircraft within the ramp area. The strategic positioning of video cameras at the gate area and around the terminal apron can support these requirements. Where there is no ramp tower present, it is important for the ATC to have a clear view of all aircraft ramp areas.

V.1.4 Emergency Equipment Access Roads

To achieve the recommended response time for emergency equipment access to the aircraft gate area, a number of design variables should be analyzed. The width and vertical clearance of the emergency access roadway should allow for the largest emergency vehicle deployed to clear any obstacle. When the surface of the road is indistinguishable from the surrounding area, or in areas where snow may obscure the location of the roads, edge markers should be placed at adequate intervals to provide visual reference. The emergency access road should be designed to have as few turns as possible. The turning radii must be designed to allow emergency equipment to safely

Table V-2. Taxiway/taxilane separation standards.

ITEM	FAA ADG (FT)						ICAO ARC ELEMENT 2 (M)					
	I	II	III	IV	V	VI	A	B	C	D	E	F
Taxiway Centerline to: **Parallel Taxiway/ Taxilane Centerline**	69	105	152	215	267	324	23.7	33.5	44	66.5	80	97.5
Fixed or Movable Object	44.5	65.5	93	129.5	160	193	16.2	21.5	26	40.5	47.5	57.5
Taxilane Centerline to: **Parallel Taxilane Centerline**	64	97	140	198	245	298	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Fixed or Movable Object	39.5	57.5	81	112.5	138	167	12	16.5	25.5	36	42.5	50.5

Source: FAA AC 150/5300, Change 12, ICAO Annex 14 maneuver through turns. Adequate separation between aircraft wingtips should be provided to allow vehicle access to all aircraft gate/stand positions and the terminal building. In addition, adequate staging areas should be provided at various points along the terminal to provide space for emergency vehicles so they do not block aircraft gate positions for an extended period.

V.1.5 Airside Security

For purposes of this airside security overview, the airside of an airport consists of all those parts of the airport that are not open to access by persons other than those who have been screened and duly authorized to enter those areas. In most airports, the airside also consists of those parts of the terminal that can only be accessed by passengers and staff that have passed through a security screening process, and all parts of the airfield and structures that have direct access to the airfield. Table V-3 provides an overview of the various areas of concern that are involved in securing the airport's airside operation.

As is apparent from Table V-3, a principal technology used in securing these diverse functional areas of the airport's airside is video analytics, which is video imagery technology combined with a computer program. Video imagery technology allows security personnel to monitor numerous areas simultaneously, covering the vast distances associated with the numerous and diverse locations of these security areas of concern.

Video analytics is simply a sophisticated computer program integrated with the closed circuit television (CCTV) camera system that can be programmed to respond to very specific types of movements or events within its field of vision. At an airport with hundreds of cameras, it is not possible for an operator to give equal attention to all of them; therefore, the analytics program is tuned to watch everything but to respond primarily to anomalies. This is a significant labor-saving "force multiplier," which allows the operator to focus only on those areas where something out of the ordinary is occurring and to initiate law enforcement and other asset response only where necessary.

Table V-3. Overview of threat and principal technology used in areas of concern at an airport.

Areas of Concern	Threat	Principal Technology
1. AOA/outer perimeter boundaries	Unauthorized access Persons and vehicles Anomalous behavior, at and beyond perimeter	Multi-sensor, including Video Analytics
2. Vehicle access gates	Unauthorized access Persons and vehicles	Video Analytics Access Control
3. Employee access portals	Unauthorized access Persons	Video Analytics Access Control
4. Terminal lobbies and external access to AOA	Unauthorized articles, Improvised explosive devices (IEDs)	Video Analytics
5. Terminal roadways	Vehicle-borne IEDs	Video Analytics Access Control
6. Passenger screening checkpoints	Security breaches Exit lane	Video Analytics

Source: TranSecure

Video analytics however carries a very important caveat. The mathematical algorithms are complex, and very specific; they are written to address a specific concern at a given location within certain parameters. For example, the analytics of one camera may be watching a particular segment of fence line, masking certain backgrounds and peripheral motion, creating narrowly defined virtual zone lines as “trip wires” for pedestrian intrusions in one direction but not others. That series of algorithms will not work for a surveillance camera used at a vehicle gate to differentiate among large and small vehicles with different physical characteristics traveling at different speeds and directions or for an indoor camera watching for congestion, abandoned bags, or piggy-backing and may not work at all at night or when weather or lighting conditions are less than optimal.

Further, as the initial sets of rules are established for monitoring “normal” conditions, however those might be defined, there will also be changes in threat conditions, issuance of new TSA Security Directives, and other modifications of what and where to look for anomalies. All of these occasions will require changes in the algorithms that define alerts and alarms and, equally important, changes in the response procedures for the operator and law enforcement responders, both in volume of alerts and where resources must be directed. These changes cannot be made by “on-off” switches at the security operations center (SOC); they are re-programming concerns to be addressed in the initial procurement process and during the establishment of the baseline operating rules.

Although the outer air operations area (AOA) portions of the perimeter may be long fence lines surrounding remote facilities that are well removed from commercial passenger activity, other security areas of concern are at the center of such activity. Whether in a single- or multiple-terminal environment, the terminal and operational buildings themselves are also typically part of the close-in perimeter and become a key security concern both externally, where the fences meet the building walls, and internally, where physical and electronic boundaries separate the public landside from the secured operational airside. Other security areas of concern include employee and tenant access points, both inside and out; loading docks adjacent to roadways and vehicle and pedestrian gates; and the TSA screening checkpoint. To some degree, the public approach roads and curbside are also included, where vehicle-borne improvised explosive devices (VBIEDs) can approach unprotected public areas and persons as well as initiate breaches into the close-in terminal environment.

Although many of those elements extend beyond the scope of this terminal planning guidebook, each of them has an impact, not only on how the passenger terminal design will accommodate the security system, but also on the design of the underlying IT network. The IT network connects the security system and transmits data to and from every point on the system and ultimately to an SOC, typically in the terminal, which collects data and initiates responses to alerts and alarms.

The key point is that terminal security concerns cannot be isolated from the rest of the airport’s overall technology infrastructure; there must be a single integrated network that supports the key objectives of *detection, situational awareness,* and *domain awareness* as well as the communications and data retention and analysis capabilities necessary for immediate response to events.

Detection = Situational Awareness = Domain Awareness

- Detection is the ability to “see” virtually everything of interest that is happening in real time, whether by visual cues, electronic signals from sensors, or any other means of data collection and convergence that can identify events—or in some cases, a non-event, such as a left parcel or inappropriately parked vehicle. Detection is the necessary first step toward prevention, or at least mitigation before problems occur.
- Situational awareness is about identifying anomalies—which may or may not be security-related events. It is the ability to make sense of the accumulation of dynamic data by identifying,

categorizing, collating, organizing, analyzing, and prioritizing in the context of rapidly changing security environments.

- Domain awareness is the ability to see and understand one's total environment and to manage events—possibly multiple simultaneous events—as they continue to evolve. This ability requires not only the technology to accomplish that mission, but also the necessary motivation, training, and experience to utilize the technology to its best advantage.

Recent trends in networking technology and readily available low-cost and high-bandwidth communication links have nearly eliminated the concepts of time and distance in terms of sharing data and information. These trends have significant implications on an airport's surveillance and response needs, the centralized command and control capabilities to direct them, and the ability to establish the necessary infrastructure and operational upgrades to share data with multiple users.

The primary SOC where the information is collected, analyzed, and distributed can be housed anywhere, including the terminal, but the need for airport-wide infrastructure to support the security system remains constant, including in many cases, the need for a redundant backup SOC facility for emergency and incident response management. It should also be noted that the SOC may or may not be co-located with the day-to-day airport operations center (AOC) or the emergency operations facility. The three centers serve very different functions, although such space-sharing arrangements are not uncommon, particularly at smaller airports.

V.1.5.1 Security Terminology Definitions

TSA terminology for various security-related areas in an airport environment is not the same as the operational definitions of the FAA, the CBP, or other federal agencies. Further, TSA security concerns differ from those of local law enforcement issues such as vehicle traffic, parking lots, or common criminal activity such as theft or assault. Nonetheless, both have an impact on terminal planning and must be coordinated with TSA and relevant law enforcement agencies.

The TSA's generic regulatory terms for security areas are defined in §1540.5, and further refined in other subsections of regulatory language for secured areas (§1542.201), air operations areas (§1542.203), and security identification display areas (§1542.205). However, each airport's site-specific definitions, descriptions, and boundaries are found *only* in its written Airport Security Program (ASP); most airports have unique physical and operational characteristics that often blur the boundaries and transitions of some security areas. Generally, those areas can be described as follows:

- Terminal: The area fully accessible to the general public, with no screening or regulatory security constraints beyond perhaps general CCTV or law enforcement surveillance.
- Sterile area: The area *after* passengers have gone through the security screening checkpoint, including waiting areas and some concessions, up to the door(s) with controlled access to the loading bridge ("loading bridge" is the generic term; "Jetway" is a specific brand name) and/or doors to the ramp.
- Secured area: The most robustly protected of the regulatorily mandated areas, generally immediately outside the terminal where aircraft load and unload and service functions such as catering and fueling take place, and specifically including baggage make-up areas. There might be multiple secured areas where, for example, an airport has both main and remote terminals. Secured areas must have access control measures in place that meet TSA §1542.207 requirements and must meet various procedural requirements such as personnel background checks, ID display and challenge measures, and security training.
- Security ID display area (SIDA): Similar to a secured area, the SIDA relates *only* to ID display and challenge procedures. A SIDA does not require access controls and is not necessarily contiguous with a secured area; it may occur in physically separate areas, such as a fuel farm or

maintenance area, but is still within airport-protected boundaries such as the air operations area perimeter.
    - Note: Therefore, a secured area is always a SIDA (requiring ID display), but a SIDA is not necessarily a secured area (no access control requirement, although many do incorporate them as an extra measure).
- Air operations area: Similar to the FAA operational definition, the AOA is where aircraft maneuver, including runways, taxiways, ramps, etc. From a security perspective, its boundary is typically the perimeter fence, which will also have basic access controls; the distance and response time to the main concerns of the terminal and loading aircraft are typically deemed an adequate buffer zone for security purposes.
- Restricted area: TSA does not operationally or regulatorily define a restricted area at all, although many airports use the term in their ASP for such areas as cash rooms, communications closets, utility rooms, or other areas where there is a technical or procedural reason for restricted access but no *TSA-related* requirement to do so.
- Clear zone: Similarly, there is no regulatory security definition or requirement for a clear zone, although in the general context of best practices, it is typically seen as an obstacle-free cleared area of a few feet inside and/or outside a security fence line.

V.1.5.2 Vehicle and Pedestrian Gates and Portals

Although the design of each individual access point is usually very site specific, collectively they serve the same purpose: maintaining the integrity of the secured areas of an airport. They are typically tied to the integrated access control/CCTV surveillance system, so although they are often different in physical design, they must be consistent in their electronic characteristics to be of value in the airport-wide system and to operate within the policies and procedures of the Airport Security Program.

It is not the goal of this document to provide specific types of individual design; there are literally dozens of common and perfectly acceptable types of hardware and software—access control and ID badging systems, cameras, key locks, doors, and gates. Security specialists can assist the designer in specifying appropriate equipment, but the designer must first consider the types of traffic at each access point, and the levels of security necessary for each area, to bring about an optimum system design. For example, where a simple chain and padlock might suffice on a remote fence gate that is used only rarely by grass mowers, it is much more critical, and common, for high-throughput doors leading from public areas in and around the terminal into the secure areas where aircraft and service vehicles operate to have an electronic system that, by regulatory mandate (§1542.207), must be able to differentiate and allow entry only to those persons authorized for access to that area.

This introduces the relatively new topic of biometrics. With the traditional magnetic stripe or proximity access control card, one need only swipe the card or other token, and perhaps enter a personal identification number, to gain entry. Thus, the simple possession of a lost, stolen, or borrowed card might provide any holder with immediate access to the security areas. Biometrics adds the third element of one's own unique biometric identifier, such as a fingerprint or iris scan, so that only the authorized user can activate the system.

There is extensive new guidance available in *Integrated Security System Standard for Airport Access Control* (*31*). The document contains much more than standards and guidelines for airport security access control; it is a full systems approach to facility security including operational requirements, perimeter intrusion detection, video surveillance, access control with the stress on biometric user authentication, and responder communications. These standards present functional requirements and performance characteristics for use by designers, manufacturers, service providers, operators, and users of automated systems.

V.1.5.3 Planning for Vehicle Checkpoints

TSA regulations do not require airports to carry out a comprehensive security program in public areas well removed from the terminal(s) and outside of the secure areas. But any attack or civil disturbance at a domestic airport could be catastrophic, particularly at close-in points; therefore, some degree of planning for such possibilities is in order.

Attacks on the airsides of airports launched through vehicle access gates have been relatively rare events. A threat perpetrators' principal motivation could be to commandeer or destroy aircraft or to simply create damage and chaos.

Any common vehicle approaching the airport perimeter may constitute an anti-aircraft IED "Trojan Horse" and is a potential threat, because an IED capable of destroying an aircraft could have a volume of less than 12 fluid ounces (the volume of a soda can) and be in almost any imaginable shape. Mitigation of this threat requires an integrated perimeter security system designed to produce the maximum degree of deterrence, detection, and delay, in order to facilitate the most timely and effective response.

Mitigation becomes more difficult if it is judged necessary to also screen cleared employees at perimeter vehicle and personnel entrances before allowing them access to the secure area. In the framework of risk management, there is a disparity between screening known workers for weapons and IEDs (or their components) as they enter a secure area and ensuring that complex vehicles and their random occupants not be used to bring in the same objects.

The use of a well-planned airside vehicle security program is essential to the design and implementation of an integrated perimeter security system. Airport vehicle access gates are most often controlled by physical barriers and manned checkpoints monitored by CCTV. Today's typical fence-gate barriers have relatively low stopping capability, which presents a significant vulnerability. Main vehicle gates, particularly those adjacent to terminals, should consider a barrier capable of meeting the minimum threat of a 65,000 pound vehicle at 50 mph, producing kinetic energy of 5.5 million foot-pounds. (Estimate is based on a dump truck typically used during airport construction.)

Video technology options also apply to vehicle gate security. Radar may assist in following identified targets within the perimeter to some degree but does not provide actionable imagery of vehicles or persons in a high-clutter environment.

Measures that apply generally to unmanned gates include strategically placed bollards or remotely operated pop-up barriers as well as dedicated CCTV and analytics software for assessment of activity. For certain gates requiring a higher level of control for vehicle passage, either physical or virtual sally port designs should be considered. Sally ports are designed so that only one of the paired gates can be open at a time. The space between the gates must be sufficient to accommodate the largest semi-trailers allowed to enter at that portal. Manned guard posts are recommended to have a protected guard booth with a full range of security communications and CCTV monitoring capabilities, as well as computer network access for validating credentials.

CCTV cameras, enhanced with video analytic functions, are an excellent means of virtually assessing vehicle passage through gates. Video analytic programming may change with the TSA threat levels and can include related video functions such as optical character recognition (OCR) of vehicle license plates for verification or under-vehicle inspection. The guard booth itself should be inside the fence or other barriers; CCTV will monitor both vehicle and personnel loitering, and can be used in the sally port example above to confirm that authorized vehicles remain in place until the gate has closed.

Note that while many of these items are procedural and technology oriented, their success still derives from the initial planning and design decisions that determine their location and their operational and infrastructure capabilities. In addition to technology options, additional operational items to be considered during the terminal design include the following:

- Reduce the number of vehicles that require airside access. In some design scenarios, that could mean leaving receiving docks and marshaling areas outside the perimeter.
- Minimize access points where goods and concessions will be delivered. Consider redesign or moving primary point of concession acceptance to low-traffic areas.
- Integrate the airport vehicle permit program with managed biometric ID systems, to validate both the vehicle and driver. This higher degree of confidence may allow the design of close-in access points.
- Implement full communications capabilities at all manned vehicle gates for contact with the SOC and primary first responders.
- Create pedestrian access portals at vehicle gates with appropriate CCTV surveillance and biometric authentication capability.

This discussion leans primarily on procedural solutions. No physical system, gate, camera, perimeter fence, lock, or any other component or system is "the" sole answer; all are entirely dependent on not only the whole of the physical system design and placement and the IT infrastructure that supports it but also the strength of the policies and procedures surrounding their implementation.

V.1.5.4 Apron Areas

Once a person is inside the controlled doors and gates, security on the ramp is almost exclusively procedural, depending largely on the willingness and capability of the employee community to remain aware of the persons and operations around them and to remain vigilant regarding ID badges or unusual behavior, while also performing their own responsibilities. Some technology assistance is available, such as CCTV and video analytics that can maintain watch over persons and equipment crossing virtual alert lines, although that is the very nature of most work on the apron and may be difficult to monitor effectively.

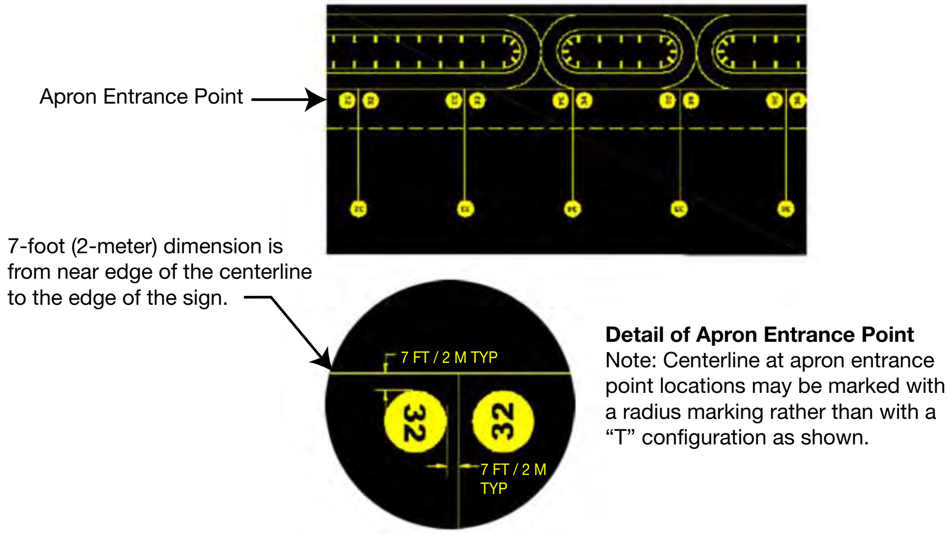
Technology might also be employed to limit vehicles on the airside to pre-approved equipment with ignitions operated only by biometrically enrolled drivers. In the context of terminal design, however, perhaps the most consistently effective approach is a strong biometrically enabled access control system and CCTV surveillance at the portals (along with accompanying procedures), so that the ramp population is rarely infiltrated in the first place. After successful entry, employee vigilance is the best preventive measure.

V.1.6 Aircraft Apron/Gate Access Points

Aircraft access the terminal gates via the taxiway and taxilane system. The positioning of these taxi access points can vary based on the terminal and airfield configurations. In some cases it is helpful for the pilots to utilize gate access points for direction to and from the apron area. Aircraft access points to the terminal gate area will generally appear as the aircraft transits through the taxiway entrance onto the apron, while indicators for gate access points will be located on the taxilanes within the terminal apron.

Apron entrance pavement markings are placed to provide pilots with visual direction toward the terminal and gate areas. They can also assist pilots in finding their position on the apron, which can be difficult to pinpoint when long distances separate terminals and taxiway access points. The location for these types of markings occurs approximately 7 feet from the taxiway centerline on the side the aircraft will be turning toward the apron. Figure V-5 illustrates such markings.

Specific gate access points appear in the form of pavement markings that indicate gate identification signs and are highly beneficial in times of low visibility on the airfield. Painted gate



Source: FAA Advisory Circular 150/5340-1J

Figure V-5. Surface painted apron signs.

identification signs can be placed in close proximity of terminal buildings and are located alongside taxiway centerlines on the side that the aircraft should turn toward the gate. These markings may display one or more rows of gate designations, such as a range of gates located in a particular direction or area.

V.1.7 Aircraft Deicing

There are two general forms of aircraft deicing: decentralized deicing and centralized deicing. Decentralized deicing usually takes place at the aircraft's gate before push-back. While this form of deicing does not require the construction of a dedicated deicing apron, collection of spent deicing fluids is required and needs to be taken into account when planning the apron drainage collection system. One potential concern with deicing at the terminal gate is the increased holdover time between application of the deicing fluids and taxiing to the runway end for departure. The taxi time between the gate and departure will need to be considered because of the amount of time that glycol will prevent ice from forming on the aircraft surfaces (approximately 10 to 15 minutes depending on weather conditions).

Centralized deicing usually requires the construction of a dedicated deicing apron, which can be located just outside the terminal gate area or close to the runway departure ends. Some advantages of a centralized deicing operation include maintaining better control of collecting spent deicing fluids, freeing up the gate area for arrivals, reducing taxi distance to the departure runway ends, minimizing vehicular traffic in the gate area, minimizing the need for secondary deicing, and providing for a common-use deicing operation.

In some cases it may be appropriate to provide remote deicing facilities located near departure runway ends or along taxiways when taxiing times from terminals or other centralized deicing facilities exceed holdover times. In this condition it will be important to ensure that the aircraft and mobile deicer boom heights are not in violation of the Part 77 imaginary surfaces.

V.1.8 Electronic Interference

During development of the terminal building and aircraft parking apron areas, it is advisable to determine if these proposed terminal facilities will interfere with any existing or future ground navigational aid (glide slope, localizer, DVOR/DME, etc.) and airport surveillance radar (ASR) facilities. It will be necessary to use computer modeling to analyze these potential impacts.

V.2 Terminal Apron Planning Criteria

Planning criteria for the terminal apron, combined with the analysis of aircraft gate requirements, drive the general configuration and the area required for the airside component of the terminal complex. These criteria cover the following:

- Aircraft gates and parking positions
- Aircraft gate wingtip clearances
- Aircraft parking guidance systems
- Apron gradients
- Blast fences
- Apron service roads
- Aircraft servicing
- Ground service equipment storage
- Apron lighting
- Apron snow removal

V.2.1 Aircraft Gates and Parking Positions

The aircraft gate/stand is a designated area intended for parking an aircraft so that passengers and cargo can be loaded and unloaded. For simplicity the term "gate" will be used. The gate is the interface between passenger and aircraft flow. This section is devoted to discussing the multiple forms of aircraft gates/stands and the attributes that should be considered when planning these facilities.

V.2.1.1 Gate/Stand Capacity and Fleet Mix

When discussing airport capacity, there are two different forms of capacity: dynamic capacity (i.e., airfield capacity as it is related to the flow of aircraft on and around the airfield) and static capacity (i.e., gate capacity as related to the ability to accommodate aircraft). Gate capacity is defined as the maximum number of aircraft that a fixed number of gates can accommodate during a specified interval of time (typically 1 hour). Gate capacity is affected by a number of factors including but not limited to the following:

- The number and type of gates available
- The fleet mix demanding apron and gate space
- The use of passenger loading bridges or ground passenger loading
- Any operating restrictions on the use of any or all gates

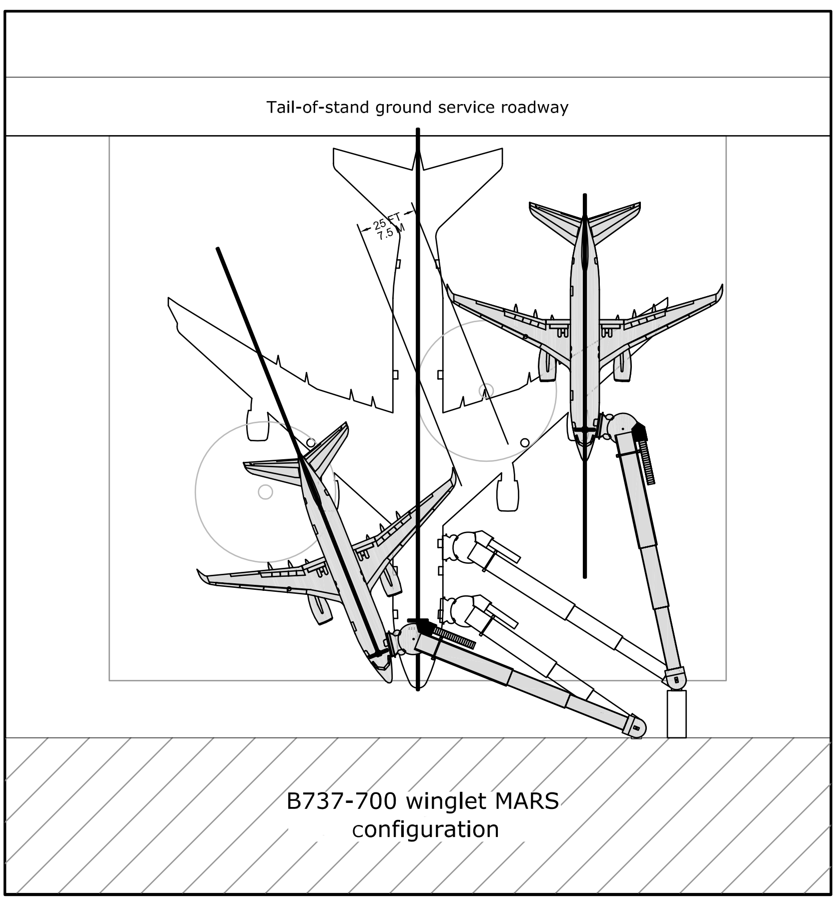
The nomenclature "gate" is typically associated with an aircraft parking position situated at a terminal building and is often referred to as a "contact" gate. Aircraft parked remotely from a terminal building on an apron area reached by a bus operation is frequently referred to, particularly outside of the United States, as "remote stand" or "stand." Consistently using this set of nomenclature assists in differentiating the location and functional capability of a particular aircraft parking position.

From a macro prospective, gates and stands are sometimes referenced by one of three broad aircraft size categories: widebody, narrowbody, and commuter or regional. A reference to widebody aircraft typically includes ADG IV–Widebody, ADG V–Jumbo, and ADG VI–Super Jumbo from the FAA AC 150/5300-13. In essence this includes all aircraft that have two aisles with the exception of the B757, which has a wingspan that falls into ADG IV but only contains a single aisle. The term narrowbody includes ADG III aircraft. The term regional includes the FAA's large and small commuter/regional categories of ADG I and II, respectively.

To maximize gate capacity, it is recommended to plan gates so that they are as flexible as possible. Various arrangements are used both in the United States and overseas to accomplish this goal. The IATA *Airport Development Reference Manual* shows one approach referred to as the Multi-Aircraft Ramp System (MARS). Figure V-6 depicts the basic MARS configuration adapted to include a tail-of-stand ground service roadway as opposed to the head-of-stand road typically used at most overseas airports. MARS is a modular approach that allows two narrowbody aircraft to operate independently within the same footprint area of typically a Jumbo or Super Jumbo utilizing the same two loading bridges to serve all three aircraft positions.

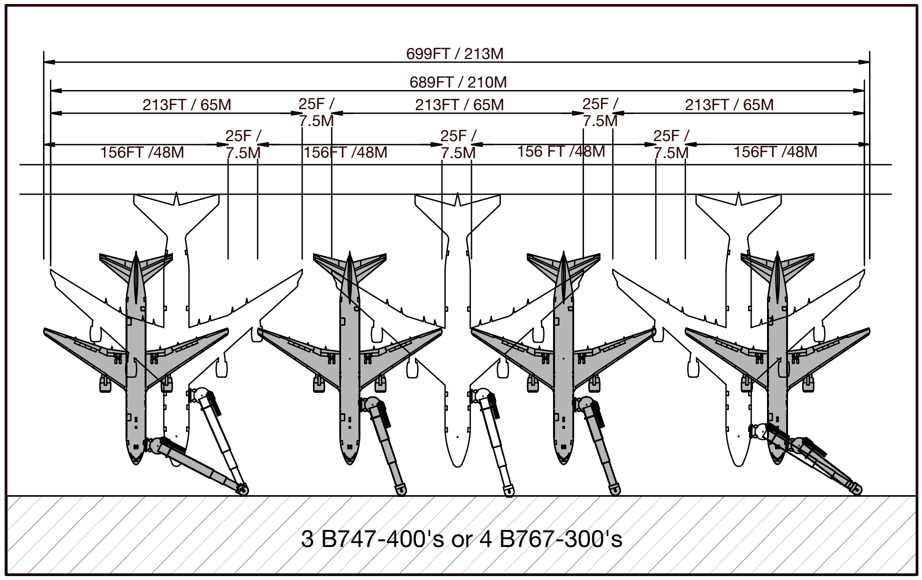
Another approach for optimizing gate flexibility is show in Figure V-7. This configuration is similar to the MARS but is not based around a specific aircraft module with service roads in-between. In the example shown in Figure V-7, gate use flexibility is achieved by parking multiple types of aircraft along the same flightline of the building with different lead-in lines per aircraft type, serviced by appropriately situated loading bridges. While obtaining a slightly higher density of aircraft along a comparable MARS wingspan frontage, this approach does require more loading bridges to achieve its flexibility of use.

An operational approach for optimizing gate/stand capacity is to maximize flexibility by preventing operational or airline preferential restrictions on gate usage. Reserving gates/stands for specific airlines or aircraft types can cause major capacity limitations because certain gates are not used to optimize the number of aircraft turns (an arrival or departure) that could be accommodated



Source: IATA *Airport Development Reference Manual*, 9th Edition, Jan 2004; modified for U.S. equivalent by Landrum & Brown

Figure V-6. Example of MARS with widebody aircraft.



Source: Landrum & Brown

Figure V-7. Aircraft parking flexibility.

during the period of the day. Common-use aircraft gates are another means to maximize gate capacity.

V.2.2 Aircraft Gate Wingtip Clearances

Minimum wingtip clearances will vary by ADG or ICAO code. Table V-4 presents the current planning criteria contained in FAA AC 150/5 and ICAO Annex 14 (*32*) when planning for gate wingtip clearances. These requirements are considered to be minimal. Most airports will require wider separation for ADG II and III, typically 20 and 25 feet, respectively. Additionally, it is important to consult with the planned airline/tenant of the terminal facility because many airlines have their own wingtip separation requirements that are different from those recommended by the FAA or ICAO.

V.2.3 Aircraft Parking Guidance Systems

V.2.3.1 Visual Docking Guidance System

A visual docking guidance system should be provided when it is intended to indicate, by a visual aid, the precise positioning of an aircraft on an aircraft gate/stand and when other alternative means, such as wing walkers, are not practicable.

Table V-4. Aircraft gate wingtip clearances.

FAA AIRPLANE DESIGN GROUP	ICAO AIRCRAFT CODE LETTER	WINGTIP CLEARANCE (FT/M)
I	A	10 / 3
II	B	10 / 3
III	C	15 / 4.5
IV	D	25 / 7.5
V	E	25 / 7.5
VI	F	25 / 7.5

Source: FAA Advisory Circular 150/5 and ICAO Annex 14

Several factors need to be considered when evaluating the need for a visual docking guidance system. Those factors include the number and type of aircraft using the aircraft gate/stand, weather conditions, the available space on the apron, and the degree of precision required for maneuvering due to aircraft servicing installations, passenger loading bridges, and other obstacles. Design requirements for a visual docking system include both azimuth and stop guidance displays.

Various types of visual docking systems can satisfy the operational requirements and specifications. Figure V-8 illustrates a visual docking guidance system that uses a graphical display and laser-based sensors to provide azimuth guidance, distance to go, and stopping position.

V.2.4 Apron Pavement Design

Gradients on an apron should be sufficient to prevent accumulation of water or deicing fluids on the surface of the apron but should be kept as level as these requirements permit. As a general rule of thumb, for the ease of fueling, towing, aircraft taxiing, and the collection of excess deicing fluids, apron gradients should never exceed 1%. In areas where aircraft are being fueled, every effort should be made to keep the apron slope within 0.5%. However, local laws and ordinances should be consulted to ensure their requirements are also met.

At the beginning of the apron pavement design process, the *Airplane Characteristics for Airport Planning* manuals for the critical aircraft should be consulted. These manuals, produced by the aircraft manufacturer and available on its website in most instances, provide designers with the maximum loads exerted on single points of pavement based on aircraft landing gear configurations. Using this information, the pavement structure and load bearing strength can be determined by using the current version of FAA AC 150/5320-6 (*33*).

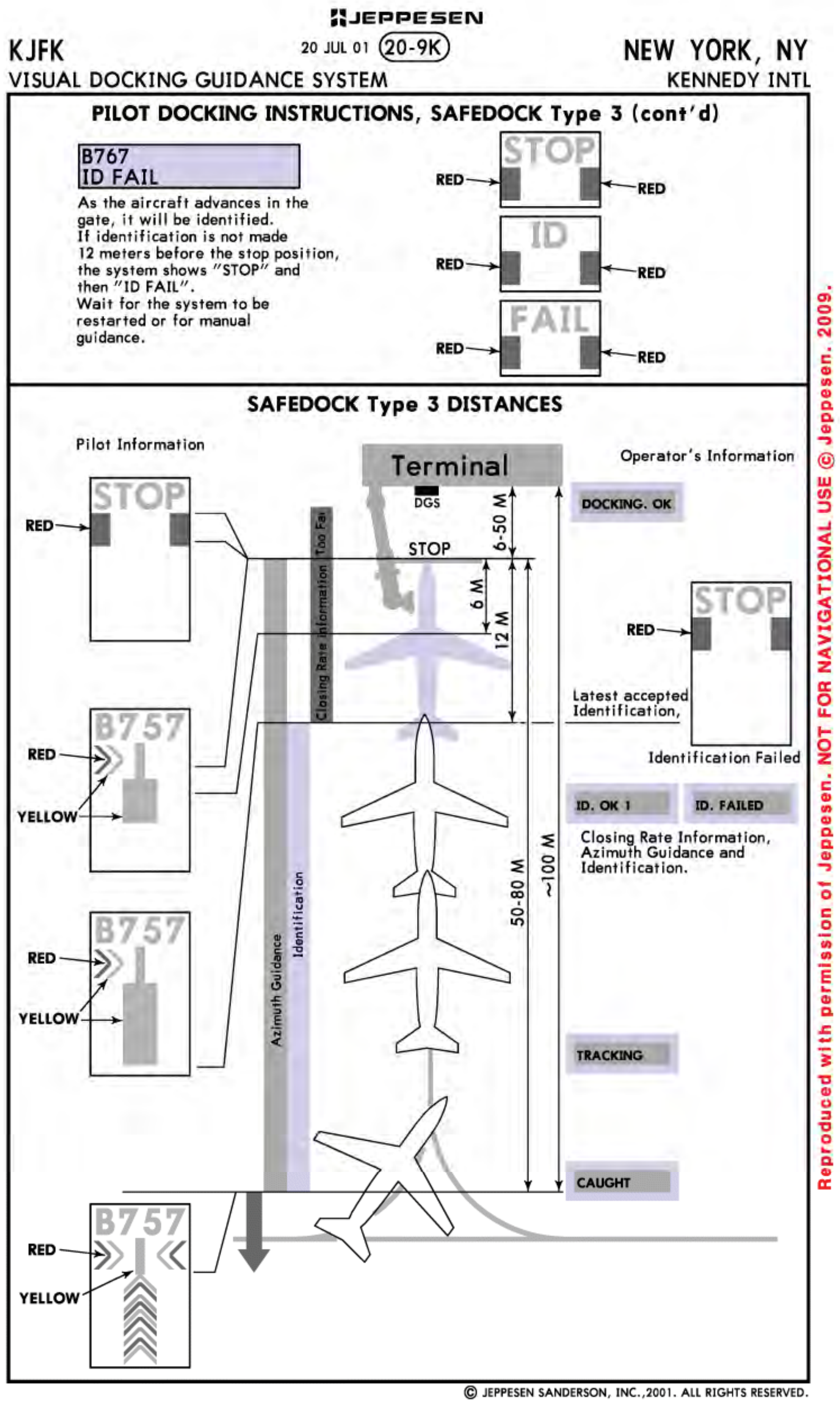
V.2.5 Blast Fences

The use of a blast fence may be necessary in order to mitigate the potential effects of aircraft engine jet blast at vulnerable parts of the airport. Blast fences are regularly used in terminal apron areas where aircraft routinely taxi within close proximity to the terminal, ground equipment, and ramp personnel. They can also be located near runway end areas, run-up pads, and other locations that require shielding of airport pedestrian or vehicular traffic. When possible, the blast fence should be located outside of the runway and taxiway object-free area and should not penetrate the obstacle-free zone surface. Additional consideration should be given to its location relative to navigational aid critical areas. Blast fences are typically constructed using metal or concrete barriers that can consist of perforated, corrugated, louvered, or smooth surfaces. In some cases, the blast fence should be located on frangible mounts if it is within close proximity of aircraft takeoff and landing operations. In addition to the use of blast fences, any natural or man-made surface (earth berm) positioned between the aircraft engine and protected areas can be considered for jet blast protection.

V.2.6 Apron Service Roads

There is a shared responsibility between the airport operator and airlines to reduce risks involving aircraft-to-vehicle and vehicle-to-vehicle conflict when regulating vehicular traffic movement on or around the airfield. When possible, designated service roads should be provided because they restrict service vehicle movements to a confined area and provide routes where aircraft pilots are familiar with seeing vehicular activity.

Factors to consider when designing service roads for accommodating existing and projected vehicular and GSE movement include space, sufficient bearing strength, height clearance, proper separation from runways and taxiways, and turning radii. In addition, secure access points need



Source: Jeppesen Sanderson, Inc., 2009

Figure V-8. Visual docking system.

to exist to prevent any unauthorized entrance from public or non-service vehicles to the area. Such points may consist of fencing, monitored gates, and/or manned entrances and would allow maintenance, fire and rescue, fuel, baggage, freight, and aircraft service vehicles access to the roads. If service roads pass beneath the terminal complex, access points to and from the service road and the terminal should be thoroughly secured as well.

The service road width depends on the anticipated level of traffic on the roads, and each lane of service roads should be of minimum width to accommodate the widest equipment used on the road. If service roads involve cargo operations, they should be able to support unit load device transporter equipment between cargo terminals and aircraft, and exclusive use of part of the roadway system may become necessary by some categories of vehicles, such as unusually wide or high vehicles.

As a minimum, the apron service road should have one lane in each direction with an overall width of 24 feet (12 feet each lane). In high-congestion areas it may be necessary to include a separate turn lane (12 feet wide) to provide vehicle-queuing and by-pass capability.

V.2.6.1 Configurations of Apron Service Roads

Three configurations exist for apron service roads, and they are identified based on location relevant to an aircraft's parked position: tail-of-stand/apron edge, head-of-stand, or between aircraft.

Tail-of-Stand/Apron Edge. Tail-of-stand service roads positioned behind aircraft, also known as apron edge service roads, are typically routed along the edge of the aircraft parking apron, outside of taxiway or taxilane clearance areas, and along the aircraft parking limit lines. With this type of service road, potential conflict between aircraft and vehicles can be an issue. If possible, additional clearance beyond the parking limit lines should be placed to protect aircraft from potential vehicle deviations on the service road. Clear markings are necessary to determine boundaries and to prevent impingement on apron taxiway/taxilane operations. Proper clearance should be defined and maintained from the rear of aircraft to the service road and on to the apron taxiway. Tail-of-stand service roads are beneficial for linear concourse pier terminals when airlines operate gates on both sides of the pier.

Head-of-Stand. Many large overseas airports that primarily service widebody aircraft tend to favor head-of-stand service roads located between the face of the terminal building and the aircraft parking and servicing area, because significant portions of operational servicing activity occur at the front of the aircraft. However, the main problem with head-of-stand service roads is clearance height issues for large vehicles that may need to pass under passenger loading bridges. A minimum height clearance of 14 feet (4.2 meters) for the road surface beneath loading bridges and terminal buildings is recommended per IATA standards. A head-of-stand road usually requires the addition of a fixed bridge section that spans over the service road from the terminal to a loading bridge pedestal. This additional distance of the head-of-stand roadway increases the total depth of the aircraft apron. Adequate room for pushback procedures should be planned to allow for aircraft tug maneuverability space that will not interfere with the service road and potentially cause congestion. Conflicts may also exist between these roads and GSE storage beneath the terminal building and apron-level door exits.

Between Aircraft Wingtips. These service roads usually occur in conjunction with tail-of-stand service roads and allow smaller size vehicles to pass under the terminal building and/or concourse instead of having to go around the entire face of the building. When roads are placed between aircraft, increased aircraft wingtip separation will be required to protect against aircraft damage in case of vehicle deviation from the service road.

V.2.6.2 Apron Safety Clearances

The required safety clearances on the apron vary greatly depending on the type of operations being conducted. Safety clearances ensure that aircraft can maneuver into/out of gate/stands without colliding with other aircraft, terminal facilities, ground service vehicles, and pedestrians or causing damage from jet blast. For example power-in/power-out gates/stands must be much larger and have their respective GSE kept farther away because of the turning radius of the wingtips and the jet blast associated with the power settings required for zero radius turns. Several procedures and enhancements can dramatically increase the effectiveness of these clearances:

- Gate/stand lead-in lines
- Nose-gear hold lines
- Apron safety lines
- Dedicated equipment areas
- Dedicated service vehicle road
- Use of wing-walkers during push-back procedures

V.2.6.3 Apron Markings

Ground Service Equipment Parking and Staging. The staging and parking is usually limited to the area between the apron safety line—which is painted in red—and either the head-of-stand service road configuration or the terminal building and tail-of-stand service road configuration.

Taxiway/Taxilane Centerline. Taxiway and taxilane centerlines provide a visual cue to the pilot to facilitate safe taxiing of the aircraft. The standard for taxiway/taxilane centerline marking is a solid yellow line that is equidistant from either edge of the pavement for taxiways and meets the required safety separation for taxilanes. The width/separation requirements, as well as turning radius requirements, can be found in either FAA AC 150/5300-13 (*15*) or ICAO Annex 14 (*32*).

Ground Vehicle Roadway Markings. When planning apron spaces, it is essential to delineate where ground vehicles are permitted to operate to prevent unnecessary interference with aircraft operations or passengers. This delineation can be accomplished through the use of ground vehicle markings on the apron pavement. The standards for ground vehicle roadway markings are either solid white lines or a white “zipper” marking for a low-visibility condition Surface Movement Guidance and Control System (SMGCS) to delineate the roadway edges. The roadway should be wide enough to accommodate the largest vehicle anticipated to be operating at the airport. An SMGCS provides guidance to, and control or regulation of, all aircraft, ground vehicles, and personnel on the movement area of an airport. SMGCS will be applied to all airports where scheduled air carriers are authorized to conduct operations when the visibility is less than 1,200 feet runway visual range.

Passenger Walkways. Passenger walkways should be provided on the apron area and if necessary across service roads. The walkways should be painted with white stripes across any active roadway surface. Passenger walkways should be clearly marked and designed to keep movement of passengers clear of hazards and confined within a specific area for security control and safety.

Aircraft Maneuvering. From time to time under certain apron conditions and locations, it is necessary for aircraft to perform non-standard maneuvers in the apron area. To assist pilots in completing these maneuvers, special paths for the taxiway/taxilane centerline or gate/stand lead-in line should be painted on the pavement. An example of this would be the marking of an aircraft push-back line that a tug would follow to ensure adequate clearances are maintained.

Aircraft Lead-in Lines. Another form of guidance to a specific aircraft parking position is the use of lead-in lines that help to guide the aircraft into the parking position from the apron taxilane. The exact location and geometry of the lead-in line is based on the type of aircraft that will be using the parking position. Gate parking positions may have multiple lead-in lines for specific aircraft types. Lead-in lines may require arrow heads to indicate the direction to be followed into the stand, nose-gear stop position, and aircraft type, along with the gate designation number or letter.

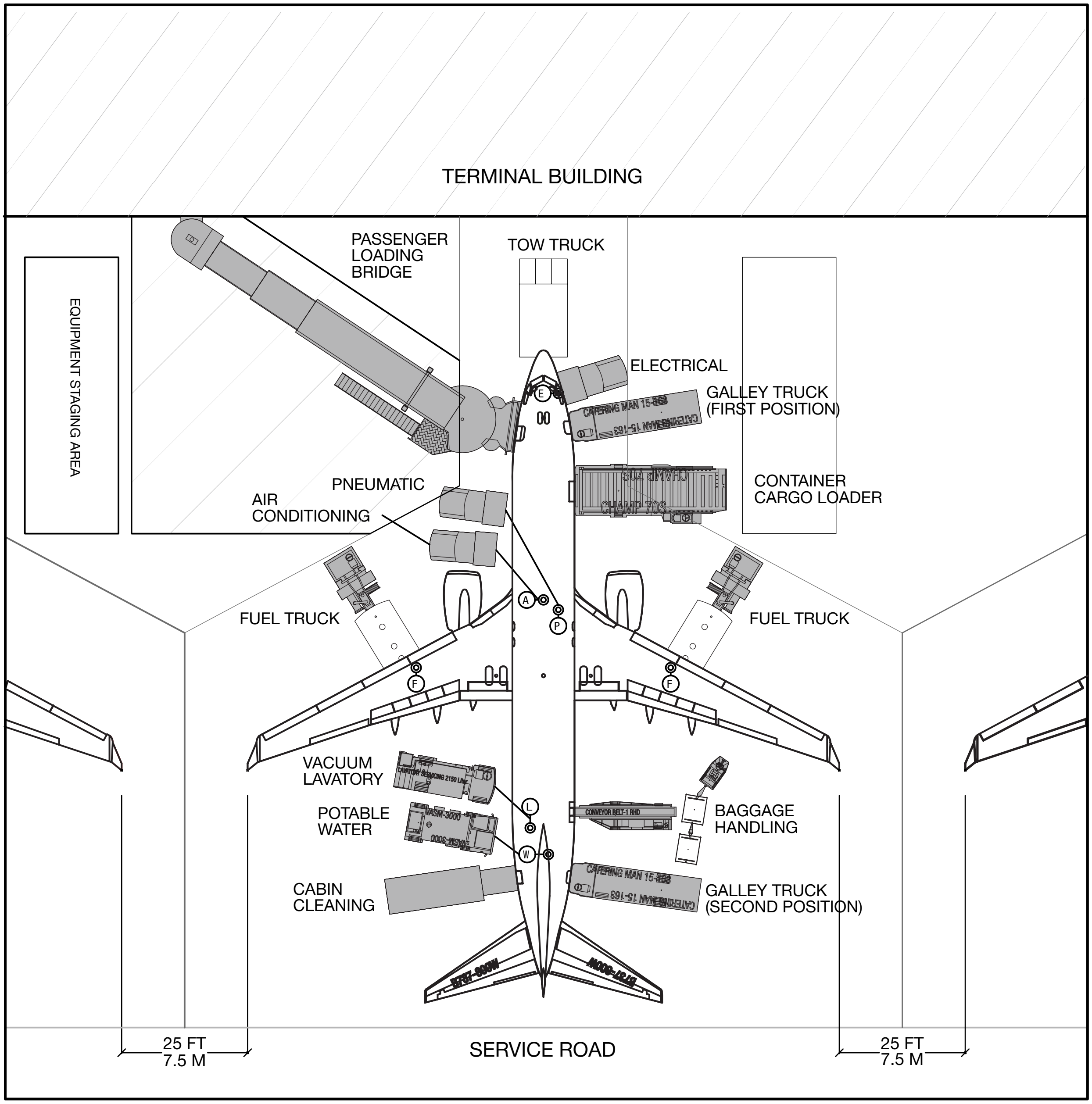
Aircraft Nose–Wheel Stop Marks. Whether parking at a remote or contact gate/stand, the aircraft must be properly positioned. An aircraft parked out of position can cause many problems, not the least of which are blocking the flow of aircraft taxiing onto and around the apron, colliding with the terminal building, and being unable to align with the passenger loading bridge. Aircraft nose–wheel stop marks are used to bring the aircraft to a complete halt in the optimal position based on its size and door position. These marks consist of a yellow hash mark perpendicular to and bisecting the gate/stand lead-in centerline, and a corresponding label noting the aircraft type for that mark. Additionally these marks ensure proper alignment of the aircraft for fueling and servicing.

Non-Movement Area Boundary. The terminal apron normally has a portion that is part of the non-movement area and a portion that is part of the movement area; therefore, it is important to delineate between these two areas of the apron pavement. A non-movement area boundary marking is located on the boundary between the movement and non-movement area. A non-movement area boundary marking consists of two yellow lines (one solid and one dashed) and will be outlined in black on light colored pavements. The solid line is located on the non-movement area side, while the dashed yellow line is located on the movement area side. This line denotes the point at which aircraft will be transferred over to the ATCT ground control frequency. Aircraft will not proceed past this point without having contacted ground control for permission to taxi onto the taxi movement area surfaces.

V.2.7 Aircraft Servicing

Ground support services are provided to aircraft while at the terminal gate or remote stand position. For these services to be conducted in a safe and efficient manner, standard locations with ample space for ground equipment placement and operation should be planned when designing the airport gate and apron areas. A staging area should be provided for the necessary GSE around each aircraft parking position. These staging areas provide for pre-positioning of the necessary GSE to provide service to aircraft on arrival at the gate. Proper pre-positioning of GSE around the aircraft parking position will help to minimize the aircraft turnaround time and the potential for aircraft/GSE conflicts. Figure V-9 depicts the typical staging area and servicing units for an aircraft. Areas on the right side of the aircraft nose, forward of the wing and just outside the apron safety lines (the defined aircraft parking envelope, and also called “equipment restraint lines”), are often used to pre-position GSE. The amount of space required for the GSE staging area is determined by the number of vehicles and equipment needed to perform the specific aircraft services.

Aircraft servicing is typically provided by a combination of movable vehicles and equipment and fixed servicing installations. Movable vehicles and equipment usually assemble in GSE storage and/or staging areas, depending on their function and the amount of equipment on site. Fixed servicing installations are commonly located on or under the apron, or on the terminal building contiguous to the aircraft gate. Aircraft gates that contain fixed utility installations benefit from less congestion on the apron from GSE and shorter aircraft servicing times. Possible negatives include some reduction in flexibility to handle different types of aircraft parking configuration and relatively high up-front capital costs. Ultimately it is for the airport owner to weigh the



Source: Landrum & Brown referencing Boeing 737/BBJ Document D6-58325-6, Section 5.0 Terminal Servicing

Figure V-9. Typical aircraft servicing equipment.

comparative costs and benefits, including potential environmental benefit, before determining whether or not to install any fixed servicing systems at airports.

The types of ground servicing typically required by aircraft include the following:

- Supply of fixed ground power and preconditioned air (during servicing)
- Replenishment of potable water
- Removal and disposal of toilet waste
- Catering/cabin cleaning
- Air start services
- Fueling
- Maintenance of oxygen system

V.2.7.1 Ground Power

To avoid use of the aircraft's auxiliary power units (APUs) while parked at the gate, ground power units (GPUs) can be utilized in conjunction with preconditioned air systems. Depending on the size of the aircraft, different types of GPUs can be used. Larger aircraft require 400 hertz power supply, which can come from a centralized location or from equipment provided at each gate. GPU equipment at the gate can be either in a mobile cart form or mounted on the passenger loading bridge. Centralized ground power systems generate aircraft-compatible power in one location, from where it is distributed to each gate. Smaller aircraft require 28 volt DC converter GPUs, which cannot be provided from a centralized location. For all types of GPU systems, electrical power transfers through a cable connecting the GPU to the aircraft, and GPUs should be operated only if they are at least 20 feet from aircraft fueling vents and venting points.

V.2.7.2 Preconditioned Air

When parked at the gate, the aircraft cabin is heated or cooled using either its on-board APU or preconditioned air from ground sources. The preconditioned air (PCA) can be supplied by either mobile or stationary units. Mobile units are typically self-contained, truck-mounted air-conditioning units powered by diesel engines. More prevalent at larger airports are stationary PCA units that are mounted on, or near, the loading bridges and connect to the aircraft by a flexible hose. Stationary systems have the advantage of less ground congestion, and lower emissions and energy use. Point-of-use systems have individual air-conditioning units that serve a single gate. Central chiller systems have a single chiller that heats or cools a heat transfer medium (usually water or a glycol/water mix) and then distributes this to air-handling units at each gate. In general, central PCA systems have higher capital costs but lower operations and maintenance costs than point-of-use systems.

V.2.7.3 Potable Water

Most airport terminal configurations provide for a potable water supply that can be tapped and linked to aircraft. Water cabinets and sources of water from the terminal are typically apron or loading bridge mounted and transfer water via a hose to the aircraft. When potable water supply cannot be replenished from the terminal facility, a water servicing vehicle provides potable water to aircraft. It is important to assure that the source of water is routinely checked for purity and any contamination that may occur.

V.2.7.4 Lavatory Cleansing and Waste Removal

Servicing involving removal of waste, replenishment of flushing medium (if any), and conveying of waste to disposal systems is generally conducted by ground service vehicles. Potable water service vehicles and lavatory service vehicles must not be parked in the same vicinity when servicing aircraft, or be serviced by the same personnel. Cabin waste originating from domestic and international air carrier flights must be removed and destroyed in conformity with local health codes and airport authority regulations. Usually this destruction involves incineration of the cabin waste in a properly designed facility. Local environmental rules and regulations must be adhered to with respect to emissions and proper disposal of the residue.

V.2.7.5 Air Start

Pressurized air must be provided for aircraft without APU, and air start systems supply this service. This type of system can be permanently installed similar to other utility systems, or truck-mounted systems can be utilized. The latter is the most common type of equipment currently used. Air requirements for air start range from 120 to 270 pounds per minute at 40 pounds per square inch (psi).

V.2.7.6 Fueling

Airports should seek feedback from airlines and oil companies when planning fuel supply systems at the terminal gate area. Aircraft fueling can be conducted through fuel service vehicles or hydrant systems. The type of system used should be determined in relation to the expected rate of aircraft movements at the airport. In addition, because of the potential for fuel spills and leaks, it is recommended that the aircraft parking apron area should be constructed with portland cement concrete.

Whenever possible, a distance of 10 feet should be maintained between fueling equipment and GSE. The provision of adequate aircraft service envelopes is vital for allowing safe maneuvering distances between ground equipment or service vehicles and aircraft at the stand.

Truck Fueling. Fuel trucks or tankers carry limited amounts of fuel directly to aircraft, pumping it through connecting hoses into the aircraft, and then return to the fuel farm or fuel distribution point to refill when necessary. For safety purposes, provision of grounding rod locations is required for the fueling truck positions. As already mentioned, the type of fuel system an airport utilizes depends on the level of aircraft activity an airport expects to receive. Fuel trucks typically suit airports with low levels of activity or service smaller aircraft, because adequate apron space is likely to be available and fuel requirements are not too high. At busier airports, fuel trucks are usually not the best option because they tend to cause congestion and take up ramp space. When fuel trucks are present, stop positions for such vehicles should be clearly marked near aircraft stands.

Hydrant Fueling. Hydrant systems, a form of underground aircraft fueling, may be preferred over fuel pits and/or mobile fuel trucks because they eliminate the duplication of equipment required for each apron hydrant valve. This type of system does not entirely remove the need for vehicles on the apron because hydrant fueling systems utilize a mobile self-propelled or towed hydrant dispenser unit consisting of a pump filter, meter, and air eliminator. This mobile hydrant unit serves as the connection between the apron hydrant valve and the aircraft fuel service point providing fuel transfer. By comparison, a fuel pit system is equipped with its own hose, reel, filter, and air eliminator at each pit location, thereby eliminating the need for the mobile dispenser unit. Both types of hydrant systems reduce the number and size of ground equipment, aid in decreasing ramp congestion, and enable quick aircraft turnaround times. Hydrant systems lend themselves to modular aircraft parking stands when a single hydrant valve could be utilized for different types of aircraft parking at the stand. A typical planning convention is to design the aircraft stands so that each aircraft's fueling service point falls within a 30-foot (~9-meter) radius of the apron hydrant valve. However, installation of such systems often requires that apron parking stands offer this modular flexibility. The number of hydrants necessary per stand depends on the type of aircraft using the park position. When planning a hydrant fueling system, knowledge of the aircraft configuration is required, because the number and location of hydrant valves on the apron are dependent on the number of gates needing fueling service and the specific aircraft fleet using each parking position. Because hydrant systems are permanently constructed under the apron, any future reconfiguration of the airport terminal buildings or aircraft stands could be limited and/or affected by the location of the hydrant valves.

V.2.8 Ground Service Equipment Storage

Storage spaces for GSE are defined as the location where equipment utilized in servicing aircraft is positioned when not in use. Airport requirements for GSE storage space and clearances will primarily be determined through consultation with airlines being serviced at the airport. Individual airlines may have varying space requirements depending on the amount of traffic and the nature of their operations. Airport size, terminal configuration, and amount of airline operational activity determine the number of GSE storage areas that should be planned. Storage facilities should be designed of adequate size to accommodate all equipment in regular use in each and every sector of the airport and should allow for speedy and convenient access to the apron.

When possible, the major GSE storage area should be located in a separate area within close proximity to the aircraft apron. A remote location will help to avoid interfering with regular apron operations but should not be so far away that it takes excessive time to reach the aircraft parking positions. There is also a need to have some GSE storage adjacent to the aircraft parking apron to be readily available when it is required, ensuring an efficient operation. The storage areas, which should be well delineated, should be properly sized to accommodate all equipment used on a regular basis to serve the parked aircraft in that section of the apron area.

V.2.9 Apron Lighting

Various degrees of illumination are required for outdoor apron areas during darkness and low-visibility conditions, and the section of apron containing aircraft stands requires a relatively high level of illumination compared to other areas of the airport. Apron area lighting ensures safe, secure, and efficient airport operations by increasing general visibility in this critical area.

Apron lighting enhances airport security by enabling observation of passenger and employee activity, identification of personnel on and near aircraft stands, and detection of possible unauthorized persons. Adequate apron lighting is also important to ensure the effective operation of CCTV cameras. If the primary purpose of lighting a particular part of the apron is for security and safety purposes, the system should be backed up by an emergency power supply.

Specific criteria should be considered when designing or modifying apron area lighting. These criteria include dimensions of the apron(s), arrangement of aircraft stands, specific types of aircraft using apron parking positions, taxiway arrangements and traffic schemes, adjacent areas and buildings (i.e., control towers), and location/status of runway and helicopter landing areas. The light angle and shielding of glare should be considered to assure there is not impact on aircraft landing, takeoff, or taxiing operations.

Maintenance expense and access to replace lights may also be a factor in reviewing potential apron lighting options. Lights should be placed so they will be easily accessible without using special equipment. If access to lights is difficult, it may be more economical to change lamps on a group replacement basis. The cost of replacing lamps in high-mast lighting can be significant, so long-life lamps should be used.

Aprons are often illuminated from lights that are either attached, or adjacent, to the terminal building or concourse face. Night-time illumination levels should be a minimum of 20 foot-candles (215 lux) adjacent to the terminal and a minimum of 2 foot-candles (~22 lux) at the tail of aircraft. ICAO Annex 14 (*32*) recommends average horizontal luminance on aircraft stands of 20 lux with a uniformity ratio of not more than 4:1 and, for other apron areas, 50% of the average luminance on aircraft stands with a uniformity ratio of not more than 4:1. The area between aircraft stands and apron limits should be illuminated to an average horizontal luminance of 10 lux, and, if high-mounted headlights do not light the area adequately, glare-free lighting of the street-lighting type should be utilized. Height restrictions for apron lighting may also need to be in place, depending on how close the runway is to the terminal or concourse.

In general, ICAO recommends average vertical luminance should be 20 lux at a height of 2 meters above the apron in all relevant directions. The FAA advises that mounted floodlights, sometimes referred to as high-mast lighting—and a commonly preferred type of apron lighting, should be placed at a height of 25 to 50 feet (8 to 15 meters) with maximum spacing of 200 feet (60 meters). FAA regulations require airports to be responsible for ensuring that all lighting on the airport, including that for aprons, is placed at a level that is adequately adjusted and shielded to prevent interference with air traffic control and aircraft operations, without reducing necessary illumination of critical areas. To minimize direct and indirect glare, mounting heights for floodlights should be at least two times the maximum eye level of the cockpit of aircraft regularly using the airport. The location and height of light masts should be placed to keep inconvenience to ground personnel due to glare at a minimum but to provide desired illumination levels.

Additionally, uniform luminance of entire aircraft stands should be present, compared to individual direction of lighting toward aircraft. Even lighting levels can be accomplished by arranging and aiming lights in two or more directions toward aircraft stands, and minimizing potential shadow areas. In areas where unavoidable shadows occur, supplementary lighting may be required. On taxiways adjacent to aircraft stands, a low degree of luminance should be utilized for providing a gradual transition to higher luminance on aircraft stands. Light distribution should be such that all colors used for aircraft markings can be correctly identified, if necessary, through adaptation by the use of screens.

Light sources most suitable for identifying routine servicing and surface markings are incandescent halogen and high-pressure gas discharge lamps. Because discharge lamps produce color shifting, a three-phase electrical supply system should be utilized to avoid this stroboscopic effect. Colors resulting from discharge lamps must be checked during daylight and artificial lighting situations to ensure correct color identification. High-pressure sodium or mercury halide lamps should be used when adjusting color schemes used for surface and obstruction markings.

V.2.10 Apron Snow Removal

During snow removal operations on the airfield, the potential exists for interaction between ground vehicles and aircraft, whether taking place in the movement or non-movement areas. For this reason it is important to coordinate all snow removal operations with the ATCT and determine which activity will have the right-of-way throughout the airport. In some cases the snow equipment will have the right-of-way in order to clear a pavement area to allow aircraft operations to move in a more safe and efficient manner.

V.2.10.1 Snow Haul Route

When planning for snow removal operations on and around the terminal apron area, it is important to provide dedicated routes for the collection and hauling of snow from the apron area. Provision of dedicated routes can usually be accomplished by using the existing airside service roadway network; however, it may also require a secondary roadway network within the terminal ramp area to efficiently conduct the snow removal operation.

V.2.10.2 Snow Melter Operations

Airports that utilize snow-melting equipment (mobile or in-ground) within the terminal ramp area should identify an area where they will position this equipment such that it does not affect aircraft operations or gate positions. The terminal ramp area should be graded such that any snow-melting operations that take place do not cause ponding and eventual re-freezing of water in the ramp area. Adequate drainage must be provided in the location where snow melting is taking place. Local and U.S. Environmental Protection Agency environmental regulations for the treatment of contaminated groundwater must also be considered when deciding to use snow melters in the terminal ramp area.

V.3 Aircraft Gate Requirements

V.3.1 Aircraft Gate Types

When planning an airport apron layout, an important aspect to consider is passenger loading and unloading between the terminal building and aircraft. The decision on which type of gate to use will depend largely on the level of aircraft traffic that is to be accommodated, the terminal layout, and local airport conditions.

Aircraft gates are either considered contact gates or remote gates. Contact gates are either in physical contact with the terminal through the use of a passenger loading bridge or in enough proximity to the terminal to allow passengers to walk to the aircraft. Remote gates (or stands) are far enough from the terminal to require some type of bus or transporter for passengers. The terms "remote gate" and "stand" are synonymous, with the term remote gate being more commonly used in the United States.

Airports with lower levels of air service, or service by regional aircraft, have tended to use apron ground loading. Larger airports with higher commercial aircraft activity by mainline aircraft typically employ passenger loading bridges. Some of these differences have been disappearing as airlines operating regional aircraft request loading bridges to provide the same level of passenger service as the mainline equipment they replace.

V.3.1.1 Contact Gates

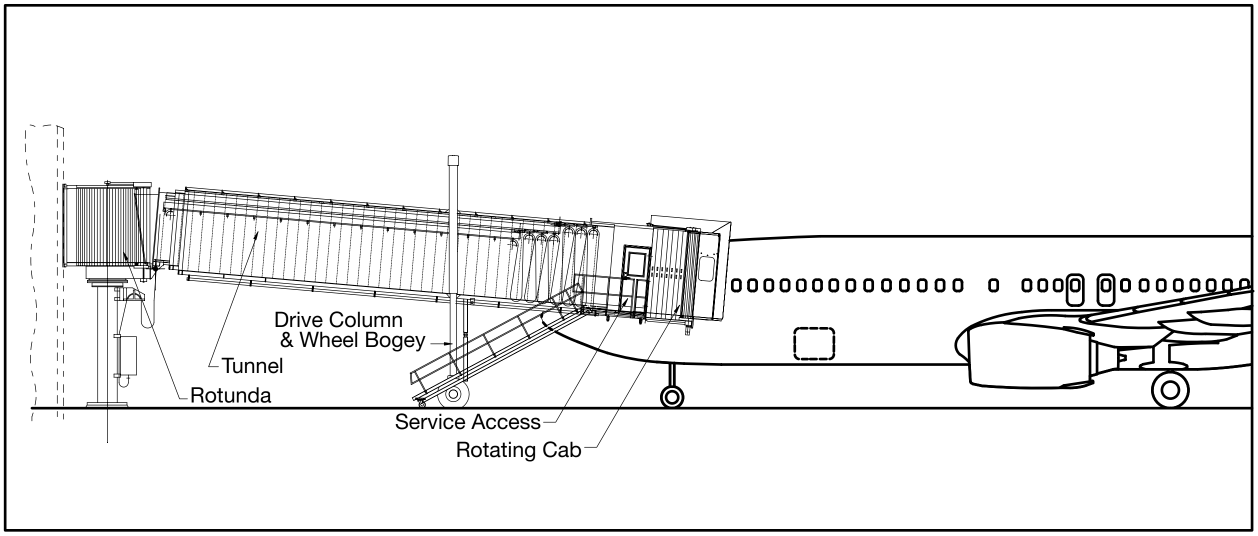
When planning contact gates, consideration must be given to providing sufficient space for GSE operations and staging (See Sections V.2.6.3 and V.2.7.6). Aircraft must be parked so as to allow safe operation of passenger loading bridges for the range of aircraft that are expected to be using each gate. If passengers are to walk to their aircraft, well-marked paths must be maintained at a safe distance from ground equipment and engines of parked aircraft.

Loading Bridges. Passenger loading bridges are positioned to bring passengers to left-side aircraft boarding doors, with the bridges located forward of the aircraft wing. Many aircraft types support passenger boarding through only a left-side door. When compared to conventional air stairs and mobile lounges, loading bridges tend to reduce passenger disembark/embark times, resulting in 25% faster movement of passengers. They also improve passenger and staff safety, passenger experience, and disabled access between the aircraft and terminal building in comparison to ground loading of passengers.

General loading bridge requirements include the ability to communicate with passengers queuing between the gate and aircraft in case of an emergency, bridge emergency escape stairs, backup systems, fire suppression systems, emergency lighting, and clear maneuvering range markings on the airport apron. Also, maximum gradients must comply with ADA requirements of 1:12, while a 1:10 slope is recommended by IATA and ICAO. In the United States, the National Fire Protection Association requires that no transparent or translucent walls, surfaces, or windows be in passenger loading bridges, except for in the cab area and on the ramp service door.

Primary factors to consider when planning passenger loading bridges include aircraft door sill heights and door positions. The type of passenger loading bridge and its length are determined based on apron dimensions, aircraft wing span, aircraft door locations, fixed aircraft services, adjacent aircraft positions, and economics. Two primary types of loading bridges and slight variations of these tend to be utilized: apron drive bridges and fixed bridges.

Apron Drive Bridges. Apron drive bridges provide the most flexibility in serving a wide range of aircraft types. Apron drive bridges consist of a rotunda, two or three telescoping tunnels, and a rotating cab that docks to the aircraft as depicted in Figure V-10. Depending on the size of the



Source: Landrum & Brown

Figure V-10. Apron drive bridge.

apron and aircraft parking locations, a fixed link section may be installed between the terminal and the rotunda. The rotunda is a fixed unit on the aircraft apron, and the main support mechanism for the loading bridge.

Apron drive bridges move on three axes: vertically about a pivot point on the rotunda, laterally through telescopic section movement, and on an arc rotating about the bridge rotunda. The cab that docks with the aircraft also rotates and can either be non-leveling or self-leveling. The self-leveling cab is generally recommended because it is safer for passengers and staff when telescopic sections are on maximum gradient. However, it produces less effective slope length, which may be a consideration when aircraft must be parked very close to the terminal. For apron drive loading bridges, the maximum extension and minimum retraction limits (operational range) and maximum passenger loading bridge slope requirements must be examined and approved in overall apron and gate planning. The three-tunnel bridge is generally recommended for use when the range of aircraft height differential varies the most.

The apron drive bridge's operation should not interfere with other aircraft or GSE movements. If a fixed section is used from the terminal building to the apron drive pedestal in a "head of stand" service road configuration, as frequently done outside of the United States, then this fixed bridge section must be positioned to allow the highest GSE vehicle anticipated to use the service road that passes beneath. Most airports prohibit vehicle traffic or parked equipment under the movable portion of an apron drive bridge and therefore the apron should be striped as a no parking/ no traffic area.

The floor elevation of the terminal, or concourse, along with the floor levels of the fixed section, the rotunda, and the tunnel sections of the loading bridge itself, must provide a gradual transition for passengers walking to and from the aircraft without any steep slopes. In the United States, no ramped surface in the passengers path to and from the aircraft to the building should exceed the ADA maximum slope requirements of 1:12.

A specific category of an apron drive loading bridge, called the "over-the-wing apron drive bridge," docks with the rear door of aircraft. This configuration permits two or three loading bridges to service a single aircraft. Figure V-11 depicts an over-the-wing bridge servicing the upper-deck passenger doorway of an A380. The downside to dual- and triple-service apron drive bridges

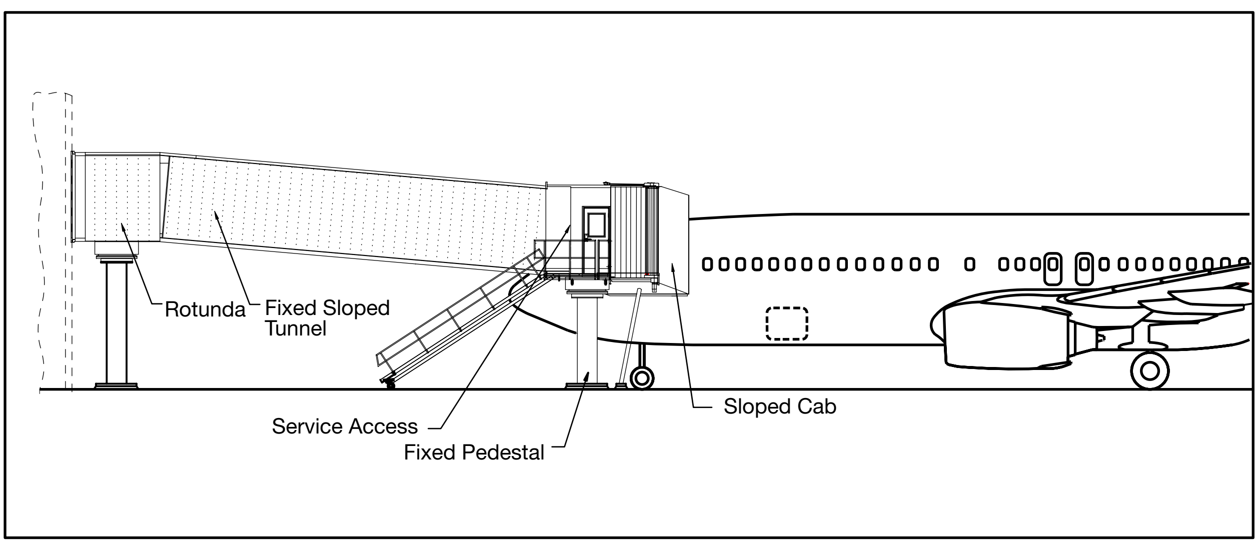
Source: Landrum & Brown

Figure V-11. Over-the-wing bridge.

includes restricted GSE movement around aircraft, more equipment in the gate area, and less general flexibility than single-service apron bridges. Also, utilization of dual- and triple-service loading bridges should not interfere with adjacent aircraft parking positions, and special striping for bridge movement should be present.

Fixed Bridges. Airports with gates servicing one type of aircraft, or aircraft of similar sizes and door sill heights, may opt for fixed loading bridges. As depicted in Figure V-12, fixed bridges typically consist of a fixed link from the terminal to a pedestal, a two-tunnel telescoping section, and a cab with limited rotation as compared to an apron drive bridge. Fixed bridges are more economical than apron drive bridges, but less flexible in accommodating different types of aircraft with wide-ranging door sill heights.

Fixed bridges move on two axes: vertically about a pivot point at the end of the telescoping section, and laterally through telescopic section movement. It is possible to service aircraft of separate size categories via this type of loading bridge, but doing so can result in a steep tunnel for multiple aircraft lead-in centerlines. Also, fixed bridges require the aircraft to be stopped more accurately than is required for apron drive bridges, because cab movement is limited. However,



Source: Landrum & Brown

Figure V-12. Fixed bridge.

less protection of the apron area is necessary compared to the apron drive bridge because the tunnel section moves over less apron space with the fixed bridge.

Apron-Level or Ground-Loaded Gates. Ground-loaded gates are typically used for smaller regional aircraft but may be used for mainline aircraft when traffic volume or terminal design does not justify a loading bridge. Planning for passenger walking routes between the terminal and aircraft should involve determining the shortest possible route and maintaining free movement of aircraft, vehicles, and passengers while avoiding conflict between them. Pathways for passengers must be clearly marked, free of obstacles, and closely monitored for safe and secure movement between aircraft and the terminal.

In an effort to improve passenger service and provide some of the amenities of mainline aircraft boarding for regional aircraft, various passenger boarding assistance devices have been developed that provide weather protection for apron loading. Some of these devices include ramps that substitute for the aircraft's stairs, and separate wheelchair lifts. When planning for using weather protection devices, the method of movement and materials must be considered to minimize conflicts with aircraft parking and push/power-out movements. Apron drainage must also be considered.

V.3.1.2 Remote Gates/Hardstands

The alternative to contact gates is remote gates or hardstands. These remote parking positions for commercial aircraft can be located close to the terminal, but further than walking distance, or quite far away depending on the available space.

Remote gates can have some benefits (depending on configuration) including the following:

- Potentially allow for a greater number of gates/stands on a finite amount of apron space
- Can be configured to allow taxi-in/taxi-out operations
- Allow for less constrained ground service vehicle operations
- Can serve a wide range of aircraft gauge within a single gate and accommodate multiple aircraft mixes on the remote apron
- Can require lower infrastructure cost than contact gates

While remote gates are initially less expensive to develop, their operating costs can exceed those of contact gates because of the need to operate a system of busing or other forms of transportation to take passengers to and from the terminal. Other disadvantages would include possible conflict between aircraft flows and buses on and around the apron, increased passenger enplaning and deplaning times, and a lower level of passenger service.

There are two basic types of vehicles for transporting passengers between the terminal and remotely parked aircraft:

- **Transporters (or mobile lounges):** This special type of airport equipment is designed to elevate vertically, connect with a terminal dock and/or aircraft, and drive between each location. Passengers typically walk directly into the transporter on the same level as the terminal or aircraft. One early type of mobile lounge used an elevating gangplank with 6 to 10 feet (1.8 to 3 meters) of extension, which adjusted to various aircraft sill heights. Most transporters in current use and manufacture have an elevating passenger compartment and loading bridge–type coupling to allow compatibility for proper aircraft positioning. This type of equipment adds to the number of vehicles operating on the apron and may require construction of larger service roads. Also, more than one mobile lounge may be required to accommodate all passengers on a flight and increases the amount of time required for passenger processing. Although a few airports were designed around transporters (Washington Dulles being the best known example), transporters are more typically used for overflow remote gates.

- **Buses:** Around the world airside buses are the most common means of transporting passengers to and from aircraft parked at remote gates. The size of the bus can be matched with the type of aircraft and range in capacity from less than 50 to approximately 130 passengers. Specialized apron buses are designed with low floor height, wide doors, and minimum seating around the cabin to accommodate a large number of passengers, as well as disabled passengers. Location for loading and unloading passengers from buses should be as close as possible to the terminal building and airside waiting area to limit distance required for passenger walking. It is generally recommended that arrival and departure flows should be separated with separate bus loading/unloading areas.

  There are two basic ways to board or disembark at remote gates/hardstands:

- **Mobile stairs:** Mobile stairs must be provided for most aircraft at remote gates. These stairs can be covered or uncovered, and are pushed or driven to aircraft and set at door level. Fitting mobile stairs with canopies will improve customer service standards. Some types of aircraft (primarily regional aircraft) contain integral steps, which are only accessible when the crew releases or opens an aircraft door allowing passengers to board or disembark. When stairs are the only method that passengers can take to or from the aircraft, wheelchair lift devices must be provided allowing passengers with mobility impairments to board.
- **Permanent remote gates:** When hardstands are used on a regular basis, some airports have developed permanent remote gates that include a covered bus loading/unloading curb, a ramp system, and a loading bridge. This allows a faster and easier boarding and disembarking process with the weather protection of a contact gate. An example is the West Pad gates at Los Angeles International Airport as depicted in Figure V-13.

V.3.2 Aircraft Push-back Zones

When planning the terminal ramp areas, it is important to remember that aircraft will require space to push back from their respective gate. This space can be provided by either a dedicated area for push-backs, multiple parallel taxilanes so that the aircraft being pushed back can use one of the taxilanes, or a combination of a dedicated push-back lane with multiple parallel taxilanes (usually reserved for larger airports with heavy peak congestion periods). The push-back zone

Courtesy of: ©2009 Microsoft Corporation, ©2008 NAVTEQ, and ©2008 Pictometry International Corp.

Figure V-13. West Pad gates of Los Angeles International Airport.

depth should be adequate to position an aircraft such that it can power-out and not cause damage due to excessive jet blast.

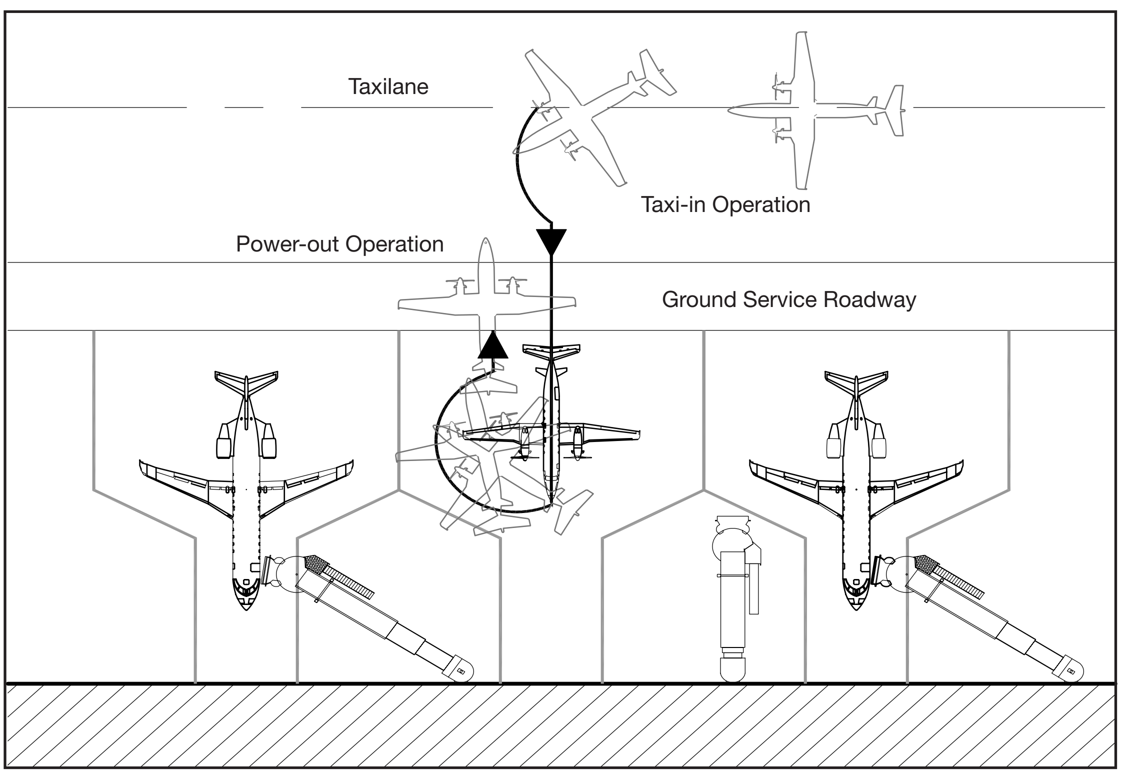
V.3.3 Power-out and Power-back Operations

The two ways in which an aircraft can leave a gate position under its own power are referred to as power-out and power-back operations. The power-back operation is when the aircraft uses its thrust reversers to power straight back from the gate position. This type of operation should not be considered as part of normal operating procedure because of the concern of foreign object damage kick-up into the engine intake and jet blast damage to ground personnel and equipment. In addition, there is additional fuel burn associated with the power-out operation that is expensive.

The power-out operation is depicted in Figure V-14. This operation is accomplished by the aircraft moving forward slightly under its own power and turning to exit the gate position. This operation is normally only acceptable at smaller, less congested airports because of the large amount of ramp space required and the inability to use a passenger loading bridge. In the United States this power-out operation is typically conducted by smaller commuter aircraft that are located at apron parking positions; passengers typically load and unload to and from the apron level through the aircraft's built-in passenger stairway. These types of power-out and power-back operations can generate the potential for significant jet blast on surrounding areas, which should be analyzed and considered during the detailed planning phase.

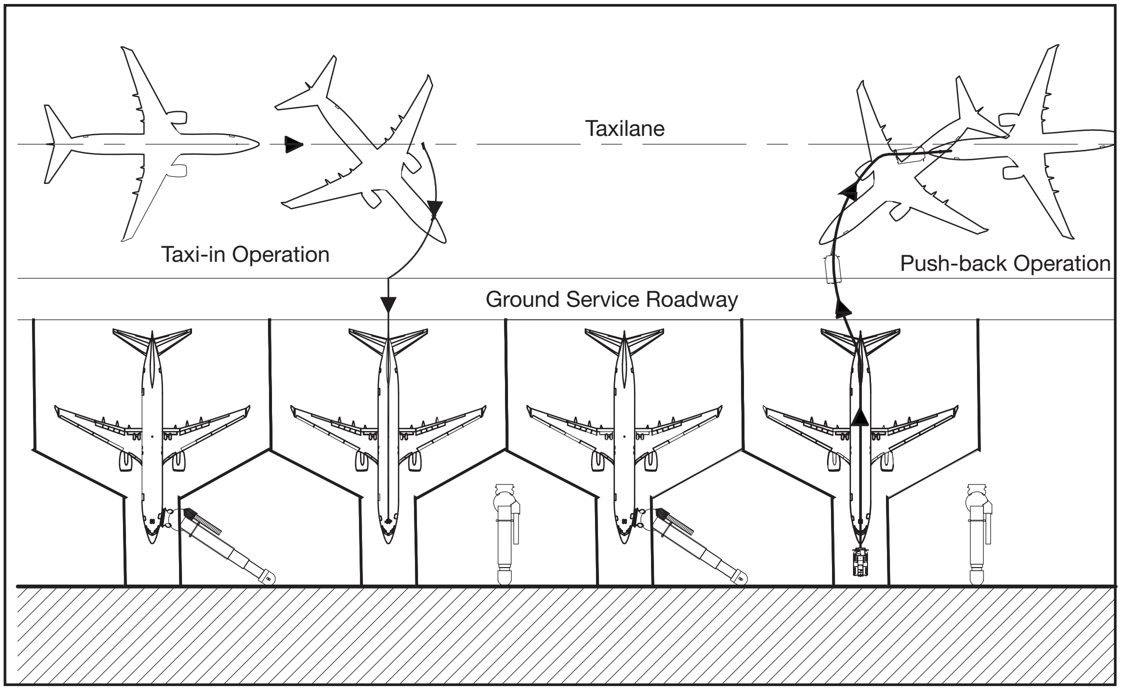
V.3.4 Taxi-in and Push-back Operations

The most prevalent aircraft parking operation at U.S. terminals is the taxi-in/push-back procedure associated with various types of loading bridges at the terminal or concourse. In this



Source: Landrum & Brown

Figure V-14. Taxi-in and power-out operation.



Source: Landrum & Brown

Figure V-15. Taxi-in & push-back operations.

operation the pilot brings the aircraft in under its own power following the lead-in line associated with each gate position. During this maneuver the pilot is typically assisted by wing walkers on the apron to ensure that the aircraft is clear of any obstacles out on the ramp. The pilot may also be assisted by a visual docking guidance system, which is described in more detail in Section V.2.3.1. For the aircraft to leave the gate, a tug either is brought into position or has already been positioned before the aircraft's arrival and is connected to the aircraft's nose gear. The tug then performs a push-back operation by maneuvering the aircraft out of the gate area to a position out on the apron or taxilane where the pilot can safely power up its engine(s) to proceed under its own power. Figure V-15 depicts the taxi-in and push-back operations.

V.3.5 Tug-in Operations

In areas of confined terminal apron space and the need to maximize the number of gate positions, an operation known as tug-in should be considered. This practice is seen as preventative in order to eliminate the potential for aircraft collisions and jet blast in such tight operating areas. When planning for such operations, it is important to remember the time in which aircraft are waiting in the movement areas for their respective tug and the effect these stationary aircraft might have on the movement of other aircraft. Adequate vertical and horizontal clearances must be maintained between all aircraft surfaces during this operation.

V.3.6 Apron Circulation

When planning for apron circulation, a number of factors must be considered such as the type of terminal facility the apron area serves, the number of gates, the number of operations, the type and size of the aircraft operating on the ramp, and the type of vehicles servicing the aircraft.

For standard linear or satellite terminals, a flow-through taxiway/taxilane would be the preferred form of circulation into, out of, and through the apron area. For pier finger–style terminals or those terminals with apron areas having only one way in and out, dual parallel taxilanes are the recommended form of circulation when more than six or eight gates are served. As stated previously, dual taxilanes allow for uninterrupted access to all gates served by the apron.

V.3.7 Jet Blast Effects and Mitigation

In certain terminal configurations, especially when the aircraft are operating under their own power (taxi-in/out), it is important to consider the potential effects of aircraft jet blast and propeller wash. When planning airside facilities, it is important to consult the specific *Airplane Characteristics for Airport Planning* manuals for the aircraft that will be using the airport. These manuals are produced by the aircraft manufacturers and are available on their website in most instances. Using these manuals, it can be determined what areas will be affected by the aircraft jet blast. Once these areas have been determined, blast fences, or other types of jet blast protection, can be considered as a means of mitigating potential damage. It is also important to consider the effects of jet blast on the terminal building windows and façade in those areas where a blast fence cannot be installed. These surface areas must be able to withstand jet blast velocities if power-out use is anticipated. Section V.2.5 contains expanded information relevant to blast fences and jet blast protection.

V.3.8 Forecasting Gate Demand Using Design Day Flight Schedules

If a DDFS has been developed for a forecast year (or annual activity level), a relatively detailed study of gate requirements can be performed. Typically a DDFS is developed when airside simulation modeling is done for an airport. See Section IV.4, Peak Hour Demand Analysis, for additional information about using and creating flight schedules.

In many cases a DDFS is produced as separate lists of flight arrival and departure records in a spreadsheet format. For it to be used for gate requirements analyses, arrivals and departures must be matched up. This matched schedule can then be analyzed in a spreadsheet or by various proprietary models to determine the number of gates required during the course of the day. Two types of charts are used to display gate requirements information:

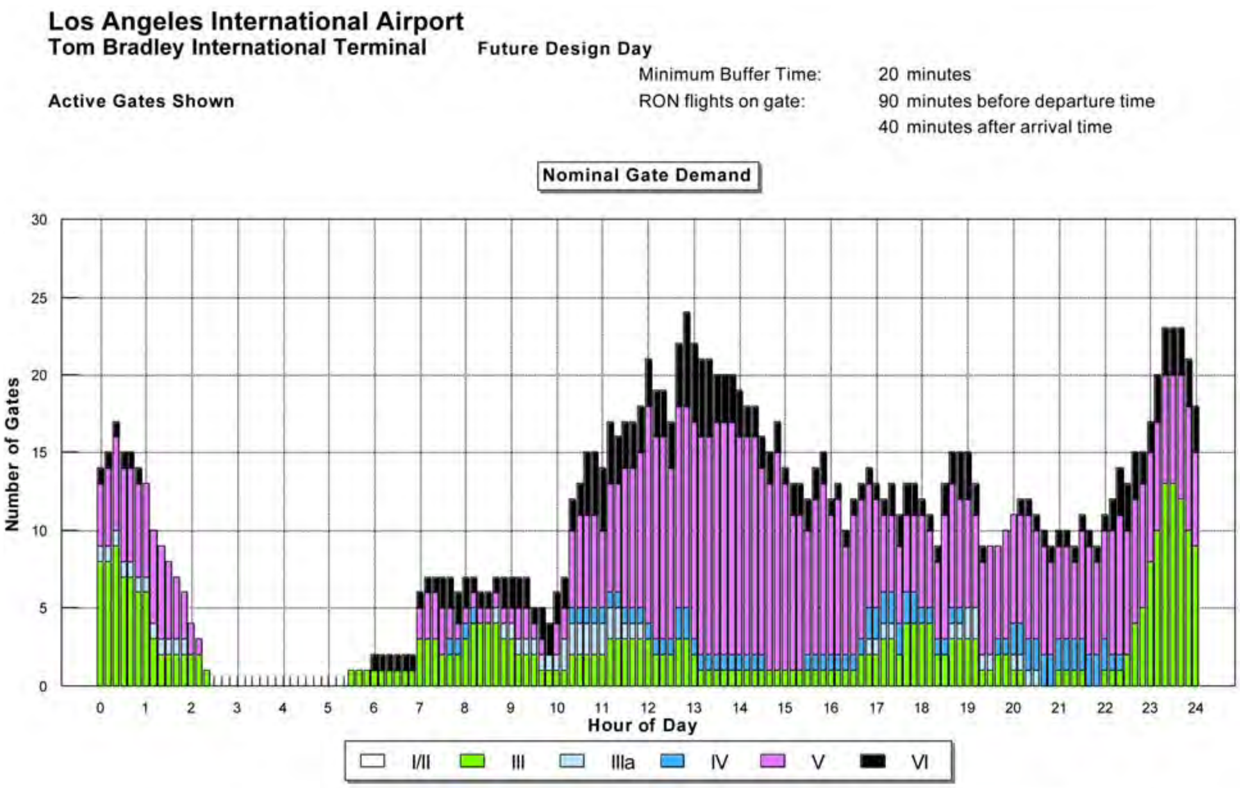
- Histograms or bar charts that show the number of gates used by time of day
- Gantt or "ramp" charts that show how each gate gets used by time of day

Both types of charts can use colored bars to indicate different airlines or aircraft types in the analysis. While this type of analysis can be very detailed, it is dependent on the assumptions used to add flights by specific airlines or aircraft types over time.

Figure V-16 depicts an example histogram or bar chart showing the number of gates needed by time of day. This analysis was prepared using a spreadsheet model that analyzed a matched DDFS. The analysis summary shows gate requirements by aircraft type (in colors) and time of day.

An alternative to using a spreadsheet model is to create a Gantt or ramp chart of gate usage that shows, by time of day, which flights were assigned to which gates. These charts can be drawn by hand or created using special purpose (often proprietary) software. This special purpose software also can determine which flight goes on which gate based on a database or "rule" base that describes which airline can use which gates, aircraft gate sizes, and whether the gate can accept international flights. The chart shown in Figure V-17 depicts an example of a ramp chart developed using special purpose software. Figure V-17 shows gates (vertically) and hours of day (horizontally), and each color represents a specific airline. Ramp charts can be a useful method to show a high volume of specific gate use information in an easy-to-read format.

Both types of analysis consider both the time the gate is actually occupied by an aircraft and a "buffer" time when the gate is unoccupied. This buffer time allows airlines to reposition ground equipment for the next aircraft. In addition, the buffer time accounts for the variability between scheduled and actual times that normally occurs in day-to-day operations. A buffer time of



	I/II	III	IIIa	IV	V	VI	Combined
Maximum Number of Gates:	0	13	2	2	15	6	24
begins at:		2320	1010	1240	1330	1250	1250
Avg. Scheduled Time on Gate:	NA	106	108	118	125	169	126 minutes

Source: Hirsh Associates

Figure V-16. Example of a gate requirements chart from a spreadsheet.

15 to 20 minutes is normally used. Longer buffer times may be used at international terminals, where on-time performance is likely to be more variable. Shorter buffer times may be used in day-to-day operations on a domestic terminal.

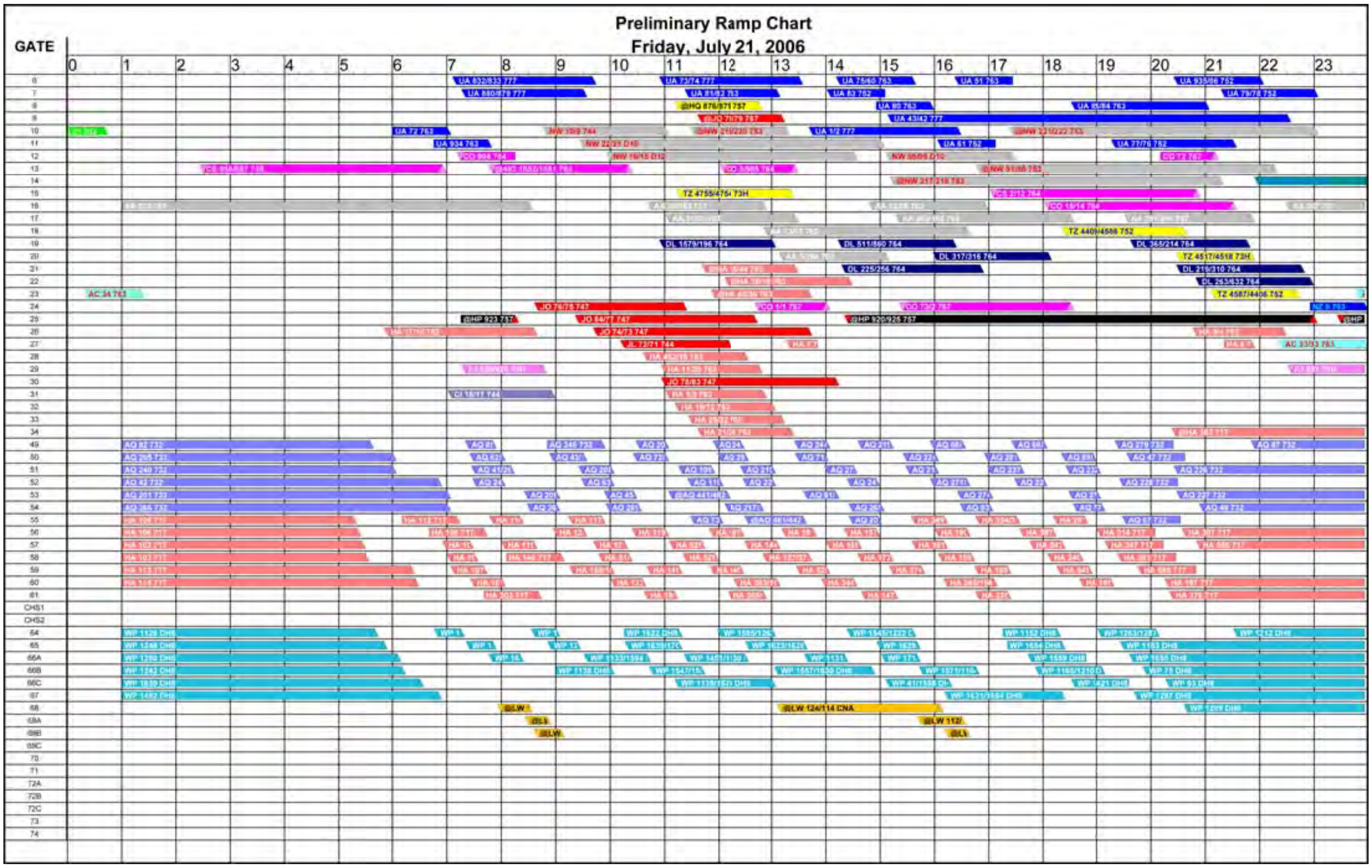
V.3.9 Forecasting Gate Demand Without Using Design Day Flight Schedules

When a DDFS is not available, two other approaches can be used. These approaches also allow the terminal planner to easily do "what if" sensitivity checks on basic assumptions, including those that may underlie a DDFS.

V.3.9.1 Average Passengers per Gate Approach

The first approach (example shown in Table V-5) uses the current ratio of annual passengers per gate, adjusted for forecast changes in fleet mix and annual load factors. This methodology assumes that the pattern of gate utilization will remain relatively stable over the forecast period. The changes in passengers per gate would be due to changes in enplanements per departure (due to fleet seating capacity and/or passenger load factors), as opposed to increasing (or decreasing) numbers of departures per gate.

The basis for the existing factor is the number of gates in use. This number may be less than the number of gates available at an airport. In rare cases of over-crowded terminals, aircraft may be double parked at existing gates, so it is important to determine the true demand for active



Source: Landrum & Brown

Figure V-17. Example of a ramp chart.

aircraft parking. From the existing passenger activity and annual departures, the current ratios of annual passengers per gate and enplanements per departure are calculated. Similar calculations can be based on total annual passengers, airline operations, or a combination of these, depending on how the airport keeps its statistics and develops its forecasts.

Forecasts for annual enplanements and departures (or total passengers and operations) are forecast separately. As noted in Chapter IV, annual departures are typically forecast based on assumptions for fleet size and load factors, which are applied to the passenger forecasts.

Table V-5. Enplanement per gate approach.

	A	B	C	D	E	F
	Year	Annual Enplaned Passengers	Annual Departures	# of Gates	Enplaned Passengers per Gate	Enplaned Passengers per Dept.
	2006	3,462,920	62,670	36	96,200	55
	2007	3,336,027	63,808	36	92,700	Multiply 52
	2008	3,399,000	63,000	36	Equals 94,400	54
FORECAST	2010	4,429,000	79,500	45	97,500	56 Ratio
	2015	5,287,000	91,500	52	101,100	58
	2020	6,240,000	106,500	61	102,500	59
	2025	7,096,000	121,000	69	102,600	59

1/ EnPax per Gate = EnPax per Gate Prev. Year x EnPax per Dept. Current Year / EnPax per Dept. Prev. Year
2/ Gates = Annual EnPax / EnPax per Gate

Source: Hirsh Associates

The ratio of enplanements/gate for each forecast year is calculated by multiplying the current (2008 in this example) factor (Column E) by the percentage increase in enplanements/departure. For example, enplanements per departure increases from 54 in 2008 (actual) (Column F) to 56 in 2010 (forecast), thus the factor would increase from 94,400 enplanements/gate (2008 data when 36 gates were in use) to 97,500 for 2010, and 102,600 enplanements/gate by the end of the forecast period without any further increase in the number of daily departures per gate.

Future gate requirements are then estimated by dividing annual forecast passengers (Column B) by the estimated passengers per gate factor for that forecast period. For example, in 2010, 4,429,000 enplanements (Column B) divided by 97,500 enplanements/gate (Column E) results in a demand for 45 gates (Column D). This approach results in a forecast demand for 69 gates by the end of the forecast period.

The future gate requirements determined in the model are in bold and are driven by the growth rates of enplaned passengers per departure. The growth in enplanements per departure is used to determine the enplanements per gate for forecast planning years. The number of required gates in those years is then determined by dividing the annual enplaned passengers by the enplaned passengers per gate values. The values listed in the table show relatively small increases in the passengers/gate and passengers/departure ratios over the forecast range.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Gate Demand model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model takes the user through the steps to estimate the future gate requirements using the two methods described in Tables V-5 and V-6.

V.3.9.2 Departures per Gate Approach

The first methodology has as an underlying basis that the pattern of service is basically stable. While this may be true at many airports and for some airlines at a given airport, it is often likely that gate utilization will change to some extent for other airlines. With a forecast reduction in mainline jets, for example, additional flights by regional aircraft may be scheduled as demand grows. Similarly, airlines may add flights to their hubs from spoke cities, which typically results in higher average gate utilization.

However, if an airport attracts service by new entrant airlines, these carriers are often likely to initially follow scheduling patterns similar to existing carriers. This could result, for example, in a demand for more gates during the morning departure peak, and a reduction in average daily gate utilization.

For the departures per gate approach (example shown in Table V-6), the ratio of annual departures/gate for each forecast year is calculated by multiplying the current (2008) factor by the percentage change in assumed daily departures/gate. In this example, it was assumed that average daily gate utilization would increase from 5.0 departures/gate in 2008, to 5.2 departures/gate by 2010, and gradually increase to 6.5 departures/gate by 2025. Thus, the annual gate utilization factor would increase from 1,750 annual departures/gate (2008) to 2,290 by 2025.

The future gate requirements determined in the model are in bold and are driven by the growth rates of daily departures per gate. The growth in daily departures per gate is used to determine the Annual departures per gate for forecast planning years. The number of required gates in those years is then determined by dividing the annual departures by the annual departures per gate values.

Table V-6. Departure per gate approach.

A	B	C	D	E	F
Year	Annual Enplaned Passengers	Annual Departures	# of Gates	Annual Departures per Gate	Daily Departures per Gate
2006	3,462,920	62,670	36	1,740	5.0
2007	3,336,027	63,808	36	1,770	5.1
2008	3,399,000	63,000	36	Equals 1,750	Multiply 5.0
FORECAST 2010	4,429,000	79,500	44	1,820	5.2 Ratio
2015	5,287,000	91,500	47	1,930	5.5
2020	6,240,000	106,500	50	2,110	6.0
2025	7,096,000	121,000	53	2,290	6.5

1/ Ann. Dept. Gate = Ann, Dept.per Gate Prev. Year X Dly Dept.per Gate Current Year /Dly Dept. per Gate Prev. Year
2/ Gates = Annual Departures / Annual Departures per Gate

Source: Hirsh Associates

Future gate requirements are estimated by dividing annual forecast departures (Column C) by the estimated departures per gate factor (Column F) for that forecast period. For example, in 2010, 79,500 departures (Column C) divided by 1,820 departures/gate (Column E) results in a demand for 44 gates (Column D).

For most airports that assume increasing gate utilization, the departures per gate approach will result in a demand for fewer gates than the annual passengers per gate approach.

V.3.9.3 Remain Overnight Aircraft Parking

At many airports, the pattern of airline service results in more aircraft being on the ground overnight than the number of active gates. This is more pronounced at "spoke airports" when an airline may have, for example, hourly service to its hub for the first few hours of the day. Because it may take until mid-morning before aircraft begin to arrive, a single gate may accommodate two to three aircraft departures for which the aircraft must be parked overnight. Because the cost of building a terminal for contact gates is significant, these remain overnight (RON) aircraft are usually parked remotely, or in some cases double parked on contact gates if the apron geometry allows. If RON aircraft are parked remotely, they are typically towed to a contact gate for departure and towed off a contact gate to the RON parking area after the evening arrival.

Estimating the number of RON positions for planning should take into account the airport's air service pattern, the forecasts for cities to be served in the future, whether these are hub or direct destination flights, and the relative utilization of gates. The location of the RON parking apron should consider the distance from the terminal for towing aircraft and the route to be followed to minimize the effect on other aircraft movements.

V.3.10 Gate Equivalents

Airport comparisons are also frequently made on the basis of passengers per gate or terminal area per gate, but these lack a consistent definition of the term "gate." To standardize the definition of "gate" when evaluating aircraft utilization and requirements, two metrics have been developed: narrowbody equivalent gate (NBEG) and equivalent aircraft (EQA).

V.3.10.1 Narrowbody Equivalent Gate

This metric is used to normalize the apron frontage demand and capacity to that of a typical narrowbody aircraft gate (see Table V-7). The amount of space each aircraft requires is based on the *maximum* wingspan of aircraft in its respective aircraft group. FAA ADGs used to define runway/ taxiway dimensional criteria have been used to classify the aircraft as in Table V-7.

Table V-7. Narrowbody equivalent gate index.

FAA Airplane Design Group		Maximum Wingspan Feet	Maximum Wingspan Meters	Typical Aircraft	NBEG Index
I.	Small Regional	49	15	Metro	0.4
II.	Medium Regional	79	24	SF340/CRJ	0.7
III.	Narrowbody/Lrg. Regional	118	36	A320/B737/DHC8/E175	1.0
IIIa.	B757(winglets)	135	41	B757	1.1
IV.	Widebody	171	52	B767/MD11	1.4
V.	Jumbo	214	65	B747,777,787/A330,340	1.8
VI.	Super Jumbo	262	80	A380/B747-8	2.2

Source: Hirsh Associates

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Gate Demand model** provided in *Volume 2: Spreadsheet Models and User's Guide.* This part of the model shows how the equivalent NBEG or EQA are determined using the index factors illustrated in Tables V-6 and V-7 through a cumulative summation.

Group IIIa has been added to more accurately reflect the B757, which has a wingspan wider than Group III but substantially less than a typical Group IV aircraft.

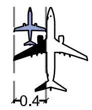
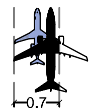
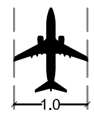
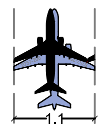
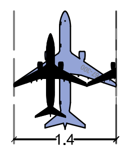
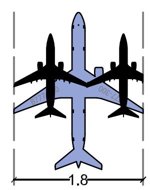
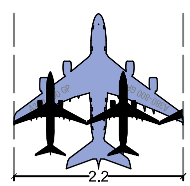
In developing terminal facilities requirements, the apron frontage of the terminal, as expressed in NBEG, is a good determinant for some facilities, such as secure circulation. Terminal concepts also can be more easily compared by normalizing different gate mixes. Figure V-18 depicts NBEG comparison.

V.3.10.2 Equivalent Aircraft

The concept of EQA is similar to that of NBEG, which is a way to look at the capacity of a gate. EQA, however, normalizes each gate based on the seating capacity of the aircraft that can be accommodated. The EQA measure was originally developed in the early- to mid-1970s as a technique for sizing terminal facilities and comes from *The Apron & Terminal Building Planning Manual* (*2*). When the manual was developed, the majority of jet aircraft had 80 to 110 seats, thus the EQA measure centered on the 80- to 110-seat range. Smaller aircraft had an EQA of 0.6 and larger aircraft fell into seating ranges with the center of the range determining the EQA of that range. One hundred seats was equal to 1.0 EQA, aircraft in the 211- to 280-seat range had an EQA of 2.4, and so forth.

In considering the modern fleet mix of regional and jet aircraft, and in order to have some relationship with the physical parameters associated with the NBEG, the basis of EQA has been revised from the 1970s definition. The current EQA is also a Group III narrowbody jet. Most of the larger aircraft in this class typically have 140 to 150 seats. Therefore, the basis of 1.0 EQA is 145 seats. As with the concept of NBEG, smaller aircraft may use a gate, but the EQA capacity is based on the largest aircraft and seating configuration typically in use. (See Table V-8).

While most terminal facility requirements are a function of peak hour passenger volumes, some airline facilities are more closely related to the capacity of the aircraft. For example, while the total number of baggage carts required for a flight are a function of peak hour passengers

Airplane Design Group (ADG)	Maximum Wingspan Feet	Maximum Wingspan Meters	NBEG	
I. Small Regional	49	15	0.4	 No. of Narrowbody Aircraft in wingspan of ADG I Aircraft = 0.4
II. Medium Regional	79	24	0.7	 No. of Narrowbody Aircraft in wingspan of ADG II Aircraft = 0.7
III. Narrowbody	118	36	1.0	 No. of Narrowbody Aircraft in wingspan of ADG III Aircraft = 1.0
IIIa. B757	135	41	1.1	 No. of Narrowbody Aircraft in wingspan of ADG IIIa Aircraft = 1.1
IV. Widebody	171	52	1.4	 No. of Narrowbody Aircraft in wingspan of ADG IV Aircraft = 1.4
V. Jumbo	214	65	1.8	 No. of Narrowbody Aircraft in wingspan of ADG V Aircraft = 1.8
VI. Super Jumbo	262	80	2.2	 No. of Narrowbody Aircraft in wingspan of ADG VI Aircraft = 2.2

Source: Hirsh Associates and Landrum & Brown

Figure V-18. Narrowbody equivalent gate comparison.

Table V-8. Equivalent aircraft index.

FAA Airplane Design Group	Typical Seats	Typical Aircraft	EQA Index
I. Small Regional	25	Metro	0.2
II. Medium Regional	50	SF340/CRJ	0.4
III. Large Regional	75	DHC8/E175	0.5
III. Narrowbody	145	A320/B737/MD80	1.0
IIIa. B757 (winglets)	185	B757	1.3
IV. Widebody	280	B767/MD11	1.9
V. Jumbo	400	B747,777,787/A330,340	2.8
VI. Super Jumbo	525	A380/B747-8	3.6

Note: With updated values based on today's equivalent aircraft (Group III).
Source: *The Apron & Terminal Building Planning Manual*, for U.S. Department of Transportation FAA, by the Ralph M. Parsons Company, July 1975.

(and their bags), the number of carts staged at any one time are generally based on the size of the aircraft. Thus, the EQA capacity of the terminal can represent a better indicator of demand for these facilities.

The number of seats in each ADG can vary considerably from the basic definitions. For example, larger regional jets in Group III can be in the 100- to 110-seat range, while a Group III A321 narrowbody can have over 180 seats. Similarly, as fuel economy and range become more important, most widebody aircraft are being designed with wider wingspans in Group V but may have seating capacities in the low 200s. For a given airport, it may be appropriate to modify the EQA metrics to better match the fleet mix expected when using EQA to determine some terminal facilities.

CHAPTER VI

Terminal Building Facilities

The planner of today's airport passenger terminals must address a wide range of differing needs. While the goals of functionality and flexibility remain paramount, the planner must also consider ways of creating a building layout and environment that supports the highest levels of passenger service and facilities in balance with the size of the building envelope and available budget. Terminal building projects are a major investment commitment, both as a direct expense in terms of rates and charges and as an indirect cost if poorly planned and consequently under-utilized or expensive to operate. Planners must also be innovative in the ways of creating spaces that maximize concessions' revenues. This challenge includes creating areas where passengers may be expected to spend significant periods of time (food courts/retail nodes, etc.), as well as heavily trafficked concourses where travelers move quickly and purposefully to or from their gate and have limited time to make purchases.

In addressing these diverse needs and challenges, the terminal planner must work closely and effectively with the airport client, the airline customers, and other business stakeholders. The planner must also exercise firm but sensitive leadership within a team of professionals including the architect, engineers, and specialists in a wide range of technical disciplines such as information technology and security systems, baggage handling, people mover systems, and ground transportation planning.

This chapter begins by setting out the overarching planning considerations that should guide the planner when setting out to quantify the terminal facility requirements and develop the terminal program. This chapter also discusses in detail the methodologies for quantifying the amount of space required to accommodate key passenger processing functions and how the methodology applied can influence the type of facilities and equipment specified.

The chapter also provides a fuller understanding of the service objectives and modalities underpinning some key operational functions such as airport security, baggage handling systems (BHS), and IT. While the terminal planner cannot and is not expected to be an expert in all of these fields, it is important that terminal planners have a good grasp of the relevant operational and functional requirements that will drive the spatial and building layout considerations.

In essence, this chapter of the Guidebook contains information needed to undertake the terminal planning and design process previously described in Chapter II. The first step in this process is to gain a clear understanding of the mission for the project. In-depth discussions with the sponsor and primary stakeholders in the project assist the planner in identifying the project's mission. With an understanding of the mission, and as the planning process begins, there are key terminal planning issues and concept types to consider. Quickly identifying the mission and concept type allows the planner to better define both the terminal facility and systems requirements for the project. This chapter provides guidance in addressing the following categories of items involved when developing terminal building facilities:

- Terminal planning and design considerations
- Terminal concept development
- Terminal facility requirements
- Other building considerations

VI.1 Terminal Planning and Design Considerations

At the start of a terminal planning project, there are a number of key terminal planning considerations with ramifications for the terminal's ultimate design that should be explored and discussed with the airport terminal sponsor and key stakeholders. The considerations presented in this section will focus on the terminal building itself as compared to the more macro considerations such as land use compatibility, Airport Master Plan, ground access transportation, terminal site, environmental, and business planning strategies that have been previously discussed in Chapter III. Specifically, this section will address the following terminal planning considerations:

- Mission
- Balance
- Level of service
- Passenger convenience
- Flexibility
- Security
- Wayfinding and terminal signage
- Accessibility
- Maintenance

VI.1.1 Mission

The airport terminal is the major connection between the ground access system and the aircraft. It consists of a ground access interface, a system of components for the processing of passengers and their baggage, and an aircraft or flight interface. It includes facilities and amenities for the processing of passengers and baggage; cargo handling; and airport administration, operations, and maintenance.

In the terminal building, as well as its airside and ground access interfaces, facilities may be nearing capacity and, in some cases, may have even exceeded their design limitations. Airside areas can be saturated sometimes during peak periods with both maneuvering restrictions and physical limits to accommodate existing or any future aircraft demand. Terminal and passenger concourse facilities may also be cramped and too physically constrained for needed future expansion to occur. While forecast airside capacity typically drives future terminal requirements, constructed facilities must be in balance with ground access capacities and capabilities that include not only parking and curb frontage but also accessibility to and from the airport. Planning for the airport's infrastructure is typically associated with a long-term planning horizon from an Airport Master Plan or developed from the best available information. Inevitably, however, there will be many changes of usage, need, priority, and policy during the lifetime of these investments, so flexibility and the ability to adapt facilities to such changes are vital. Furthermore, it is extremely important to understand that opportunities to increase terminal facility capacity are rare opportunities within the nation's system of airports. Open land areas and existing terminal infrastructures at airports are a limited resource. Each terminal planning project requires careful study and deliberation to maximize each opportunity and to successfully plan for changing airport demand and operational requirements.

Guidance in the planning of airport terminal facilities at commercial service airports is complicated by a variety of factors that affect planning decisions:

- Existing configuration and size of airport facilities
- Volume of airport traffic
- Airport service area
- Passenger characteristics
- Presence and proportions of domestic and international service
- Airline route and station characteristics
- Operating procedures and policies
- Aircraft fleet mix
- Extent of non-scheduled airline service

Apart from obvious influences, such as physical size and topography, some of the more significant characteristics that influence the airport terminal plan include the following:

- Population profile of the area served
- Per capita income and the potential for growth
- Geographic location of the airport relative to other airports with similar service characteristics
- Degree of commercial/industrial activity that may generate a relatively high propensity for air transportation
- Proximity of major vacation or recreational areas.

There are two basic categories of passengers: business travelers and leisure travelers. Significant variations in the characteristics and ratio of these two passenger types can influence terminal space requirements and staffing. Local business travelers will be familiar with the airport and its processing procedures, will arrive at the airport nearer to flight departure time, may spend whatever time they have in an airline lounge, and thus may be less likely to use the full range of terminal services and concessions. Leisure travelers are more likely to arrive well in advance of flight departure time, have time to explore and use a wider range of terminal facilities, and generate a larger number of well wishers and/or meeters and greeters. At one end of the spectrum, an airport serving a vacation or resort area, perhaps with a relatively short season of intense activity, will have quite different planning requirements from an airport handling comparable peak-month volumes throughout the year and a high proportion of business travelers.

The extent to which passengers are accompanied or met by visitors influences the planning of various terminal facilities. In particular, all terminal facilities must accommodate, as smoothly as possible, passengers and visitors with physical or mobility limitations.

Airports with international flights have other characteristics that influence terminal planning and design. One such characteristic is a tendency toward higher aircraft activity peaks, because of the heavy dependence on schedules for city pairs related to time zone differences. Such flights typically have relatively long ground service times required for long-range aircraft servicing. Additional requirements for customs and immigration facilities and the provision of sterile areas for international passenger segregation also affect terminal planning.

The route structures of the scheduled airlines serving an airport influence the character and, consequently, the facility requirements of the terminal. Over the years, most major airlines have changed their route structures from a line-haul system with a series of intermediate stops to a hub-and-spoke system. The primary function of the hub is to optimize airline scheduling and load factors by feeding passenger traffic to and from smaller centers of demand (the spokes) and then consolidating demand for onward service at the hub. The services provided by airlines generally fall into three categories:

- O&D service accommodates passengers who start or end their particular journey at the airport, whether a hub or spoke city. As a result, they generate the preponderance of demand for key passenger processing functions such as ticketing and check-in, passenger and baggage security screening, baggage reclaim, and ground transportation services.
- Through service tends to have a relatively lower boarding load factor for O&D passengers at any given city because the aircraft capacity is shared among the number of city pairs served by that route. Therefore, terminal passenger processing function demands are reduced as compared to flights that serve a single destination or hub.
- Transfer, or connecting, service has a significant proportion of passengers transferring between flights at the same airport, therefore generating less proportional demand for curb frontage, passenger check-in, and baggage claim facilities, but more demand for concessions, flight information, ticket change, and baggage transfer facilities. For transfer airports, there are typically higher load factors requiring larger holdrooms.

Often airports will have a combination of airlines providing various types of service and, therefore, the type of service provided by a particular airline at an airport will determine the facility requirements for that airline. Similarly, the existence of, or the potential for, inter-airline operating agreements will influence facility needs at an airport to the extent that the sharing of particular facilities is desired and implemented.

The mix of aircraft expected to use an airport, specifically their physical size, geometry, and passenger capacity, can significantly affect terminal planning. Airports serving a large variety of aircraft types and sizes require more flexible and complex gate/concourse configurations than those serving predominantly one class of aircraft, which are more conducive to the provision of standardized areas and facilities at, and adjacent to aircraft gate positions. Terminals at airports serving widebody aircraft require the ability to accommodate the large passenger surges, which normally occur when these aircraft load and unload. Similarly, airports with a significant amount of commuter or small regional aircraft, particularly at transfer airports, require careful consideration on the mechanisms for accommodating these aircraft and the facilitation of passenger transfers between connecting flights.

Many commercial service airports serve a variety of non-scheduled operations such as charter flights, group tour flights, and air-taxi operations. At some airports, a relatively high volume of airline charter or other non-scheduled operations may warrant consideration of separate, modest terminal facilities for supplemental carriers. Occasionally, scheduled carriers may desire separate apron hardstands and buildings to serve charter operations that exceed the capabilities of facilities required for normal scheduled operations. Any such proposal should be evaluated thoroughly, because a separate facility can often create inefficiencies in logistics, staffing, and ground equipment utilization.

Each of the factors discussed above, as well as other factors, have the potential for influencing the configuration and size of terminal buildings. Standards and guidelines for determining facility needs should, to the extent possible, address the variability introduced into the planning process through the consideration of these factors. Terminal planners need to review those factors with airport management and the other stakeholders at the airport to ascertain which factors influence the facility requirements at the subject airport and the effect of such factors on overall facility planning.

VI.1.1.1 Operational Mission

Before terminal configuration alternatives can be developed, how the new terminal is to operate must be understood. A careful study of the Airport Master Plan or Terminal Program will identify what assumptions were made for terminal operation and passenger throughput. This study will identify if the terminal is expected to be operated primarily as a hub transfer terminal, O&D terminal, or commuter terminal. Each type of terminal tends to perform better in certain configurations than others. Therefore, understanding terminal operational characteristics will help to rationalize the number or types of alternatives that will need to be generated and evaluated.

Domestic and International Terminals. One of the primary distinctions of the mission of a terminal facility is whether it will be processing only domestic passengers, dedicated to international operations, or handling both domestic and international passengers. Facilities serving international operations must comply with the requirements of the U.S. Customs and Border Protection described in *Airport Technical Design Standards—Passenger Processing Facilities* (*12*). The facility requirements for international arrivals are described in Section VI.3, Terminal Facility Requirements, and the flow of passengers and baggage through international terminals is depicted in Section VI.2.2, Flow Sequences.

Examples of U.S. terminals that are specifically dedicated to international operations include Terminal 5 at Chicago O'Hare International Airport and the Tom Bradley Terminal at Los Angeles International Airport. Examples of terminals that handle both international and domestic passengers include International Terminal D at Dallas/Fort Worth International Airport and Concourse A at Denver International Airport. Having the ability to "swing" the use of aircraft gates between international arrivals and domestic departures/arrivals provides additional flexibility and higher utilization of the gate resource, and also avoids the need to tow the aircraft to a domestic terminal gate when the operation changes. This flexibility requires a separate sterile corridor to each gate with doorways that prevent the mixing of international arrivals with domestic passenger flows, which does add additional complexity to the design and construction cost of the terminal facilities.

O&D Operations. O&D/terminating terminals require a good balance between accommodation for landside functions (ticketing, security screening, baggage claim) and airside functions (concourse, holdrooms/gates) because all passengers, either originating (enplaning) or terminating (deplaning) pass through both sectors of the terminal. Here, the key element is minimizing walking distances between curb and gate, and vice versa. Therefore, pier or linear terminals offer better configurations than a satellite or transporter terminal because passenger flows are intuitive and movements or changes in direction are minimized.

Connecting Hub Operations. In hub terminals, connecting passengers remain on the secure airside of the terminal complex transferring between aircraft, rarely entering the unsecured landside of the terminal. This occurrence increases airside usage and reduces the load on landside functions. This imbalance in landside and airside capacity will have an effect on the overall terminal configuration; in particular, transfer flows must be made to be as easy as possible and without many changes in direction. A well-designed concourse will allow rapid turnaround times for aircraft and, therefore, higher gate utilization. For hub terminals, the ticketing and baggage claim facilities need not relate directly to the airside concourse because movements between these functions are less than movements between gates. However, even at a large hub airport, 30% to 60% of activity will be O&D passengers and must be considered in developing the terminal concept.

Linear and linear/satellite configurations tend to function better for hubs because most movements are contained in a single concourse while allowing the terminal functions to be sized appropriately or even separately. Transfers within a single concourse allow passengers to change gates quickly and easily and enable airlines to schedule tight connection times. In large hubs, like Atlanta or Denver, that have multiple concourses connected by a people mover system, longer connecting times must be allowed for passengers required to move between concourses. Concourses with a single pier are effective hub configurations but may need to be comparatively long, requiring a very deep site. Multiple piers, on the other hand, tend to increase walking distances, create confusion in wayfinding between piers, and usually require a long site to accommodate efficient aircraft movements between piers.

Commuter/Regional Operations. In addition to hub and O&D operations at an airport, it is important to understand the effect of commuter/regional activities anticipated for the new terminal. In developing alternative configurations, propeller or jet regional aircraft have significant effect on the apron, as well as terminal space requirements. The Airport Master Plan or Terminal Program will indicate the amount of regional traffic expected at the new terminal. This traffic demand will indicate activity levels that must be accommodated by the terminal configuration. If a large number of regional aircraft are anticipated at a hub facility, a linear configuration might be appropriate because it allows for easier transfer between aircraft. At an O&D airport, a pier configuration might be more appropriate if one pier or one side of a pier is to be used for regional aircraft. This configuration can allow for more efficient use of space, but care must be given to minimize the effect of jet blasts from larger aircraft.

Regional aircraft also affect the use of apron space. Propeller aircraft usually power-in and power-out by rotating in position. This maneuver requires more apron area than the conventional power-in and push-back operation, which is more indicative of jet aircraft. This increased area might reduce the space available for the gate concourse building on the site, thereby reducing the number of possible alternative configurations. Because regional aircraft have lower sill heights than large jets, the relationship between aircraft and terminal floor elevations becomes very important. In multi-level terminals with second level boarding, the relationship between the holdroom floor elevation to the aircraft door is critical, especially with the trend toward using passenger loading bridges to connect the building to regional aircraft. Here, the slope of the bridge must not exceed ADA requirements. If a terminal section is too high, this connection becomes costly and problematic.

VI.1.1.2 Low-Cost Air Carriers

Low-cost or "no frills" carriers have traditionally served low-budget leisure travelers but increasingly are also attracting cost-conscious business travelers. Many low-cost carriers operate high-frequency, point-to-point services that rely on very fast turnaround times to optimize operating efficiencies. Because every dollar of airport-related cost is significant to the bottom line and ultimately the ticket price, low-cost carriers frequently build their operational network at lower cost secondary airports. Some larger airports that cannot lower their basic charges have built separate and more modest terminal facilities to accommodate low-cost carriers. Such purpose-designed terminals can be tailored to suit their different operating characteristics such as a higher proportion of O&D flights to multiple destinations, and fewer through and transfer passengers. Low-cost carriers do not typically "interline" (sell tickets or transfer luggage) with other carriers, which allows the low-cost carriers to operate independently from other carriers. Low-cost carriers usually deploy only one or two types of aircraft, which streamline and simplify operations (maintenance, training, gate utilization, and ease of operation to name a few attributes). General implications for terminal performance follow:

- Low-cost structure: It is important for the airport to offer low-cost options for passenger parking, tenant lease space, operation and maintenance costs, and reasonable landing fees. A good concessions program, with a variety of reasonably priced food and beverage offerings for consumption on board, is also desirable to serve passengers and raise revenue for the airport.
- High-frequency markets: The airport will be able to get better overall gate utilization because of the high frequency of flights and more flights spread throughout the day. The curbsides, lobby, checkpoints, concourses, gates, and claim areas should all be sized appropriately to accommodate sustained high volumes of traffic.

- Decreased turnaround times: The quick turnaround times mean less time between departing flights, which tends to generate a need for a slightly larger than normal holdroom for the aircraft type used because some passengers for the subsequent flight will begin showing up while departing passengers for the current flight are using the holdroom. The apron parking, equipment staging, baggage loading and unloading, and cleaning and fueling operations all need to be geared to supporting quick turnaround of the aircraft.
- Aircraft types: Because the aircraft fleet is uniform, gate striping and the layout are made easier. When one type of aircraft is being used, planning hydrant fuel systems, deicing facilities, and hangar projects is easier.
- Non-interlining: By not interlining, carriers avoid complications that result in delays and problems with transfers of luggage and passengers between multiple concourses and terminals. Elaborate baggage systems are not typically necessary for baggage transfer.
- Secondary airports: Because of cost, ease of turns, and added congestion to large airports, low-cost carriers are drawn to secondary airports that are typically not over-crowded and congested, slot controlled, or growth constrained. The secondary airports in proximity will typically draw this type of business from larger airports, which tend to attract passengers from outlying areas as well. This tendency should be factored into growth forecasts. Secondary airports may not have the infrastructure in place (access roads, parking lots, terminal building size, additional gates, and runway length capacity) to accommodate the increased passenger flows associated with the initial startup of an established low-cost carrier.
- Allow for growth: Low-cost carriers have a tendency to stimulate a given market by providing lower fares and forcing other carriers to follow suit. The net result is growth for that airport. It is important to promote that growth throughout all facets of the airport. When master planning, designers must provide for building growth, parking needs, appropriate utilities, airfield expansions (runways and taxiways), and roadway infrastructure.

VI.1.1.3 Remote Passenger Processing

The advent of increased security requirements at U.S. airports has tended to erode passenger convenience and the quality of the user experience. Next generation airports will need to be planned based on the continuing evolution of passenger processing technologies and potential new models for passenger and baggage check-in. Fundamentally reengineering the functionality and flexibility of next generation airport terminals will involve optimizing an integrated system of passenger processing and utilizing the benefits of current and new technologies to supplement existing terminal processing capacity at remote locations.

The technological advancements of Common Use Terminal Equipment (CUTE) and Common Use Passenger Processing System (CUPPS) are enabling more and more passengers to check-in online or at off-airport locations, such as rail terminals or hotels, by means of airline exclusive-use and common-use self-service kiosks. This trend is likely to progressively reduce the amount of space in terminal buildings that needs to be programmed for conventional check-in procedures.

Today, the majority of airline ticketing kiosks connect passengers into the airline host system and allow passengers to confirm reservations, receive boarding passes, and make changes to itineraries, including rebooking flights and altering seating assignments. As such, it has become the mode of choice for frequent travelers and those seeking to avoid long lines at ticket lobbies. In remote locations such as parking garages, curbsides, rail transit stations, and hotels, kiosks help disperse demand and supplement the capacity of the primary on-airport terminal.

The Internet, off-airport airline kiosks, and remote check-in services, typically at hotels and convention facilities (per TSA approval), make up the current available modes of checking-in outside of an airport. Kiosks and online check-in facilitate the ticketing of passengers virtually anywhere. These options have been generally perceived as the most operationally effective and minimal cost solutions to process passengers before they arrive at the airport. Some airlines have developed a system in which Internet check-in passengers can check their bags at the airport 24 hours prior to their departure.

Remote hotel check-in facilities accommodate both ticketing and checking in baggage. For a fee, third-party operators with a modified version of CUTE using a Virtual Private Network (VPN) connection into the airline host system can check passengers in from the hotel, issue boarding passes, and check passenger baggage. Using TSA-approved protocols to secure and monitor baggage, the operators drive the baggage to the airport for screening and make-up.

Contingent on TSA approval and concurrence, decentralizing the passenger check-in process as much as possible (as has been done in the past at busy rail stations and as is currently done in Europe and Asia) provides a major enhancement in the effort to extend the useful life of current passenger terminal facilities. However, the overall benefits and the costs of maintaining such systems require evaluation and further analysis on a case-by-case basis.

ACRP Report 10: Innovations for Airport Terminal Facilities (*34*) envisions that Common Use Self-Service (CUSS) will become widely implemented in U.S. airports and that passengers will be able to tag their own baggage, as currently allowed in Europe. As these technologies along with radio frequency identification (RFID) and wireless personal digital assistant (PDA) technologies continue to evolve, configurations for the airport terminal complex will need to evolve with them.

VI.1.2 Balance

Once the mission of the terminal project is understood, the terminal operator and planner need to examine the proposed mission within the context of a variety of considerations to ensure that all elements of the project are in appropriate balance. Achieving the correct balance between critical airport passenger terminal components is essential for a successful terminal project. The following paragraphs describe these elements.

VI.1.2.1 Airside, Terminal, and Landside Capacity Balance

First and foremost, it is important that the passenger throughput of the terminal stay in balance with the processing capacity of the airfield and ground access components. It is generally not cost effective to build a terminal facility that has a peak period passenger processing capacity greater than the ability of the runway system to handle the arriving and departing aircraft that deliver the peak hour passenger volumes. Therefore, the planning process should aim for balance to be maintained between the primary processing components of the airside, terminal building, and landside including the following:

- Airside—aircraft gates and airside accessibility
- Terminal—passenger and baggage processing systems
- Landside—airport roads, curb frontage, parking, ground transportation

In the case of existing terminal complex infrastructures, the terminal, as well as its airside/landside interfaces, may be nearing capacity and, in some cases, may have exceeded their design limits. Airsides may be saturated during peak periods with both maneuvering restrictions and physical limits to accommodate existing and future potential aircraft. While forecast airside capacity will drive future terminal requirements, the terminal facilities that are built must also balance with landside capacities and capabilities if the overall airport is to function efficiently.

The issue of airside, terminal, and landside capacity balance should take into account any seasonal swings in average daily and peak period demands to guard against under- or over-building. Depending on the desired level of service for the terminal, the planner should strive for balance between peak and non-peak requirements, routine and non-routine operations, and present and future needs.

VI.1.2.2 Macro Contextual Balance

In a similar manner to the terminal complex's component balance, the terminal mission and project must be assessed against the macro framework of the airport itself. This macro contextual balance should examine the terminal project in relation to the airport's role in the national and international air transportation network, applicable air traffic control system parameters, the traffic demand from the immediate region and neighboring communities, and regional and city transportation plans.

VI.1.2.3 Terminal Processing Capacity Balance

What holds true on a macro basis also applies to the micro issues of aircraft operations and key passenger and baggage processing functions such as check-in, baggage make-up, security screening, gate management, and inbound baggage claim, etc. Computer simulations are often a useful tool in checking that each terminal passenger and baggage processing function is in appropriate balance with one another, thereby ensuring that no single function becomes a bottleneck that adversely affects the overall LOS. For airports that operate multiple unit terminals, it may sometimes be advisable to step back and review the allocation of specific airline activity between the existing terminal complex infrastructure in order to balance more effectively airline missions with unit terminal capacities and minimize the risk of building unnecessary additional capacity.

VI.1.2.4 Mission Balance

It is important for all stakeholders in a terminal project to keep in mind that a balance must be reached between planning for the LOS expected by the traveling public and achieving the goals of the air carriers for efficient operations at minimum cost. Passenger processing solutions of the future must be able to not only contain cost, but also work effectively to meet customer service standards.

VI.1.2.5 Total Terminal Project Balance

To achieve success with any terminal planning, design, and construction project, it is necessary to bring the factors of size, budget, quality, and schedule into alignment at the very start and maintain this balance throughout the project. All four factors need to be studied individually and collectively to achieve appropriate project balance. This balance needs to be achieved within both the planning and design stages and maintained during construction itself.

VI.1.3 Level of Service

While the concept of LOS can be a simple one to define in terms of the qualitative and quantitative parameters for each terminal component, actual measurement of the LOS and forecasting what the LOS might be in a new facility is more problematic.

LOS is a term that has been freely used by most terminal planners and airport operators but is not fully understood by most people. Adding to this confusion are terms like "world class," which are even less well defined.

LOS, in the context of airport terminal planning, is a generic term that describes, either qualitatively or quantitatively, the service provided to airport travelers at various points within the airport terminal building. It often relates to the degree of congestion or crowding experienced by travelers at the passenger and baggage processing facilities in the terminal building. It may also be a measure of the amount of waiting or processing time, or the length of the queues or lines encountered by such travelers at these facilities.

VI.1.3.1 Background

The concept of LOS, as applied to airport terminal design, was originally developed by Transport Canada (TC) in the mid to late 1970s because the then current definitions of "capacity" were considered inadequate. TC modeled its approach to define LOS on principles originally applied to traffic engineering, as well as work carried out by John Fruin a few years earlier for the bus and train terminals operated by the Port Authority of New York and New Jersey. Both of these approaches used a six-level scale (A-F) ranging from excellent to system breakdown.

TC, in *Interim Level of Service Standards* (*35*) and *Airport Services and Security* (*36*), developed a set of definitions for LOS and then made detailed observations of passenger activity at a limited number of mostly small airports in 1976. These studies were the beginning of the Canadian Airport Systems Evaluation (CASE) methodology. Coupled with an approach that followed individual passengers through the departures and arrivals processes (using a time stamp method), TC was able to calculate the amount of time passengers spent in different areas of the terminal and the passenger densities. This survey resulted in a range of areas per person that covered the different LOS definitions. Subsequent surveys at other airports helped refine the survey methodology and computer analysis programs, but did not change the initial areas/person assumptions.

An airport terminal is a series of processors, reservoirs or holding areas, and links or corridors. The LOS framework as developed by TC (and subsequently adopted by IATA) only addressed the LOS within holding areas and ignored how long passengers had to wait (i.e., the LOS associated with the processors themselves). At the time, it was recognized that processor LOS was important and additional work would be required, but that part of the study never proceeded far enough to be published.

The TC LOS definitions were as follows:

- A Excellent LOS; conditions of free flow; no delays; direct routes; excellent level of comfort.
- B High LOS; condition of stable flow; high level of comfort.
- C Good LOS; condition of stable flow; provides acceptable throughput; related systems in balance.
- D Adequate LOS; condition of unstable flow; delays for passengers; condition acceptable for short periods of time.
- E Unacceptable LOS; condition of unstable flow; subsystems not in balance; represents limiting capacity of the system.
- F System breakdown; unacceptable congestion and delays.

TC recommended that LOS C should be the design standard as it "denotes a good service at a reasonable cost" and "It is understood that LOS A is open ended on the high side." It was also recognized that terminal traffic demands are dynamic, varying according to flight schedules and loads, and that LOS and capacity are interrelated:

> Capacity is a measure of throughput or system capability. Since an airport is capable of operating at varying degrees of congestion and delay, the capacity figure must always be related to the LOS being provided. For example, a particular system might be able to process 1,000 passengers/hour at a good LOS or 1,500 passengers/hour at a poor LOS (greater congestion). (*35*)

The LOS framework recognized the difficulty in quantifying waiting and processing times within the relevant definitions and thus only proposed standards for the five primary reservoirs of a terminal: check-in (queue and circulation), waiting/circulation (not well defined in the reports), holdroom, bag claim area (without claim unit), and pre–Primary Inspection Line (PIL) or Border Control–related queuing.

Table VI-1 combines these definitions and the observations into ranges of areas per occupant. The purpose was to indicate a good LOS and the point at which system breakdown occurs. The time element, even for a reservoir, was also considered important.

> It is obvious that any subsystems operating above LOS C should not have a time standard associated with them, since the terminal could theoretically operate all day at this LOS. However, once the LOS drops below

Table VI-1. Transport Canada LOS standards.

	Level of Service Ranges (Square Meters Per Occupant)					
SYSTEM:	A	B	C	D*	E*	F
Check-In	17.2FT^2 /1.6M^2	15.1FT^2/1.4M^2	12.9FT^2 /1.2M^2	10.8FT^2 /1.0M^2	8.6FT^2 /.8M^2	
Wait/Circulate	29.0FT^2 /2.7M^2	24.8FT^{2}2.3M^2	20.5FT^2 /1.9M^2	16.1FT^2 /1.5M^2	10.8FT^2 /1.0M^2	Subsystem
Holdroom	15.0FT^2 /1.4M^2	12.9FT^{2}1.2M^2	10.8FT^2 /1.0M^2	8.6FT^2 /.8M^2	6.5FT^2 /.6M^2	
Bag Claim Area (Without Device)	17.2FT^2 /1.6M^2	15.1FT^{2}1.4M^2	12.9FT^2 /1.2M^2	10.8FT^2 /1.0M^2	8.6FT^2 /.8M^2	Breakdown
Pre–PIL 1.4	15.1FT^2 /1.4M^2	12.9FT^{2}1.2M^2	10.8FT^2 /1.0M^2	8.6FT^2 /.8M^2	6.5FT^2 /.6M^2	

* For the periods up to 15 minutes within the design hour.

Source: *Interim Level of Service Standards,* Transport Canada, CASE 1977, and *Airport Services and Security,* AK-14-06-500, Transport Canada, Revision No. 1, January 1979

> C a time duration factor is added equating to a standard of 15 minutes duration during the [design hour]. For example, if the holdroom is at LOS D for greater than 15 minutes during the [design hour], then the facility is judged to be one level lower, LOS E. Similarly, if LOS E is exceeded for 15 minutes, the facility would be assessed at an intolerable LOS F. (*35*)

The 15-minute duration might consist of multiple short durations or a single 15-minute or longer duration. This distinction was considered especially important at small terminals, which might experience peaks of less than 5 minutes.

Although TC continued its airport surveys to cover most Canadian airports, the basic area per person ranges were never refined. The focus of the research shifted to developing easier ways to track passengers and, ultimately, how to simulate terminal activity.

The TC concept was adopted by Airport Authorities Coordinating Council (AACC), now Airports Council International (ACI), and IATA and published as part of AACC/IATA's *Guidelines for Airport Capacity/Demand Management,* second edition, in 1990. A third edition was issued in 1996 without any substantial changes to this approach.

The definitions were modified as follows and have remained the IATA LOS definitions that most people use:

A Excellent LOS; condition of free flow; no delays; excellent level of comfort.
B High LOS; condition of stable flow; very few delays; high level of comfort.
C Good LOS; condition of stable flow; acceptable brief delays; good level of comfort.
D Adequate LOS; condition of unstable flow; acceptable delays for short periods of time; adequate level of comfort.
E Inadequate LOS; condition of unstable flow; unacceptable delays; inadequate level of comfort.
F Unacceptable LOS; condition of cross flows; system breakdown and unacceptable delays; unacceptable level of comfort.

Notice that terminology describing any associated delays is slightly more defined and that LOS E is not as "unacceptable" as in the TC definitions. It appears that AACC and IATA were extending LOS definitions to cover more dynamic link elements of the terminal as compared to the reservoirs that TC focused on. The AACC/IATA definitions also eliminated the TC references to related subsystems in balance at LOS C, which implied that there were linkages between some elements of the terminal. AACC/IATA retained the recommendation of designing to LOS C and the "15-minute rule."

Table VI-2. IATA LOS standards.

	Level of Service									
TERMINAL AREA	A		B		C		D		E	
Check-in Queue Area	19.4FT²	1.8M²	17.2FT²	1.6M²	15.1FT²	1.4M²	12.9FT²	1.2M²	10.8FT²	1.0M²
Wait/Circulate	29.0FT²	2.7M²	24.8F²	2.3M²	20.5FT²	1.9M²	16.1FT²	1.5M²	10.8FT²	1.0M²
Hold Room	15.0FT²	1.4M²	12.9FT²	1.2M²	10.8FT²	1.0M²	8.6FT²	0.8M²	6.5FT²	0.6M²
Baggage Claim	21.5FT²	2.0M²	19.4FT²	1.8M²	17.2FT²	1.6M²	15.1FT²	1.4M²	12.9FT²	1.2M²
Government Inspection Services	15.1FT²	1.4M²	12.9FT²	1.2M²	10.8FT²	1.0M²	8.6FT²	0.8M²	6.5FT²	0.6M²

Source: *Guidelines for Air Capacity/Demand Management,* Third Edition, ACI/IATA, 1996

Although AACC (later ACI) and IATA jointly promoted the use of these LOS definitions and standards, they have been generally referred to as IATA standards because of their inclusion in the various editions of IATA's ADRM (*3*). For simplicity, the Guidebook will refer to them as IATA standards and definitions. The IATA table of LOS areas (see Table VI-2) included the same five reservoirs but, instead of ranges, assigned an area to each LOS level (in square meters/person).

Interpretation of this table has confused many planners since it was released. For example, is 1.1 square meter/person for holdroom areas LOS B or C? In the TC table, it was clear that 1.1 square meter/person for holdroom areas would be LOS C. So the areas per person in the IATA table should be considered the minimum for each LOS, and any area per person less than those in the E column is considered LOS F.

Although the IATA LOS definitions include references to delays, there has been no quantification of these delays or any other time-based LOS standards, except for some planning standards for maximum queuing times at "world class airports" in Figure B1.1 of IATA's ADRM (*3*). It is also interesting to note that the most recent IATA publication (ADRM 9th Edition) has dropped the reference to the 15-minute rule.

VI.1.3.2 Use of Level of Service in Sizing Facilities

Most terminal projects are not "green field" sites, and many involve modifications and/or expansions to existing facilities. Thus, it is important to understand the current LOS for the major terminal elements, in order to establish baseline conditions and what would be required to bring deficient areas up to acceptable levels. New terminals are, to some extent, easier to plan for LOS because the planner should be able to optimize functional relationships and flows more easily to achieve the target LOS.

As noted, LOS C is typically recommended as a design objective for the design hour because it denotes good service at a reasonable cost, with LOS A having no upper boundary. From a practical terminal planning perspective, the challenges are to determine the occupancy of reservoirs during the peaks and establish acceptable waiting times for processors.

One of the fundamental problems associated with adopting a set of such specifications is that the perceptions of terminal building stakeholders may differ considerably on the designation of the LOS standard that should be provided or on the metrics used to define LOS. Though it may be reasonable to expect some convergence of opinion on qualitative definitions of LOS, the translation of these qualitative statements into metrics is likely to result in a considerable divergence of opinion. For example, a planning objective expressed as a standard to provide a good LOS C, which might be described qualitatively as passengers experiencing acceptable delays and a reasonable level of comfort, could be expected to engender widespread support. However, when one associates a target quantitative space standard, queue length, or waiting time with this standard, it is likely to generate considerable disagreement depending upon the perspective of the stakeholder.

Furthermore, terminal planning and LOS should reflect the specific operational characteristics of the terminal, and the volume of passengers and baggage to be handled. Managing terminal capacity and planning with LOS in mind are key issues in developing competitive airports, with long-term financial and operational implications. Once a terminal is built, its size and features tend to be effectively permanent unless major additional investments are made, with significant effect on the cost of doing business and on the bottom line. The proper LOS standard provides a tradeoff between high utilization to minimize investments and high service quality and flexibility.

Recent research for ACRP Project 03-05, "Passenger Space Allocation Guidelines for Planning and Design of Airport Terminals," has indicated that in a well-designed terminal, passengers will flow to less crowded areas when densities increase beyond their comfort level. In short, passengers avoid experiencing an LOS lower than C unless forced to. This research is consistent with observations on queuing where passengers will not necessarily move closer to the person in front of them just because the queue behind them has overflowed the designated queue area. Thus, the boundary between LOS C and LOS D, according to IATA, is when a queue overflows its designated area.

As the degree of overflow from a queue or other reservoir increases, the overflow can block adjacent functions or circulation, and cause these to have lower LOS. This case brings back the significance of the original TC LOS C definition that included "related systems in balance." In the worst case, overflow can cause the LOS in these areas to deteriorate to the point where congestion occurs, or life safety issues become a concern.

VI.1.3.3 Level of Service in Existing Terminals

To fully assess the LOS in an existing terminal, three types of data are needed for each major terminal element:

1. Floor areas and processing rates: Areas are relatively easy to measure from existing plans. Processing rates can be collected by observation surveys and some data collected by airlines or other agencies. Please refer to *ACRP Report 23: Airport Passenger-Related Processing Rates Guidebook.*
2. Number of passengers in a process or reservoir: This number is more difficult to estimate without detailed surveys of activity and processing times.
3. The amount of time that passenger density exceeds a given LOS area per person or the percentage of waiting times that exceed target goals: This number is the most difficult to estimate and often requires simulations. To give accurate results, simulations require large amounts of data about existing conditions and passenger characteristics (item 2 above).

As noted, the CASE methodology of the 1970s involved giving all users entering the terminal a card that they carried with them throughout their stay in the terminal. Various checkpoints were set up that generally identified the interfaces between the different components (i.e., check-in, security screening, holdroom, etc.). Using a time stamp at each checkpoint, each person's flow through the various areas could be calculated, as well as passenger arrival and departure distributions. While such an approach could still be used to generate accurate, terminal-specific data, it is very labor intensive and expensive to collect on a terminal-wide basis.

Taking advantage of greater computing power has allowed simulations and spreadsheet models to utilize basic data (Item 1 above), combined with some airport-specific characteristics (such as arrival time distributions), to estimate Item 2 above. If done for a design hour or similar limited time period, spreadsheet models can determine waiting times and/or passenger densities and thus indicate the LOS. Obtaining more detailed statistics such as "95% of passengers in a design day wait *x* minutes" requires simulation-type tools, but the results are often more detailed than the underlying assumptions would support. Although models and simulations allow the planner to evaluate many types of future "what-if" scenarios, caution should always be used in selecting the underlying assumptions. Results can be only as accurate as the data used to develop the models.

Based on the history of the LOS concept, the different interpretations of how to apply it and the amount of data required to determine existing or forecast conditions accurately, it is recommended that terminal planners proceed cautiously. Taking LOS C as a benchmark, each airport client should be prompted to decide what LOS is appropriate for its passengers and tenants.

In Section VI.3, Terminal Facility Requirements, methodologies will be presented to estimate the major terminal elements. Some of these will be associated with a generally accepted LOS approach, while others will have a much looser connection to LOS as commonly defined. Some processes and reservoir elements lend themselves to spreadsheet modeling; these models were developed as part of ACRP Project 07-04 and are available in *Volume 2: Spreadsheet Models and User's Guide.* References to specific models and examples are provided in Section VI.3.

VI.1.4 Passenger Convenience

An important qualitative component of the LOS at an airport terminal is how passengers perceive their experience of transiting the airport in terms of comfort and convenience. While many factors may affect a passenger's perception of convenience, three primary factors are typically associated with airport passenger terminals:

- Distance a passenger must walk and the associated ease or difficulty involved in traversing this distance
- Passenger's feelings about the terminal facilities and ambiance
- Time associated with moving through the terminal

VI.1.4.1 Walking Distance and Ease of Travel

The only absolute in dealing with the topic of walking distances in airport terminals is that they should be kept as short as possible. An industry rule of thumb concerning maximum walking distance has been that, if the distance traveled exceeds 1,000 feet, then some sort of mechanical people-mover assistance should be added. While it is clearly advantageous to minimize walking distances and the stress and exertion experienced by the passenger, there is no clear research or industry reference that defines the maximum walking distance that is tolerable for a pedestrian over a specific route (i.e., curb to plane) in an airport terminal.

As stated by John J. Fruin, "walking distances are a subjective human variable, with relatively long walking distances being accepted under some circumstances and rejected under others" (*37*). Fruin does go on to state, in reference to data coming from studies of walking trips in downtown central business districts relating to bus terminals, that "Sometimes this data is used to justify moving-sidewalk installations for longer walking-trip distances, say 1000 feet" which may be the origin of this industry axiom. Referring specifically to airport terminals, however, Fruin comments:

> There are indications that the tolerable limit of human walking distance is more situation-related than energy-related. The maximum curb-to-plane walking distances represent a normal five- to seven-minute walk for most persons, but the anxiety connected with meeting schedules, making the trip, and negotiating an unfamiliar building, tend to make these distances appear to be much longer. The tolerable walking distance for a given situation is related to such factors as the trip purpose of the individual, available time and the walking environment, rather than energy consumption. (*37*)

The factors involved in a passenger's perception of the pedestrian journey generally center on the perceived level of effort needed to reach the destination and the complexity of the path traveled. This perceived level of effort typically includes ease of wayfinding and the ability to negotiate transition points along the path, such as changes from one level of the terminal to another, and will likely be affected by whether the passenger is carrying baggage. A passenger's perception of the convenience of the distance traveled will be influenced by the availability of appropriate mechanical aids such as moving walkways, escalators, elevators, and more sophisticated APM systems. These sorts of aids are becoming increasingly necessary as aircraft wingspans continue to increase and the distance between gates is extended further. This is particularly true at airports that have a large proportion of widebody aircraft gates.

The perception and ease of walking distances in airport terminals can be affected by the amount of baggage the passenger is likely to have at each stage as follows:

- Originating passengers—may have baggage to be checked between ground transportation and the check-in lobby. Carry-on bags are a consideration from ground transportation to the aircraft.
- Terminating passengers—may have baggage that was checked between the baggage claim area and ground transportation. Carry-on bags are a consideration from the aircraft to ground transportation.
- Connecting passengers—may have carry-on bags between aircraft gates.

Thus, there is a benefit to keeping routes for passengers with checked baggage as short as possible with limited (if any) level changes. The sooner a passenger can turn his/her bag over to an airline representative (either on or off airport), the higher the LOS for this portion of the trip. Because almost all passengers have carry-on bags of some type, terminal planners should consider the effects of long distances traveled either carrying or pulling bags within the terminal.

VI.1.4.2 Passenger Perception

A passenger's perception of a particular terminal's LOS will be governed both by tangible and intangible factors. Tangible factors include whether the temperature of the terminal is comfortable, the availability and cleanliness of restroom and baby care facilities, adequate seating in common areas, and a good variety of reasonably priced retail and food and beverage concessions. Intangible factors include the helpfulness and friendliness of staff, ambient noise levels, and the relative level of stress involved in moving through the various processing functions. From a planning and design perspective, the following factors should be addressed:

- Wayfinding: The ability of passengers to make their way easily through the airport terminal facility is an important requirement. There are three primary factors that contribute to this ability:
  - A terminal layout in which the various functions progress logically and preferably in a straight line
  - A terminal design that allows a passenger clear sightlines to what lies ahead
  - Appropriate signage, directions, and other assistance to wayfinding (Wayfinding and signage are discussed in greater detail in Section VI.1.7, Wayfinding and Terminal Signage.)
- Passenger amenities: Another factor that enhances passenger perception of a terminal is a wide range of amenities. In today's terminals, amenities include access to Wi-Fi and power connections, as well as the passenger service facilities and commercial offerings mentioned above.
- Facility design: Not to be overlooked is the role that good architectural and interior design can play in enhancing a passenger's experience of traversing the facility through the creation of a sense of light and spaciousness and the inclusion of green plants and appropriately themed materials and colors for the internal finishes of the building.

VI.1.4.3 The Value of Time

Planners and designers have always assumed that it is important to create a terminal facility that facilitates a passenger's quick and direct movement from the curb to the plane, plane to curb, and plane to plane. Recent research undertaken in ACRP Project 03-05, "Passenger Space Allocation Guidelines for Planning and Design of Airport Terminals," is finding that, given the additional stresses placed on air travelers by security screening procedures resulting from the attacks of

September 11, 2001, passengers are valuing the ability to quickly move through the terminal as a primary factor in their determination of passenger convenience.

VI.1.5 Flexibility

The airport terminal is a modern building type that is particularly prone to obsolescence. The primary risk involved is functional obsolescence, which renders the terminal operationally compromised, unable to function at the desired LOS, and incapable of being modified or physically upgraded at acceptable cost.

Even though architects aspire to the permanence of monumental civic architecture, airport passenger terminals are perhaps uniquely vulnerable to the sometimes quite rapid changes in the technological, operational, airline industry, and business parameters that have an effect on passenger processing and overall terminal efficiency. Key factors that can undermine the functional effectiveness of a terminal building are the following:

- Unexpected changes in the profile or pattern of airline demand growth
- Pace of technological and building services innovation
- Introduction of new service or regulatory requirements
- Emergence of new business strategies

While planners and designers cannot anticipate all aspects of a terminal that may become outmoded, they can design for flexibility so that future owners can address possible areas of obsolescence, thereby extending the useful life of the structure.

VI.1.5.1 Unexpected Changes in Demand Growth

Growth in air travel has been remarkable, far exceeding the expectations of early airport planners. Initially considered a privilege of the elite, air travel is now affordable to the majority of the U.S. population, a fact that has had a profound impact on the design of terminals. Even though the art of forecasting annual and peak hour traffic has improved over the last 20 years, other unexpected factors have wreaked havoc on the assumptions underlying terminal design. The emergence of low-cost carriers, increased hubbing, airline alliances, fuel price fluctuations, and the advent of new trends such as the strong growth in international travel and the popularity of regional carriers have all affected terminal design, particularly if the building's plans were closely tailored to specific growth assumptions.

VI.1.5.2 Changing Technology

When the first large commercial airports were being conceived in the early 1950s, no planner could have foreseen the effects the rapid pace of technological innovation would have on terminal design. At that time, airports were designed to accommodate propeller-driven 100-seat aircraft, a passenger-plane technology that was assumed to be the standard for years to come. This assumption proved to be costly to terminals such as the original International Arrivals Building at John F. Kennedy International Airport (JFK), now known as Terminal 4.

Heralded as the terminal of the future when it was dedicated in 1958, it quickly gained recognition as the building epitomizing the coming age of air travel when its plans and photographs were published worldwide. From its elegant check-in areas to its streamlined international arrivals facilities, nothing seemed to be lacking, aesthetically or functionally. Contemporary observers compared its plan to two Empire State Buildings lying head to head; its main structure serving as the reception area for international arrivals while its two wings were devoted to international departures, a separation of uses intended to minimize passenger walking distances. For the first 10 years of the jet age, Terminal 4 served its purpose well. In the late 1960s, however, the introduction of 400-seat jumbo jets required an immediate expansion of the terminal. All aspects of the terminal's operation were compromised during this improvised expansion. The building's failure to address the needs of modern aviation led its owners to the dramatic decision to tear the building down in the mid-1990s. Even though the layout of the new Terminal 4 occupies a smaller building footprint it has a greater overall capacity than its predecessor and must now adapt further to meet the near-term demands of the continual evolving aviation industry, including the possible introduction of large, 500+-seat aircraft.

The evolution in the design and operating range of the airplane is the most obvious advancement in technology affecting the planning and design of terminals. To keep pace with increasing numbers of passengers and the accelerating frequency of flights, baggage handling has undergone a revolution as well. Initially baggage was hand carted from the terminal to the plane; now it is processed on fully automated industrial equipment whose spatial requirements were never considered by earlier terminal designers. It is not uncommon for baggage handling systems to consume over 20% of a terminal's square footage, as well as requiring 20-foot ceilings. Driven by the need to accommodate unanticipated growth, the spatial requirements of mechanized baggage handling systems have transformed terminal planning as much as the changes in aircraft.

As in society at large, information technology is driving the next round of changes in terminal design. Various management tools are now being introduced to allow for increased use in all aspects of passenger processing. Probably the largest looming impact will be electronic or e-ticketing, which raises challenging questions for the designer. Will its introduction ultimately render large ticket halls unnecessary? The ability to print your boarding pass at home combined with check-in kiosks has begun to impact the spatial requirements and geometry of today's airport ticketing halls. In considering a similar technological innovation, the electronic banking card, which effectively eliminated the need for huge banking halls, it's clear that the impact of e-ticketing and other forms of remote check-in are having a similar effect on terminal design.

VI.1.5.3 New Operational Requirements

Innovations in operational requirements have also challenged the conventional design of airport terminals. In the 1970s, when the threat of skyjackings was at its height, security concerns become paramount. Previously, security requirements had never been a major factor in terminal design, and passenger walking distances. After security became a concern for terminals, the entire circulation pattern that had formed the basis of terminal design had changed; for example, Kansas City had to set up multiple checkpoints.

Security concerns have continued to prevail and have increased exponentially in the wake of the attacks of September 11, 2001, profoundly influencing passenger processing and the operational management of terminals. The establishment of the TSA and the need to respond to newly mandated and potentially evolving sets of screening requirements for passengers and baggage has created a major new planning interface. These changes raise a whole set of new challenges in terms of how and where to program and locate the necessary space and equipment in both new and, more problematically, existing terminal buildings. Many terminal planning security issues remain to be definitively resolved. This is particularly true in relation to the amount of space to be programmed for the long term, bearing in mind that there can be no certainty as to whether threat levels will increase or decrease in the future and what the implications of such changes may be on terminal facility requirements that may make space programming challenging.

VI.1.5.4 New Business Strategies

In the late 1970s, the deregulation of the airline industry forced airline operators to adopt new business strategies, which had a tremendous effect on the planning of terminals. Recently completed state-of-the-art terminals, such as at Dallas/Fort Worth International Airport (DFW), were suddenly unable to cope with the new ways airlines were doing business. The plan for DFW was based on it being an O&D operation, marking the proximity of the car and the plane paramount. With the introduction of hubbing, when the terminal is a center for transferring passengers, the proximity of airplanes to each other became most important, rendering the premise for DFW nearly moot.

During the 1980s, hubbing became standard operating practice and each airline wanted to tightly integrate its services to the exclusion of other carriers. In the late 1990s, airlines began forming alliances, requiring the terminal to be able to integrate the services of a group of airlines, national and international, that jointly market themselves as global airlines. Not only must the airplane gates be near each other, but check-in counters need to be adjacent as well. Where once there was only one international arrivals facility, alliances have put pressure on airports, such as Chicago O'Hare, to retrofit domestic terminals for international arrivals so that these airlines can better leverage partnerships and minimize the towing of aircraft as an aircraft changes from an international arrival to a domestic departure.

At the same time, there is a groundswell of interest among terminal operators in treating terminals as commercial real estate developments catering to business and leisure travelers, as well as the large numbers of employees who work at the airport. In addition to the airline and passenger facilities required, this calls for a whole range of additional commercial facilities including a wide variety of retail. How large these commercial terminal complexes may become is anyone's guess. It is entirely possible that the main source of income for future terminal operators will be the commercial and retail enterprises located in the terminal and that an airline's service will be courted based on the type of customer it can bring to the terminal.

VI.1.5.5 Dealing with Uncertainty

Planning for a new terminal should be based on the most accurate long-term traffic forecasts available. However, these will inevitably need to be carefully reviewed and potentially adjusted during the life of the building as traffic demand ebbs and flows in response to changes in the economy and occasional unanticipated shocks such as a terrorism threat.

With this in mind, it is prudent for planners and designers of airport passenger buildings to recognize the potential variability of the levels and types of passenger and aircraft traffic that will use the facilities. During terminal concept development, a basic premise should be that any terminal facility will, at some stage, have to adapt to different passenger loads and operational modalities than those initially programmed. Therefore, planners and architects need to create flexible terminal designs that can be modified to accommodate a range of future conditions.

In practice, beginning with the identification of the project parameters and during concept development, planners should do the following:

- Consider the range of different kinds of loads that their facilities might have to serve: Terminal planners and designers should take as their starting point a range of traffic forecast scenarios, not just the most likely or "expected" case. The range of forecasts to be adopted can be validated by two kinds of analysis. The first examines the trends in variations between historical forecasts and actual outcomes. The second kind of analysis examines local patterns of variation. For example, an analysis might consider in detail the pattern of variation in the relative levels of domestic and international traffic and thus identify the amount of flexible space that might be needed to meet the range of future requirements.
- Check the performance of the design under different loads: Sensitivity analysis that compares the performance of a particular design under different sets of demand criteria is a very important tool in the planning process. The particular sensitivity cases selected should be purpose-designed to test the robustness of the base case scenario. Typically, the planner will want to evaluate the performance of the design by varying the anticipated mix and volume of different

types of traffic and assessing the impact on peak hour activity levels. Now that computer simulations of the performance of passenger buildings are becoming commonplace, this kind of analysis is more easily accomplished. The examination of the initial designs under a range of levels and mixes of traffic is likely to identify circumstances under which the preliminary design performs poorly, and where corrections and adjustments therefore need to be made.
- Amend the design when deficiencies are found in order to build in more long-term flexibility and mitigate the potential for future problems.

VI.1.5.6 Creating Flexibility—Space, Function, and Time

The options for introducing flexibility into the planning and design of airport passenger buildings can be analyzed usefully under the headings of space, function, and time as follows:

- Space: How can space be programmed to safeguard flexibility? In practice this means providing for future flexibility in the relative allocation of space for the primary function and/or adjoining or connecting facilities so that it will be easier to adjust spaces to different uses as required.
- Function: Which functions might be combined to add flexibility to future operations? For example, to what extent can the airport operator use CUTE systems that make it possible for airlines to share facilities according to their varying needs?
- Time: How can parts of a passenger building evolve over time? Is it designed so that it can grow easily, possibly because its design is modular and space has been left open for additions or perhaps because the internal partitions can be reconfigured to serve different uses should future traffic patterns make such changes desirable?

The mission of the passenger terminal building will determine, to some extent, its flexibility. This statement becomes obvious when one considers the way unit terminals created for individual airlines or functions can be inflexible. For example, the unit terminals at JFK worked well initially when domestic passengers normally terminated (or began) their journeys at this airport, and international arrivals were limited to one terminal. However, as transfers increased, the original individual units made it difficult for airlines to expand their services and coordinate international to domestic transfers. The need for more convenient connections between the various airlines was one of the principal drivers for the inter-terminal APM system.

Airport Master Plans that provide for single large terminals, or for the various unit terminals to be connected efficiently, greatly enhance flexibility. Amsterdam Airport Schiphol, for example, serves many difficult kinds of services off a central spine. This configuration permits them to adjust spaces for different kinds of traffic easily as the spine elongates and they shift functions around. Similarly, airports with mid-field concourses connected by high-capacity APM systems, such as Hartsfield–Jackson Atlanta and Denver International Airports, make responding flexibly to new demands relatively easy for the airport operator.

Shared-use or multi-function spaces inherently add flexibility to the performance of a passenger building. They permit the airport operators to allocate space to different functions as needed. Because the need for different functions typically peak at different times, shared and multi-function spaces have the potential to reduce the total space required. For example, a holdroom shared by multiple gates typically requires less space than the same number of individual gate holdrooms.

Moreover, the benefits of shared space can extend to many different aspects of the passenger building. For example, benefits may include the sharing of gates between different types of aircraft and different airlines. Benefits may also include the whole range of facilities serving international and domestic passengers. Traditional design of passenger buildings separates these functions absolutely. However, recent practice in the United States and in the rest of the world indicates that it is both practical and economical to share portions of these facilities over large blocks of the day.

The shared-use wing of the passenger building at Edmonton International Airport in Alberta, Canada, is a prime example of a shared-use, multi-function facility. It is designed to serve three distinct types of traffic for many airlines by using a system of corridors with access points that can be locked or opened to channel passengers as required. It also has a system of retractable walls that can segregate spaces being used for the processing of international, domestic, and transborder traffic, which must be kept separate. Transborder traffic refers to passengers leaving Canada for the United States, who have already pre-cleared U.S. customs and immigration according to a long-standing agreement. These travelers are technically already in the United States and thus must be segregated from other international and domestic Canadian passengers. By adopting this strategy of shared use, the terminal facility requires only about half the space that would be necessary if it were sized to accommodate each category of passenger separately with the subsequent cost and efficiency benefits.

CUTE and similar systems enable airlines to share facilities and reduce overall space requirements. Experience at Las Vegas demonstrates that the substantial savings predicted in theory can be achieved in practice as indicated by J. Feldman (*38*).

Because the ability of the terminal building to evolve over time is so important, planners should assume that these facilities will acquire different uses over their lifetime. The experience at U.S. airports over the last 20 years demonstrates this fact clearly. At Boston Logan International Airport, for example, the current International Terminal has previously served domestic shuttle services to New York via New York Air, low-fare flights on PEOPLExpress Airlines, and as a mini-hub for Northwest Airlines serving international to domestic transfers. Each of these different operations required different kinds of check-in, baggage, lounge, and aircraft facilities.

Designs that incorporate large roof spans and minimize interior load-bearing walls make it possible to relocate interior partitions easily and to reconfigure interior operations. Conversely, designs that include substantial interior load-bearing walls can lead to major downstream costs. Similarly, passenger buildings with skin facades, either glass or easily removable partitions, make it easier to relocate aircraft positions as needed.

Simply stated, flexibility is the factor that allows a terminal to accommodate future unexpected changes, unanticipated growth, technology, operations, and business plans.

VI.1.5.7 Considerations for Achieving Flexibility in an Uncertain Future

Underpinning all of the considerations discussed below is the concept of simplicity, which should extend to all elements of the plan, from the terminal's layout to its structural system.

Use a Linear Terminal Design. If the site permits, a linear terminal capable of lateral expansion (extrusion) is preferable to other types. Radial plans or compact plans such as TWA's at JFK, often suggested by the arcs of terminal roadways or the constraints of corner sites at existing airports, are inefficient by comparison and difficult to expand. A linear type of terminal is the most readily expandable, provided the sides are kept clear of elements such as mechanical, electrical, and plumbing (MEP) systems; substations; and other "hard" functions that would be costly and difficult to relocate in future expansion.

Create a Simple Rectangle Form and Use a Repetitive Structural System. An expandable linear plan suggests that the terminal should be a simple rectangular shape with clear roof spans that create large open areas unencumbered by columns. Long spans are ideal for ticket lobbies, such as a structure stretching from the front wall to the back edge of the lobby that allows for various sizes and orientations of ticket counters and for easy passenger queuing and circulation. On the other hand, long-span structures are difficult and costly to modify if that becomes necessary. Long-span structures also require attention to the design and coordination of air supply and return, because venting through the roof is difficult. The cast-concrete long-span system at Dulles International Airport could expand laterally because of the careful placement of these mechanical and ventilating systems. In the long term, however, cast-in-place, precast, and post-tensioned concrete systems are less flexible than regular two-way steel structural grids. Structural steel framing and curtain wall systems offer the greatest flexibility in terminal design and renovation. If modifications or new openings are required, systems with metal frames that hold glazing units or metal panels are more flexible and structural steel systems can be added to or modified more easily at a later stage in the life of the facility. Because they can tolerate occasional penetrations, steel beams, girders, or trusses also allow more flexible initial MEP coordination, as well as later adaptations.

Apply a Modular Approach to Design. Although this concept is subject to interpretation, repeatable modules—whether units of integrated architecture and systems such as the "dinosaur" structural columns and roof system at Dulles or a "kit of parts"—can be added to provide benefits in flexibility. The key for any terminal layout is for the planner to create a building that allows for an incremental expansion process that, when completed, adds to the unity of the whole of the terminal facility.

Provide Ample Floor-to-Floor Heights. Where possible, ample floor-to-floor heights provide flexibility for the reworking of mechanical and other systems, if the terminal needs to be modified.

Provide Ample Circulation Space. The provision of ample circulation space, especially a calculated over-provision for the design flows, allows the facility to accommodate unforeseen changes in use.

Make the Circulation Patterns Straight and Provide the Potential for Network Circulation. Non-linear convoluted circulation patterns that connect differing functional areas of the terminal are inherently less flexible than linear patterns. Although it is generally preferable to establish single, clear linear routes and collection points, they need not be permanent or otherwise constrained by the building plan, structural grid, or other fixed elements. Buildings that do not lock in a single, linear route but allow for network circulation and the possibility of setting several routes between major areas are the most flexible. Certain characteristics of building design, such as a regular structural grid and the ability to relocate non-structural partitions, permit circulation paths to be changed and allow for multiple routes as well. A change in user group or function might necessitate changing the circulation route between landside and airside. The need to phase and stage a renovation is also served by network circulation.

Avoid the Constraints of Linear/Nodal Circulation. These constraints can be defined as the mandatory convergence of all major circulation routes at nodes, crossings, single corridors, or collection points. There is a natural tendency to collect circulation routes at nodes. Heavy space demands at nodes, from public circulation and services, limit long-term flexibility. Utilities, BHS, and other systems also tend to be concentrated at nodes in these areas, further complicating any future modifications. This approach also limits options for phased renovation. Network circulation is mainly applicable to the landside building. Concourses are inherently linear, although they can benefit, in terms of flexibility, from having a regular two-way structural grid in the event that the circulation path must shift off the central axis, either permanently or temporarily.

Minimize Level Changes. Level changes, such as ramps and partial-flight escalators and stairs, are introduced for many good reasons in terminal design—mainly, to address the different needs of landside and airside parts of the terminal. However, level changes within the inbound or outbound levels should be avoided because ramps and half-level changes tend to coincide with nodal points in the circulation network and will forever constrain the optimal use of the areas, as well as other systems and services in those areas. Level changes are also very costly to modify.

Provide Transverse Transition Zones. Future terminals would be well served by offering flexibility in the form of transition zones crosswise to the passenger progression through the terminal. The flexibility of these zones is particularly welcome when security requirements are increased. A zone at the departures' entrance would allow for perimeter screening, whereas a zone after check-in could accommodate expanded security checkpoints.

Make the Curb Frontages Straight. Curvilinear curbs and circuitous, complicated connecting roads make terminal expansion much more difficult.

Place Building Services Outside of Functional Areas and Avoid Potential Constraints. Because major building services, egress stairs, electrical and communications closets, mechanical rooms, and shafts can limit the terminal's capacity for expansion, these functions should be housed outside of functional areas and, if possible, should be designed for expansion. The latter may be a difficult point to make, given the need to contain initial capital costs; nonetheless, it is a significant component of flexibility. One fundamental issue is whether building services should be bundled at the perimeters of the building, to permit flow-through holdrooms and flexible space layout, or should they be more evenly dispersed in smaller clusters throughout the building envelope? These services can be large users of space when bundled and, once established, service cores cannot be easily modified, let alone relocated. These elements do not constrain the apron when located within the building perimeter; however, they do limit the flexibility of space planning in the initial layout. Smaller elements, however, are easier to relocate, should that become necessary in the long term.

Do Not Compromise the Apron. The apron is the terminal's most important asset. Aircraft will continue to evolve in size, fleet mixes will change, and terminal gating plans will be in constant flux, but the size and shape of the apron will not change, so preserving it is crucial for flexibility.

Allow for Room to Expand in All Directions. Because future innovations in the airline industry cannot be predicted, the quickest path to designed obsolescence is not providing a way to add onto the terminal. Expanding the terminal means not only leaving extra area around it, but also understanding how to expand it, how a new structure can be attached to it, and how this construction can be implemented. This also means the possibility of expanding vertically, in which case determining what type of roof and structural systems to use becomes crucial.

VI.1.5.8 Operational Considerations

Common-Use Facilities. Congestion at airports, specifically in crowded check-in areas, as well as pressure to hold down costs on airline operations have led to an increased reliance on common-use facilities. Common-use facilities allow the shared use of valuable airport infrastructure and space by several airlines, which results in the optimal usage of space, and savings in operational costs. Common-use facilities take full operational advantage of the space by maximizing the use and increasing the efficiency of the facilities, and minimizing the amount of underutilized space. This is most evident in common-use gate environments when the airlines are assigned to gates by the airport's gate management system and when CUTE and airport-owned passenger loading bridges are deployed.

Technologies that take advantage of the common-use operational scenario are CUTE and CUSS. CUTE system technology allows multiple airlines to use the ticket counter or gate on a common-use basis, by connecting to each airline's own host system, which enables the agent to manage the passenger reservations, check-in, and boarding process in their own airline's IT network. Presently, approximately 400 airports worldwide dating back to 1984 have implemented some level of CUTE technology (*39*).

CUSS technology is a system that allows multiple airlines to provide their check-in applications on a single self-service device (e.g., kiosks). These systems allow the airport to place the devices away from the traditional check-in counter locations such as parking garages, rental car facilities, rail stations, hotels, convention centers, and the possible future utilization on cruise ships. This decentralized process alleviates congestion while improving passenger flow and provides potential savings to airlines for whom installing their own equipment would be too costly or not permitted by the airport authority.

The basic premise of these common-use technologies is that promoting the shared use of space and equipment greatly enhances the flexibility and cost efficiency of the building facilities. However, these systems need to be evaluated by the airport operator on an airport-by-airport basis. Airlines sometimes voice concern that implementing CUTE technology affects the true cost of doing business. This is because airlines may incur additional training costs for agents, software maintenance, upgrades, and modifications to the operational model in order to conform to the individual CUTE system provider's operating environment.

Swing Gates. These types of gates provide the operational flexibility to serve both domestic and international operations. Vestibule space controls access from the passenger loading bridge to both the adjacent holdroom area and sterile circulation corridor through the use of controlled access doorways. When this type of gate is used at an airport for departing (domestic/international) and arriving (domestic) passengers, the doorway from the holdroom area to the vestibule space is unlocked, while doorway access to the adjacent sterile corridor system in the same vestibule space is secured. For international arrivals, the doorway to the adjacent holdroom area is secured and the sterile corridor access to CBP is unlocked. This maximizes gate utilization for the airport by providing alternative flow patterns.

Typical swing gate configurations are summarized in Table VI-3 (*12*).

Airside Bus Operations. If peak gate demands are sporadically or temporarily greater than normally encountered on a typical basis, then busing passengers to and from remotely parked aircraft may be the best option to temporarily supplement aircraft gate capacity. This is particularly true during special events or during construction when additional gate capacity may temporarily be needed. In the United States, busing passengers to and from aircraft is considered a lesser level of service than contact gates; however, for short periods bus operations are a satisfactory means to supplement gate capacity so long as the remote aircraft is parked within a reasonable distance from the terminal. Airside bus operations can provide needed flexibility at a lower cost than a fixed guideway system. As airline airside operations change, buses allow the flexibility for routes and stations to be added or changed easily.

Table VI-3. Typical swing gate configuration.

Gate Status	Domestic Holdroom Door	Sterile Corridor Door
International Arrival	Secured	Open
Domestic Arrival	Open	Secured
International Departure	Open	Secured
Domestic Departure	Open	Secured
Gate Closed	Secured	Secured

Source: *Airport Technical Design Standards—Passenger Processing Facilities,* U.S. Customs & Border Protection, Washington D.C., August 2006, pg. 5-16

Locations for loading and unloading passengers from buses should be as close as possible to the core of the terminal building and airside waiting area to limit distance required for passenger walking. The disadvantages of operating buses on the airport apron would include possible conflict between aircraft flows, buses on and around the apron, and increased passenger enplaning and deplaning times.

VI.1.6 Terminal Security

High concentrations of people, like those found in passenger terminal lobbies, are attractive targets. Although U.S. airports have not experienced any such major attacks, in today's threat environment there is no reason to believe that airports are immune.

Improved security is achieved when the airport layout and terminal design complement the airport security plan, and when roadways, parking, and terminals are oriented with security in mind. Incorporating blast-resistant features during the initial design has relatively low incremental costs and blends with the overall building architecture much better than retrofitting a facility after the fact, which combines limited structural opportunities with greater unit costs.

An airport faces the daily dilemma of having the free movement of thousands of unscreened passengers and the public, with no idea of who they are or what they might be carrying. Facial recognition programs have been tested at some public events, but various TSA and Department of Justice pilot programs have not found them to be ready for deployment at an airport, where congestion is normal and singling out and controlling the subject's immediate environment (such as lighting, angle of presentation, pose while in motion) is difficult and an adequate database to search against is needed. However, technology is dependable that will alert security to a person who is loitering or acting suspiciously in a public area of the terminal or who leaves an item behind and departs the area.

VI.1.6.1 Terminal Lobby Issues

Given the fully accessible public environment of the terminal lobbies, and the very nature of airport congestion, fast-paced movement, and occasional and varied levels of chaos and confusion, both design and technology solutions for security concerns in public areas are quite limited.

Primary among technology applications is one that includes using additional cameras with video analytic capabilities to identify potential threats in abandoned objects or passenger and group behavior, particularly where the analytics could employ trend analysis. Another future potential is the eventual introduction of sensors for chemical and biological analysis, although these currently have significant limitations in sensitivity, selectivity, and time delay.

Expansion of CCTV coverage should include high-resolution cameras throughout selected public areas of the terminals, with a wide range of placements and lenses. In addition, CCTV should have site-specific analytic algorithms for numerous variables in terminal activities that include differences among domestic and international travelers.

Recommendations not requiring new technology enhancements, but nonetheless useful to consider, include reviewing the construction of the lobby areas and placement of various concession stands, ticket counters, the Flight Information Display System (FIDS), advertising, other signage, and so forth to facilitate CCTV lines of sight.

Security issues are federally mandated to be addressed in the design of most airport facilities; two of the three principal areas, baggage and passenger screening, are federally staffed and must comply with federal design requirements. The performance standards for the third area, general facility security for everything inside the fences and surrounding virtually every structure and operational activity, are found in Transportation Security Regulations (TSR) §1542, Airport Security (*40*), and are unique to every airport terminal environment.

Security issues are also among the basic drivers for each airport's non-security terminal design, including layout of terminals and operational facilities, paths of travel to and within both public and secured areas, access controls, surveillance capabilities, and the IT and communications infrastructure (and its own technological security) that ties everything together. These issues are outlined as follows:

- Advance security planning
  - Vulnerability assessment
  - Airport Security Program, Emergency Plan
  - Regulatory requirements, industry standards
  - Coordinate with Federal Security Director; federal/local agency—CBP, FAA, etc.
  - Access control, CCTV systems *(Coordinate with IT)*
- Functional areas
  - Approach roads, parking facilities with adequate standoff
  - Surveillance systems (such as CCTV) at curbside, doorways
  - Perimeter columns and beams that are resistant to blast
  - Vehicle barriers—prevent VBIEDs coming close or into the terminal
  - Vehicle inspection stations with queuing and standoff distances
- Bomb/blast analysis
  - Structural–non-structural
  - Blast-resistant facade and glazing
  - Limited concealment areas/structures
- Operational pathways
  - Security of service corridors and personnel circulation
  - Minimal number of security portals
  - Space for emergency response, explosive ordnance disposal
- Sterile areas
  - Tenant and concessions movement
  - Emergency response routes
- Public areas (anti-crime, not just anti-terrorism)
  - Lobby configuration, lines of sight
  - Baggage claim areas
  - Emergency exits, fire doors (vs. security doors)
  - Parking
  - CCTV surveillance
- Non-public areas
  - Corridors, stairwells, service elevators
  - Administrative and tenant offices, Security Operations Center, Airport Operations Center, and Emergency Operations Center
  - Access control, CCTV
- Chemical, biological, and radiological threats
  - HVAC system characteristics, capabilities, and physical security

VI.1.6.2 Passenger Screening

The screening checkpoints are a regulated requirement and must be designed to meet the TSA mandates for operational space and equipment support as specified in TSA's *Security Checkpoint Design Guide,* February 2006. Checkpoint design is not isolated from the full terminal design process; it affects paths of travel throughout public space, lobby space at the ticket counters, concessions placement, security queuing space, and throughput prior to the checkpoint. To some degree, the checkpoint can also affect everything after screening, depending on the checkpoint locations with respect to departure gates and their rates of throughput.

Problems at the TSA checkpoints can have a serious effect on the airport's operations, including the closing of a concourse after an incident or a screening failure at the checkpoint and the resulting need to re-screen thousands of passengers who had been cleared and must come out from the sterile area. Not only are such events costly to the airport and the air carriers, but they also leave the general public with considerably lowered confidence in the security operations at the airport. Thus, in the early planning process, it is useful to consider checkpoint placement and a closure design that could isolate a single concourse or terminal section following a breach, to avoid having to clear an entire terminal.

Table VI-4 highlights a few aspects of the current levels of confidence in screening passengers for IEDs and illustrates the need for continued high attentiveness toward persons and activities beyond the checkpoint.

Even though the checkpoint operation itself is not an airport responsibility, what happens before and after the checkpoint is. Integration of video analytics from CCTV at the screening checkpoint to the Security Operations Center enables rapid law enforcement response to the pre-screening queues, incidents within screening areas, and exit lane breaches or other anomalies after the screening.

As Table VI-4 suggests, there is a sufficiently low level of confidence in the success of screening for IEDs that the airport should consider a significant enhancement of its ability to monitor patterns of behavior on the sterile side and throughout the concourses.

Finding an IED on a passenger's body or artfully concealed in a handbag remains TSA's biggest challenge. Currently, no explosives detection is being performed on the body except for trace portals, whose functionality has come into question; consequently their use is currently suspended. Pat downs are the current method of finding explosives on the body, but very few are conducted.

The same is true for hand-carried luggage. X-ray technology has improved in recent years, but it remains very difficult to find IEDs in a cluttered bag, especially when the device is disassembled. Again, trace is only used on selectees and only on a very limited random basis, leaving an uncomfortable margin of error for the possibility of an IED within the airport's areas of responsibility beyond the screening checkpoint, and the uncomfortable fact that further access to aircraft is fairly easy beyond the screening checkpoint.

Table VI-4. Confidence level in screening passengers.

Vector	Attack Mode	Confidence Level In Current Measures
Passenger Checkpoint		
	IED in hand baggage	Medium
	IED on person	Low
	IED components in hand baggage	Low
Passenger Hold Baggage		
	IED in bag liner	Low
	IED in electronic device	Medium
	IED placed in bag after screening	High
Ramp		
	IED placed on aircraft by ramp employee	Medium
	IED placed on aircraft by unauthorized person	Medium

Source: TranSecure

Checkpoint design for general passenger screening must adapt to the types of terminals and expected distribution of passenger loads; optimize efficient space; provide flexibility for meeting fluctuating load demands and emergency conditions; and consider equipment types, sizes, number, placement, spacing, power, IT, and communications requirements as well as adjacent spaces, seating areas, supervisory and staff areas, private screening areas, and more. These issues are outlined as follows:

- General checkpoint design issues
  - Efficient space use for queuing, divestiture, secondary screening, and ADA requirements
  - Flexibility for meeting fluctuations in load demand, emergency conditions, and new regulations
  - Flexibility to accommodate changing TSA technology requirements—larger, smaller, and/or procedural support
  - Coordination with HVAC, electric, lighting, IT, and communications infrastructure
  - Coordination with TSA for support space and IT requirements
  - Protection of Security Screening Checkpoint (SSCP) integrity when not in use
- Planning considerations
  - Terminal types—central, multiple concourse, remote/satellite
  - Operational types—international, O&D, hub
  - SSCP size—type of airline service—long haul, commuter, seasonal
  - Future load and service projections
- Checkpoint elements
  - Equipment types, sizes, number, placement, spacing, power, IT, and communications requirement—i.e., magnetometer, Electronic Detection System (EDS), trace, X-ray, portals, holding/wanding stations (Current TSA specifications are available, but continue to change with evolving technology.)
  - Queuing/prescreening area; divest and composure space
  - Adjacent walls/barriers
  - Egress seating area
  - TSA supervisor and staff areas
  - Law enforcement officer station
  - Private screening areas
- Exit lane components
  - Adjacent to SSCP, or elsewhere; surveillance
- Electrical and IT data requirements (coordinate with IT)
  - HVAC, power, and lighting
  - CCTV, data, and communications

VI.1.6.3 Employee Screening

Employee screening is not currently required by regulation, although TSA continues to test the concept through various pilot programs. From a terminal design point of view, there is little difference in how such a portal is treated; access control will still be required during non-operational hours. There are extended capabilities of the access control system such as adjustable security levels, and biometrics and video analytics that can be applied to critical areas with special rules for anomalous behavior, including piggy-backing and tailgating, duress alarms or loitering at an employee door, or a human presence in a place not normally populated during non-operational times.

As before, many recommended measures for improving security at employee portals are procedural but are based on enhanced technology, which must be accommodated in terminal design. These measures include the following:

- Reduction of the number of access portals into the secured areas where not operationally restrictive. This may also reduce door-held/forced alarms.

- Delayed egress equipment on emergency exit doors, to also reduce false alarms.
- Turnstiles to address piggy-backing or tailgating, although they require extra space for installation and cannot identify attempts to gain access.
- CCTV with video analytic capabilities on both sides of the portals may provide the best cost value and can provide a greater probability of detection for piggy-backing or tailgating events.
- Biometrics throughout the access control system.

VI.1.6.4 Baggage Screening

Baggage screening is a TSA responsibility, although accommodation for design of the system is a cooperative effort between the airport and TSA as defined in *Planning Guidelines and Design Standards for Checked Baggage Inspection Systems* (*41*). As most baggage screening migrates to in-line systems (not necessarily the case at smaller airports), it demands an enormous amount of space and associated operational support including power, IT infrastructure, and connectivity. Much of that space would typically be dedicated to other uses such as operations, offices, storage, concessions, tenants, and so forth, all of which will now require alternate space accommodation, support, infrastructure, and newly thought-out integration into the overall airport operational concepts throughout the terminal. Space allocation for all terminal needs (as discussed above) is best accomplished in the initial stages of terminal design, not as an afterthought, which typically leads to the least-optimal accommodation of a wide array of facilities and systems. Baggage screening issues are outlined as follows:

- TSA requirements
  - Inline systems
  - Lobby systems
  - Curbside check-in
  - Remote check-in
- Checked baggage screening options
  - In-line systems
  - Lobby/ticket counter–mounted systems
  - Remote system
  - Stand-alone EDS
  - Stand-alone Explosive Trace Detection (ETD)
  - Flexibility/scalability to accommodate new technology, new threats, more staff, and increased traffic
- Queuing capacity, recirculation
- Facilities for oversized, selectee, suspect, and alarm bag removal
- Extra work space for that displaced by EDS installation
- Domestic and international connecting bags
- Maintenance access and removal; life-cycle replacement
- Floor loading; moving walls
- HVAC, power, and lighting
- CCTV and communications
- Vehicle access (e.g., tug, pickup, Explosive Ordnance Disposal vehicle)

VI.1.7 Wayfinding and Terminal Signage

One of the primary purposes of any airport terminal complex is to move vehicles and terminal users efficiently through the roadways and buildings in a clear and concise manner. Given the sense of time urgency experienced by most of the traveling public at airports, wayfinding needs to be as intuitive as possible in order to provide efficient and comprehensible flows. While wayfinding is more easily accomplished in smaller airports, it becomes more challenging as the level of passenger and vehicular active increases at medium and large airports, particularly those with high percentages of connecting passengers and significant volumes of domestic and international travelers.

When planning and designing a terminal complex, a primary goal is to make traversing the facilities as intuitive as possible for every user. This is often referred to as "intuitive wayfinding." The logical placement of functions, the use of clear sight lines from one decision point to the next, and visual openness to comprehend what lies ahead—all greatly enhance wayfinding, but, even in the best facility designs, these measures must be supplemented by an effective signage program.

Carefully placed and clearly worded signage can ensure an orderly flow of passengers or vehicles, which maximizes the capacity flow potential of the terminal building and roadways. A successful signage program usually provides a "concise and informative series of non-verbal messages" (*42*) that is comprehendible to the majority of users. Signage programs can be broken down into primary categories that include directional, informational, regulatory, advertising, and identification.

Airports will generally have their own established rules and policy manuals governing the physical and aesthetic characteristics of their signage. In any case, these visual cues should communicate using simple, uncluttered, universally recognized symbols paying special attention to contrast and color to aid those with visual impairments and meet the requirements of the ADA.

Additional requirements that must be taken into account include those by the FAA, TSA, CBP, U.S. Department of Transportation (U.S.DOT), and state DOT departments. Visual cues are key to enabling passengers to orient themselves in terms of where they are in a possibly unfamiliar building and how they can reach where they need to be using the most logical travel routes. Visual cues can be provided using maps, directories, and signage, both static (directional symbols and room labels) and dynamic such as FIDS. Dynamic signage, generated by the airport's communication systems network, provides the ability to display information throughout the airport and to respond to specific operational needs at any given time.

The principles behind the development of an effective airport signage program for the terminal complex are beyond the intended scope of this Guidebook. Besides *Guidelines for Airport Signing and Graphics, Terminal and Landside,* Third Edition, 2001 (*42*), the reader may wish to refer to ACRP Project 07-06, "Wayfinding and Signing Guidelines for Airport Terminals and Landside," for more details on this subject matter.

VI.1.8 Accessibility

The ADA is a landmark law that protects the civil rights of persons with disabilities. It prohibits discrimination on the basis of a disability in employment, state and local government services, transportation, public accommodations, commercial facilities, and telecommunications. To ensure access to the built environment, the ADA requires the establishment of design criteria for the construction and alteration of facilities covered by the law. These requirements, which were developed by the Access Board, are known as the ADA Accessibility Guidelines.

Terminal planners and designers need to be sensitive to these guidelines and plan for any special design features and mobility aids that will permit passengers and airport workers with disabilities to navigate the airport and terminal. Disabilities can be classified into three main categories:

- Vision impairment or legal blindness
- Deafness or hardness of hearing
- Mobility impairment

For visually impaired or legally blind persons, appropriately sized wall-mounted Braille signage should be provided to direct the passenger or employee to various points within the terminal.

Signs may also include larger type fonts, which make it easier for visually impaired passengers who are not legally blind to more easily identify and read information. In addition, digital voice messaging systems should be provided to assist the passenger in acquiring up-to-the-minute arrival and departure flight information, which is displayed on the FIDS. Additional provisions may also be made available at information desks to relay up-to-date information to these passengers. These voice messaging systems should also alert passengers of entry and exit points on assisted moving devices—such as escalators, elevators, and chair lifts, if provided—and the locations of transit systems located at the airport.

The digital voice messaging systems should also provide visual display of the same information for hearing-impaired passengers or employees. Public address systems should be clear and easy to understand with adequately located speakers throughout the public and employee areas of the terminal and associated concourses. Public telephone banks should have one clearly identified phone equipped with volume controls or a sound booster device for this group of passengers.

Terminal entrances and circulation zones with level changes should provide ADA accessible doors and ramps, with grades no steeper than 1:12 for mobility-impaired passengers and employees. Airports with longer walking distances between major functional elements within the terminal and concourse should provide wheelchairs and motorized carts. ADA accessible toilets should be provided and easily identified within the restroom locations.

Additional areas of consideration for the wheelchair-bound passengers include providing lower counter areas at check-in and telephone bank locations. Security areas should provide adequate space and access to allow for the screening of passengers in wheelchairs. Gates that require level changes should provide means for transporting heavy electric motorized wheelchairs from gate areas to the apron to be loaded onto the aircraft. This transport can be done via a lift system integrated into the passenger boarding bridge itself or shared between multiple gates.

VI.1.9 Maintenance

It is important, particularly when undertaking the architectural design of an airport passenger terminal, for the design team to develop an overall maintenance strategy. This strategy should include an assessment of the long-term implications for cleaning and maintaining the building.

To provide for functionality, capacity, efficiency, and flexibility for the operation and maintenance of terminal facilities, the design team needs to identify the many functional operational areas and various stakeholders involved with the uses of those spaces such as the airport owner/operator, the TSA, the CBP, the FAA, airlines, concessionaires, rental car agencies, commercial ground transportation providers, and so forth. An airport is like a city with its many tenants and user stakeholders acting as individual property owners within that city. Each has its own unique operating and maintenance needs to efficiently and effectively operate and manage their facilities and systems and therefore requires early assessment and understanding of the multitude of activities presented by each. These stakeholders should also include the staff or maintenance contractors who are physically responsible for the operation and maintenance of those systems.

This early assessment may lead to dedicated spaces incorporated into the design and construction process, as well as the project budget, that meet the needs of all involved leading to an overall enhanced satisfaction level with the completed project. Additional information on the subject of maintenance can be found in Appendix C, FAA White Papers, in the paper entitled, "Operational and Maintenance (O&M) Considerations in Terminal Planning and Design," by Norman D. Witteveen.

VI.2 Terminal Concept Development

The development of concepts for terminal facilities at airports is typically an iterative planning and design process involving the use of quantitative facility requirements combined with a thorough understanding of the operations of the airside, terminal building, and landside components to develop various future options for the airport terminal complex. While the specific objective may be slightly different for a greenfield terminal verses the expansion or redevelopment of an existing terminal complex, the majority of the steps in the process are virtually the same. While Chapter II, Terminal Planning and Design Process, describes the sequential steps and services that are needed to plan and design terminals, this section is intended to provide insights into the specifics of developing terminal concepts for an airport.

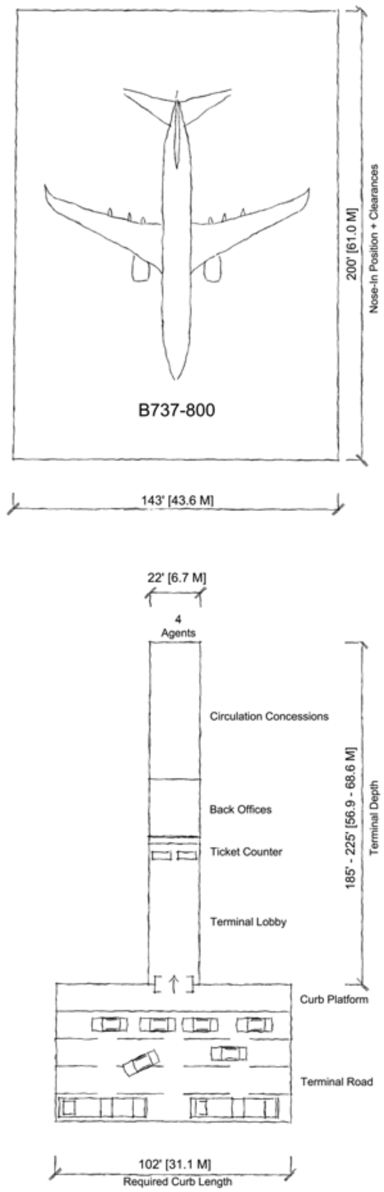
The art and science of terminal planning has evolved significantly from when commercial service first began, but the main purpose of passenger terminals has remained the same, that is, to provide a transition from ground transportation to aircraft for passengers and their luggage. As a highly specialized building form, terminals have advanced technologically to address higher passenger volumes, security concerns, and connections between flights and to provide other passenger services.

Historically speaking, it is probably true to say that typical U.S. air passengers, particularly those traveling regularly on domestic routes, have as one of their key goals getting on and off their airplanes as quickly as possible—in short, to spend as little time as possible inside the terminal building. The stringent and expanded security checks that have been introduced following the attacks of September 11, 2001, and the subsequent need to check in much earlier have led to longer in-terminal dwell times for many passengers, not to mention increased hassle and potential stress levels. At the same time, the pressure to reduce minimum connection times and to finely tune airline schedules means that some groups of connecting passengers literally disembark at one gate and move directly to their new departure gate, spending scarcely any time in the terminal.

Today airport passenger terminal buildings, particularly those at busy connecting hub airports, are being called upon to fulfill an increasingly complex variety of roles. This challenge is just one of the many faced by today's terminal planner.

As previously defined in Chapter I, in its simplest form, the terminal complex consists of three basic components: airside, terminal, and landside facilities. These basic components are depicted in Figure VI-1 (*43*). This figure offers some basic insights into the spatial relationship of these components. When all of these components are functionally active at their operational design peak, the airside component typically consumes the largest area of the three. During the arrival and departure peaks for the terminal curb, the landside component's spatial requirement is somewhat less than that of the airside. The terminal itself often has the smallest spatial footprint when compared to the airside and landside.

From purely a technical planning perspective, the airside component is the most inflexible of the three components because of the fixed dimensions of the aircraft, its associated wingtip clearances, and limited maneuverability. By contrast, humans with their mobility and adaptability are more flexible relative to their spatial requirements. People can be temporarily crowded into a limited amount of space, albeit at a decreased level of personal comfort typically described as a lesser LOS. People are also more maneuverable than either airplanes or vehicles because their paths of travel (while not desirable from a wayfinding prospective) can turn and elevate more quickly than their mechanical counterparts. Clearly responding to the needs of people using the airport terminal is more important than responding to any needs of aircraft or vehicles. However, when physically laying out a site plan for a terminal complex, the planner should take into account that aircraft have the most rigid and regulated requirements and, as such, tend to be the major driver in the configuration of the terminal complex.

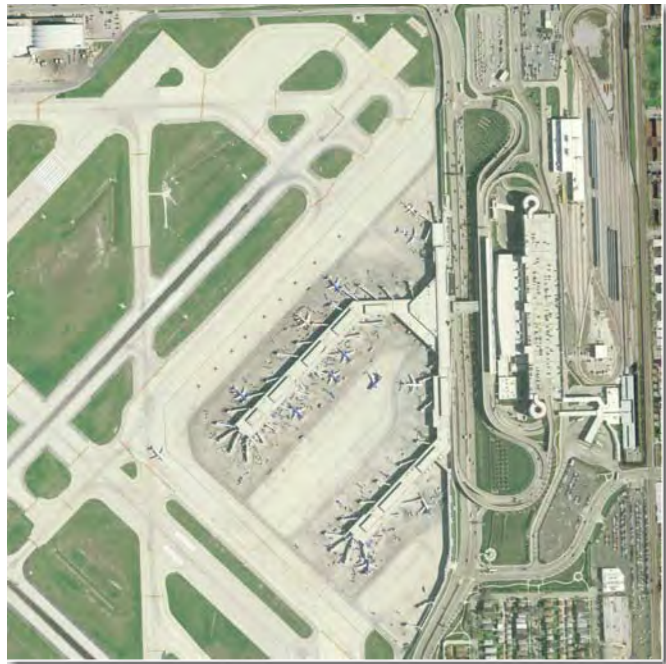


Source: Modified from *The Airport Passenger Terminal*, Walter Hart, John Wiley & Sons, 1985.

Figure VI-1. Basic airside, terminal, and landside components.

For these reasons the development process for terminal complex concepts typically starts by developing aircraft parking arrangements that will integrate appropriately with the airfield infrastructure, which in turn are predicated on the alignment of the airport's runways. The location and position of the terminal building itself is primarily dependent on its seamless integration with aircraft operations to the runways, and convenient passenger access to and from various forms of ground transportation.

There are occasions in existing airport environs when the inflexibility of rail transit and existing roadway alignments drive the conceptual development of the terminal complex. An example of such a situation is Midway International Airport in Chicago where the terminal and airside components are split by Cicero Avenue, which remained in its original alignment and serves as the main access roadway to the airport's terminal as depicted in Figure VI-2.



Courtesy of: City of Chicago

Figure VI-2. Aerial view of Midway International Airport.

The primary orientation of the terminal building has traditionally been set by establishing the most straightforward path to and from the ground transportation modes, through the terminal facilities, to and from the parked aircraft. This straightforward approach is still the most desirable terminal objective for passenger processing because it typically results in simplified passenger wayfinding and minimal walking distances, but now additional items need to be taken into consideration.

Today's environmentally aware planners also must factor in the primary orientation of the terminal relative to paths of direct sunlight. The correct orientation of the terminal can assist in providing natural light to the internal spaces of the building while maximizing opportunities for active and passive solar enhancements in order to achieve sustainability goals. Additionally, the planner must avoid protected habitats, such as wetlands.

Other location and orientation factors that should be taken into consideration are potential opportunities to link a new terminal's location to multi-modal opportunities such as mass transit, highways, rail, and water for ferry access. Equally important is the ability to take advantage of locating the terminal in a configuration that allows the potential use of immediately adjacent lands for commercial development opportunities.

Once the number of gates and the aircraft fleet mix is determined through the identification of terminal facility requirements, the initial development of terminal complex concepts can commence. At a minimum, it is best for the planner to have a clear understanding of (1) the aircraft gate requirements, (2) the approximate length and width of the terminal building or buildings, and (3) landside requirements for terminal curb length and vehicle parking before starting the development of terminal concepts. More simplistic and generalized airport terminal complex site plans can be prepared based on this limited information. Under this type of broad-brush planning approach, it is important to maintain fairly generous assumptions on the maximum size needed for the primary components in order to protect against the possibility that the initial facility requirement estimates, based on a preliminary analysis, are too low. Typically, terminal planning is an iterative process that allows for increasing levels of detail to improve facility requirement estimates and a higher definition of the terminal project with each iterative step. Clearly, the more information and detail involved in the preparation of terminal facility requirements allows for a more precise development of the project concepts.

VI.2.1 Terminal Concept Types

Once the planner understands the mission of the terminal, gains insights from the key stakeholders, and assembles the necessary facility requirements to drive the planning process, it is possible to explore the development of initial concepts. In general, there are two categories of terminal concept types. The first category addresses the organization of terminal processing into either a centralized or decentralized type of airport terminal complex. The second category then organizes the terminal into one of four generally recognized types of terminal and concourse concepts.

VI.2.1.1 Centralized and Decentralized Terminal Facilities

One of the most important decisions initially facing the planner and designer is whether the terminal complex should have a single centralized processing facility or does the mission of the airport warrant multiple decentralized passenger processing capabilities. Many factors enter into the decision of a single vs. multiple unit terminal planning approach. Some of these factors include the level of passenger and aircraft activity, the specific role of the terminal facility, and whether the project is starting with a clean slate, such as a greenfield site, or supplementing an existing terminal infrastructure, whereby a new single terminal project becomes part of a series of existing unit terminals.

Centralized Terminal Facilities. As the name implies, the underlying premise of a centralized terminal is that all passengers and baggage at the airport process through a single facility. There are many advantages to such a centralized operating philosophy:

- Maximizes the use of the facilities and staffing
  - A single consolidated terminal maximizes passenger processing capacity and eliminates unnecessary facility duplication.
  - A single consolidated terminal minimizes staffing requirements for functions like passenger security screening checkpoints.
  - A single consolidated terminal provides the opportunity to operate as a common-use facility by utilizing CUTE and CUPPS technologies.
- Minimizes interline connections: Because all airlines are operating within a single consolidated terminal facility, the connections of passengers and baggage between airlines are typically closer and less complex than in unit terminal complexes.
- Maximizes concession revenue opportunities: In a centralized facility, it is possible to achieve the maximum exposure of the departing passenger to centralized concessions, which boosts revenue production while eliminating the need to duplicate concession locations as is needed with multiple unit terminals.
- Simplifies macro wayfinding: From a macro wayfinding prospective, there is only one location that passengers need to arrive at and depart from, which typically simplifies the ground access infrastructure and decision making on approaching or departing the airport and terminal complex.
- Minimizes duplication of landside facilities: A single consolidated terminal allows a single rail transit station to serve all passengers, thereby simplifying wayfinding and minimizing the duplication of facilities and the need for connecting services within a multiple unit terminal complex.
- Adapts to airline flexibility: A single consolidated terminal provides adaptability to meet the changing needs of the airlines including minimizing relocations due to changing code-share alliances and partnership mergers.

- Increases gate flexibility and utilization: A single consolidated terminal that is appropriately designed to process both international and domestic arriving and departing aircraft and passengers, through the use of swing gates, eliminates the need to taxi or tow an internationally arriving aircraft to a different domestic departing gate.
- Provides comparable level of service: Operating from the same terminal building typically provides a comparable set of facilities and LOS for the dominant carrier(s) and other competing airlines.

Decentralized Terminal Facilities. Several unit terminals create different needs from those of a single consolidated terminal. Multiple unit terminals represent the most decentralized concept. Each terminal operates independently of the other terminals and duplicates most facilities such as restrooms, building services, vertical circulation, and related structures. Most airports with multiple terminals do not evenly split activity, so each terminal must be capable of responding to individual peaks. This requirement generally results in a combined capacity greater than the airport's combined peak facility demand. Exceptions to this would include airports such as New York JFK where all of the international terminals have similar arrival peaks (due to the dominant trans-Atlantic markets).

An airport also may have different types of airline service that require different types of terminals. A domestic terminal, or one targeted at low-cost carriers, has different needs and characteristics than a large international terminal. Each of these characteristics should be considered when deciding on a centralized or decentralized concept.

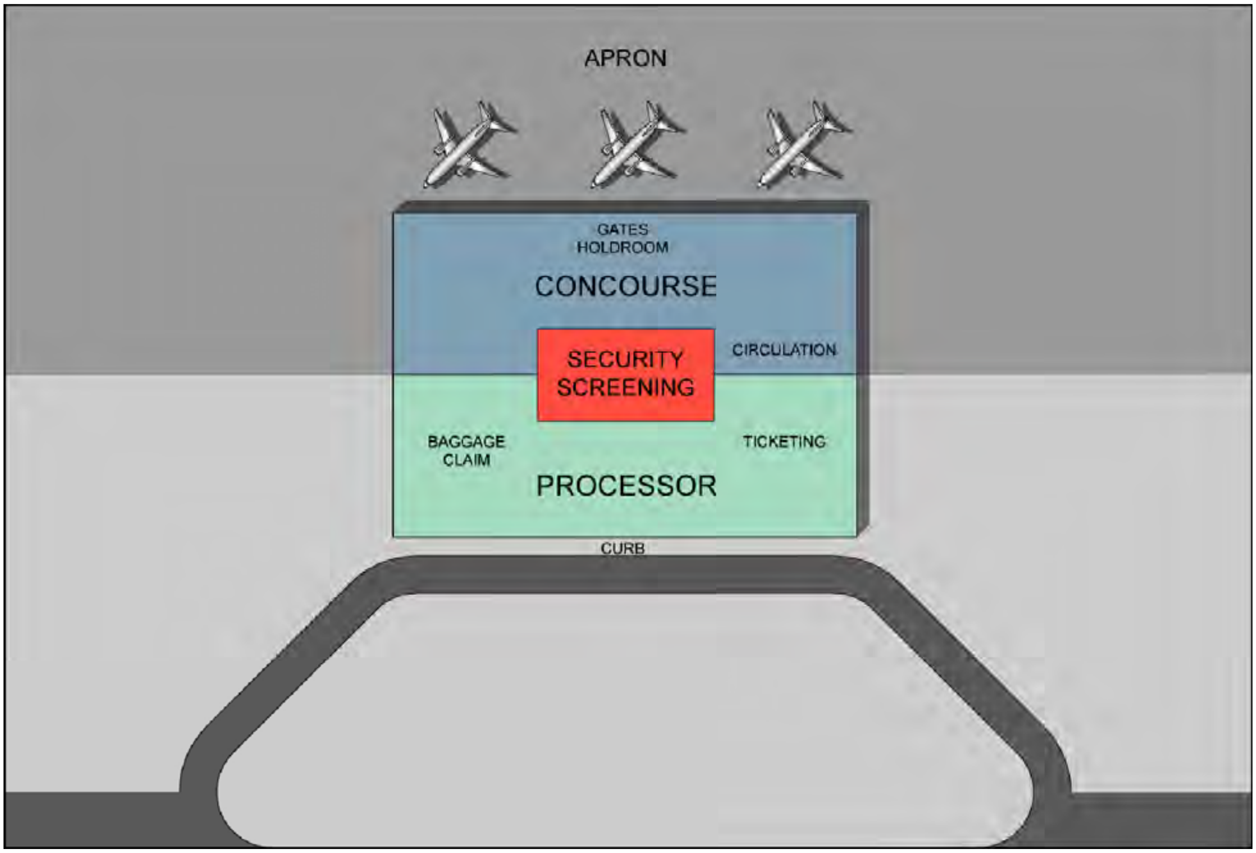
At a certain point, the size of a single terminal may become too large to truly be considered a centralized terminal. For example, to keep walking distances within desired maximums for O&D passengers, a terminal may require multiple security checkpoints that, in turn, produce multiple passenger paths and vertical circulation cores. These multiple paths may then require duplication of concessions and other services in order to be visible to all passengers. Thus, a terminal can have characteristics of a decentralized terminal within a single structure.

VI.2.1.2 Basic Plan Configurations

Over time, four basic terminal/concourse concept types have been recognized by the industry at large. These concept types are referenced in various publications including *The Apron-Terminal Complex* (*1*), which was prepared for the FAA, and in the FAA planning document, *The Apron & Terminal Building Planning Manual* (*2*). These terminal concept types are based on a specific relationship between the aircraft and the passenger processing and boarding areas. Once a decision has been reached about whether the terminal complex will take a centralized or decentralized processing approach, an initial investigation of concepts can begin by exploring any of these four basic concept types and variations on their principal mode of operation. These basic concepts differ in the way passengers are processed from the main terminal to the aircraft gate. Although at many airports, the overall airport terminal complex often combines elements of several of these types, for clarity they are each presented and discussed separately in the following paragraphs.

Linear Concept. The linear concept, in its purest form, is the simplest and most straightforward of the four basic terminal concept types. Its simple organizational principles, however, can also be seen in more complex permutations at various airports around the United States and abroad.

A simple linear terminal consists of a single passenger processing area adjacent to a single common holdroom area, which, in turn, is adjacent to the aircraft parking apron. Aircraft boarding is handled via a series of gates that lead directly to the aircraft parking apron or to passenger loading bridges, which are spaced along the terminal face. Figure VI-3 depicts an example of a



Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-3. Simple linear terminal configuration.

simple linear terminal. In this configuration, this concept type is primarily appropriate for low-activity O&D airports.

In general, the primary advantage of the simple linear configuration is that there is a direct relationship between curbside and the aircraft, and walking distances for passengers are relatively short. A linear concourse may be located parallel to, or within, the terminal face nearest the apron, with access to the terminal and aircraft gate positions at regular intervals.

Classic variations of the linear terminal's direct "to and from" ground access to aircraft gate positions are the individual unit terminals at Kansas City International (KCI) and DFW airports. These unique "drive to gate" terminals, when originally built, were the epitome of this convenient, short walking distance relationship between landside and airside. Today's more demanding security screening requirements and the need for more productive concession revenues have unfortunately rendered the narrow and curvilinear geometry of KCI's unit terminals functionally inefficient with regard to operating costs and revenue generation. The increased costs to operate the multiplicity of passenger security screening checkpoints and the inability to concentrate passenger flows to a centralized concessions area have resulted in significant functional and financial limitations of this variety of the linear terminal.

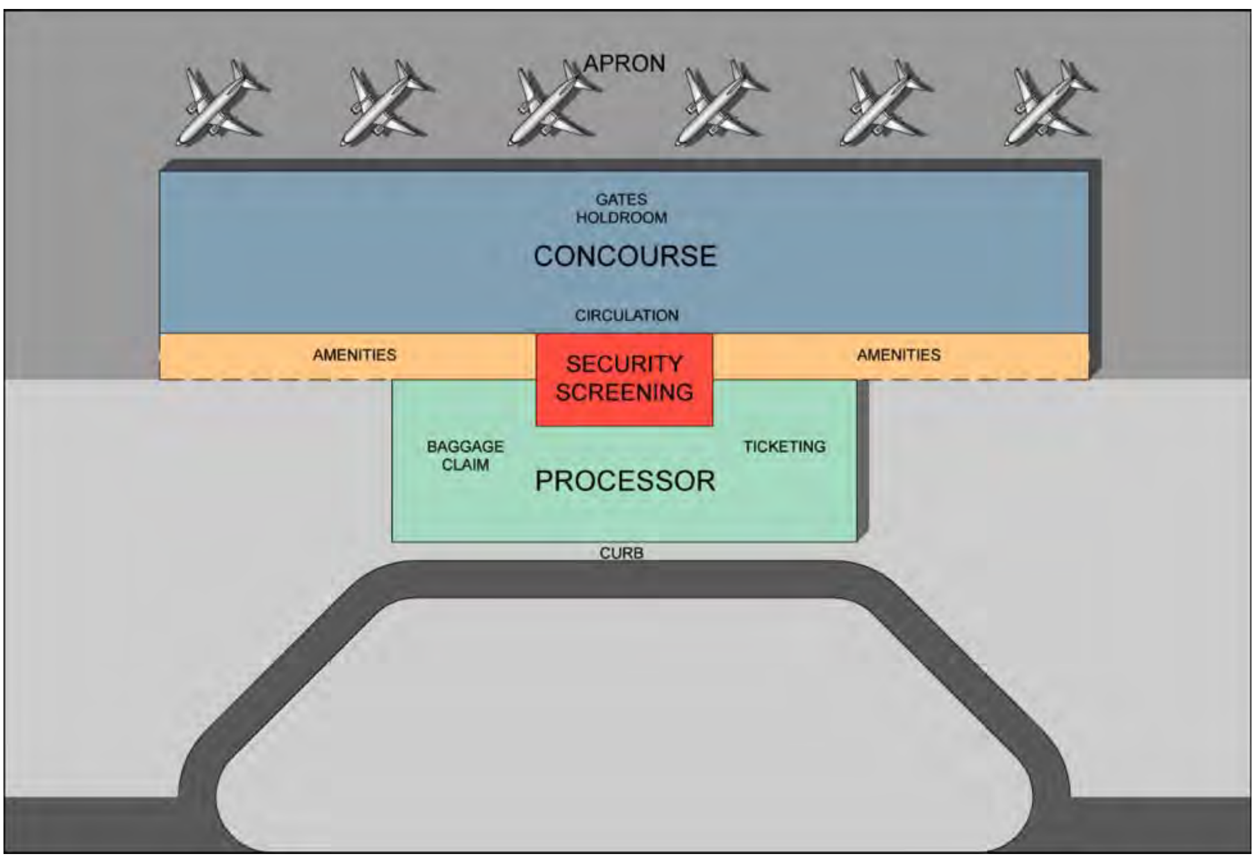
By comparison, "straight" linear terminals, with centralized passenger processing and sufficient building depth, typically gather passengers and baggage together in a single consolidated passenger security screening checkpoint (or a limited number of checkpoints). This funneling together of passengers through checkpoints provides an efficient operation for security personnel/equipment and provides the opportunity to expose the majority of passengers to a centralized concession area. An example of a straight linear concept is the integrated terminal and concourse with its mezzanine APM system at McNamara Terminal of Detroit Metropolitan Wayne County (Detroit Metro) Airport. As discussed previously, a potential drawback, however, is that this centralization inadvertently results in some increased passenger walking distances.

A primary strength of the "straight" geometry linear terminal is its ability to expand easily. This linear expansion of the facility is accomplished by extending the airside, terminal, or landside components independently or in combination. Security screening separation requirements create an easily definable split between the non-secure passenger areas of the terminal and secure concourse areas beyond the security checkpoint.

As a linear concept expands, the terminal configuration consists of a single passenger processing area adjacent to an elongated concourse, which is spread along the expanded airside face of the terminal. Passenger holdrooms are accessed from a linear corridor on the concourse that may be either single loaded, with all services on one side, or preferably double loaded, with gates on both sides of the airside concourse excluding any area needed for the terminal processor and its future expansion.

In a less efficient manner, a linear terminal can be expanded by also developing adjacent unit terminals with pedestrian connectors between them. Individual unit terminals, however, offer few opportunities for common use of equipment and facilities and thus inherently result in some duplication of basic terminal infrastructure and limit the revenue that can be gained from a larger, single linear terminal.

Figure VI-4 depicts a conceptual example of a linear terminal and concourse.



Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-4. Expanded linear terminal and concourse configuration.

Pier Concept. In the pier concept, aircraft are parked on both sides of a concourse that extends from the terminal. Aircraft are usually arranged around the axis of the pier in a perpendicular, nose-in parked relationship. Access to the terminal area is at the base of the concourse or pier. Pedestrian circulation moves down the center of the pier through a corridor with holdrooms, and various services and amenities arranged along both sides of the circulation spine serving enplaning and deplaning passengers. This concept fully separates the passenger processing functions from the concourse activities thus enabling each element to develop according to its own requirements. Because the aircraft access on the pier is double loaded, walking distances for passengers are shortened.

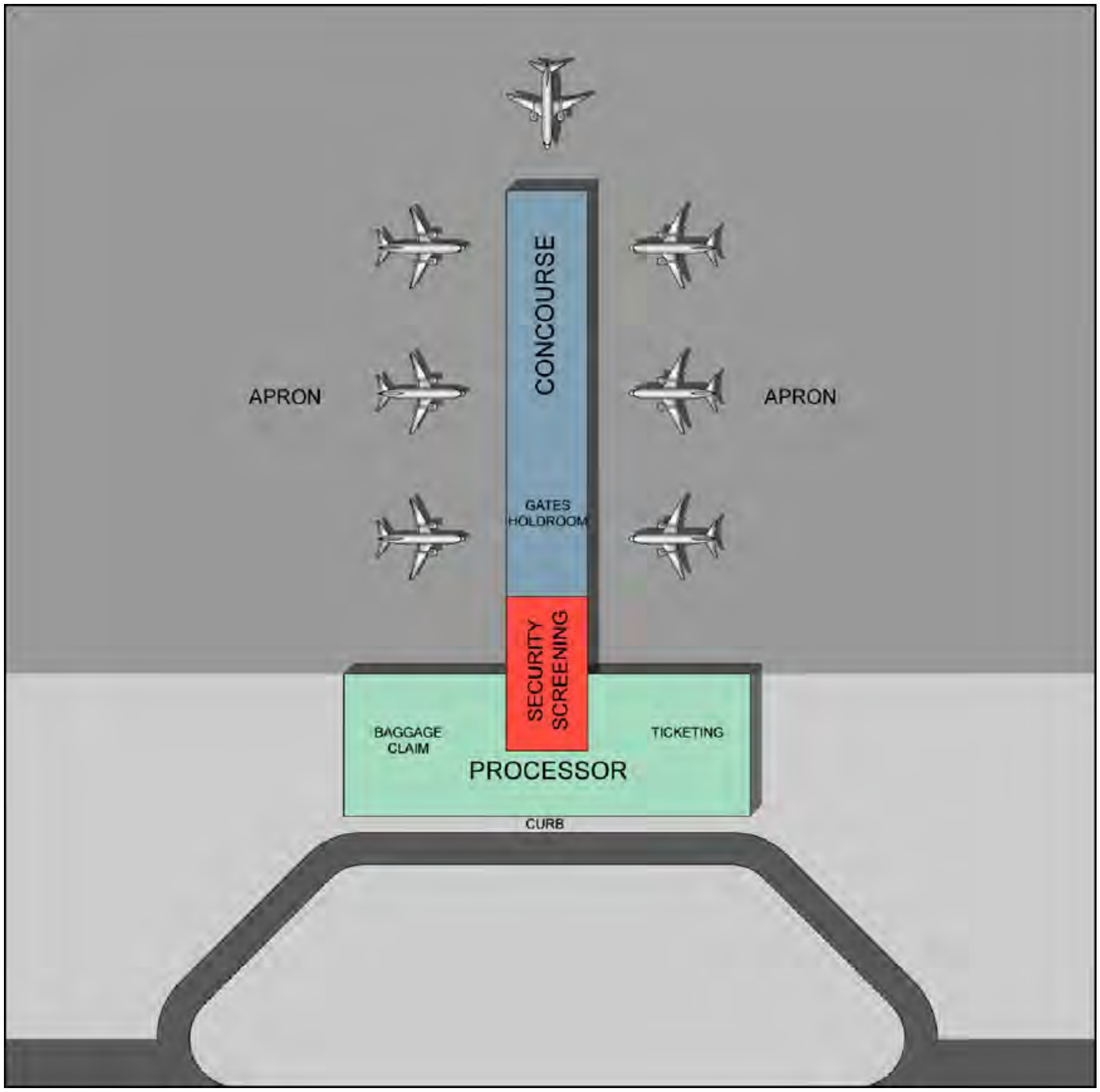
Initial expansion of the pier is accomplished by simply extending the pier to accommodate additional gates. This lengthening, however, increases the passenger walking distance from the processing area. Larger expansion can be accommodated by the development of new piers that are connected to the same terminal processing area. The distance between piers is determined by the size of aircraft the facility is designed to accommodate and by the length of the pier. As pier length increases, the distance between piers is increased because of the need for dual-lane aircraft taxiing areas between piers. This distance often is quite long and may require some type of people-moving conveyance to upgrade the passenger LOS. Multiple processing areas can be developed that can feed passengers into a network of piers. More compact arrangements of aircraft along the pier typically allow for more efficient servicing of the aircraft, thus lowering operating costs for the airlines. Examples of pier concepts are found at LaGuardia Airport in New York, Reagan Washington National Airport in Virginia, and Miami International Airport in Florida.

This configuration works well for moderate to heavy activity at O&D and hubbing airports. The primary disadvantage to this concept is the extended passenger walking distances that can result in a large airport. Figure VI-5 depicts an example of a pier concourse, and Figure VI-6 depicts a multi-pier concourse.

Satellite Concept. In the satellite concept, a building is developed on airside that is completely surrounded by aircraft and is connected to the processing areas of the terminal via an underground, at-grade, or overhead connector. This satellite building houses the passenger holdrooms, as well as various services and amenities for the passengers. The aircraft are normally parked in a nose-in arrangement around the satellite that can have common or separate departure lounges. Although the satellite concourse itself can be compact, the separation distance from the terminal is typically quite lengthy. This length requires that some type of mechanized people-moving system, such as moving walkways, bus, or APM system, be used to move passengers back and forth between the terminal processor and the satellite concourse.

One advantage of a satellite concept is that the passenger and aircraft functions become separate components that can develop independently. In this concept passenger processing is handled in a separate terminal facility. Aircraft parking and servicing occur in a compact area around the satellite, thus simplifying operations. The disadvantages are that more aircraft maneuvering area is typically required, and there is a substantial initial capital cost to install an underground or bridge connector with an APM system to connect the terminal and airside satellite. There are also the associated operating costs of either the automated train and/or moving sidewalks in the connector element. The amount of time a passenger requires to move from the curb to the aircraft is typically increased, and the walking distances may increase.

This concept works well for heavy-activity airports with O&D and a large percentage of connecting passengers. Orlando International, Hartsfield-Jackson Atlanta International, Denver International, Terminal 1 at Chicago O'Hare International, and Terminal 3 at Cincinnati/Northern Kentucky International airports are all examples of satellite terminal concepts.

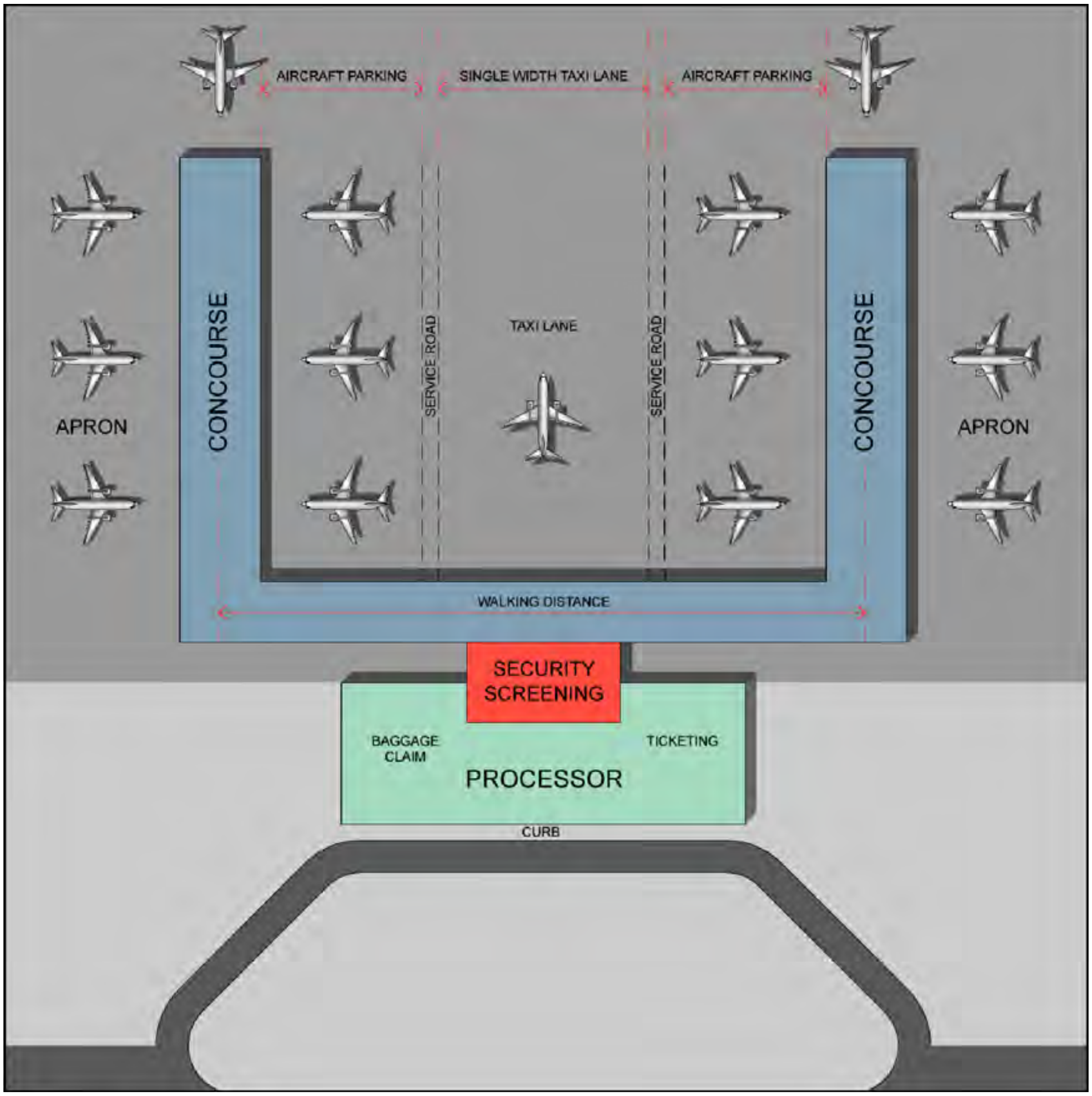


Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-5. Pier concourse configuration.

Initial expansion of this concept is handled through enlarging the satellite building. Often the satellite building will be developed as a pier-type concourse, which can then be expanded by lengthening the pier at either end. Following that, additional satellite concourses can be developed and connected to the main terminal processor building sometimes referred to as the "headhouse." Utilizing this type of system, satellite concourses may be developed specifically to meet a particular need of the airport, such as a facility to handle regional airline service or international passengers. Figure VI-7 depicts an example of a satellite terminal.

Transporter Concept. The transporter concept provides a complete separation of passenger facilities from those required to service and maintain the aircraft. Aircraft and aircraft-servicing functions are remotely located from the terminal. Originally, all passenger processing functions were to be housed in a single centralized terminal processor, sometimes referred to as the head-house, with large mobile lounges serving as temporary holdrooms. Passengers access the aircraft via the mobile lounges that leave from the terminal gates, go directly to the aircraft, and attach to the aircraft to provide weather-protected transit. A more common variation to the mobile



Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

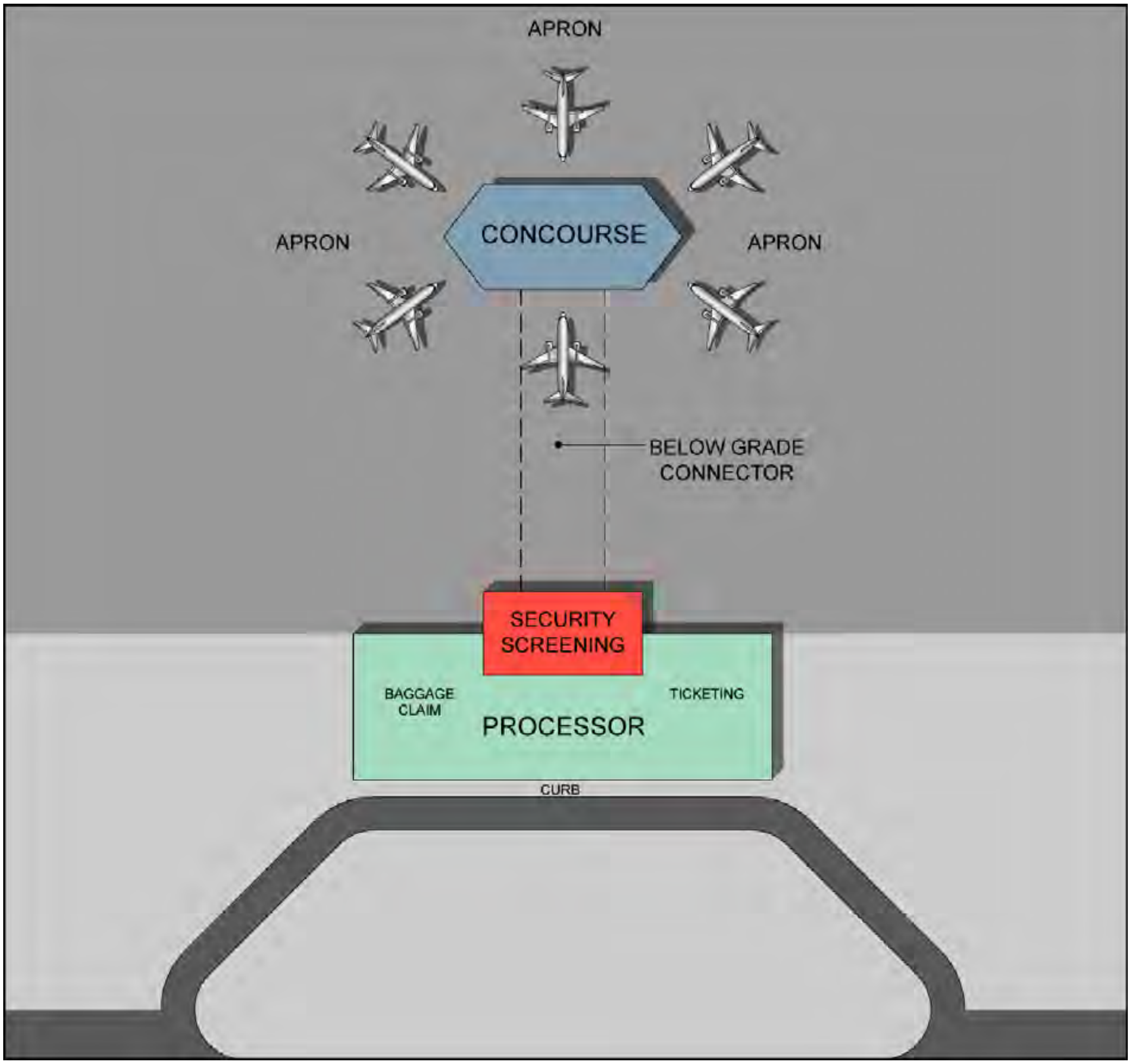
Figure VI-6. Multi-pier concourse configuration.

lounges approach is the use of buses that drop off the passengers adjacent to the aircraft on the apron.

As originally conceived, the primary advantage of this concept was to provide ultimate flexibility for each of the airport elements to develop as needed. The number and arrangement of aircraft parking positions are not directly related to the terminal location or shape, and the aircraft apron could be laid out for maximum operational and maintenance efficiency.

The most well-known "pure" transporter terminal was originally built at Dulles International Airport. The Dulles terminal has been modified to function as a satellite operation to accommodate an airline hub. It will ultimately have a below-grade APM.

The primary disadvantages to this system are that the processing time for loading and unloading aircraft is greatly increased. In particular, the necessity of an early closeout of the flight at the departure location of the mobile lounge in the terminal is a significant operational dis-



Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

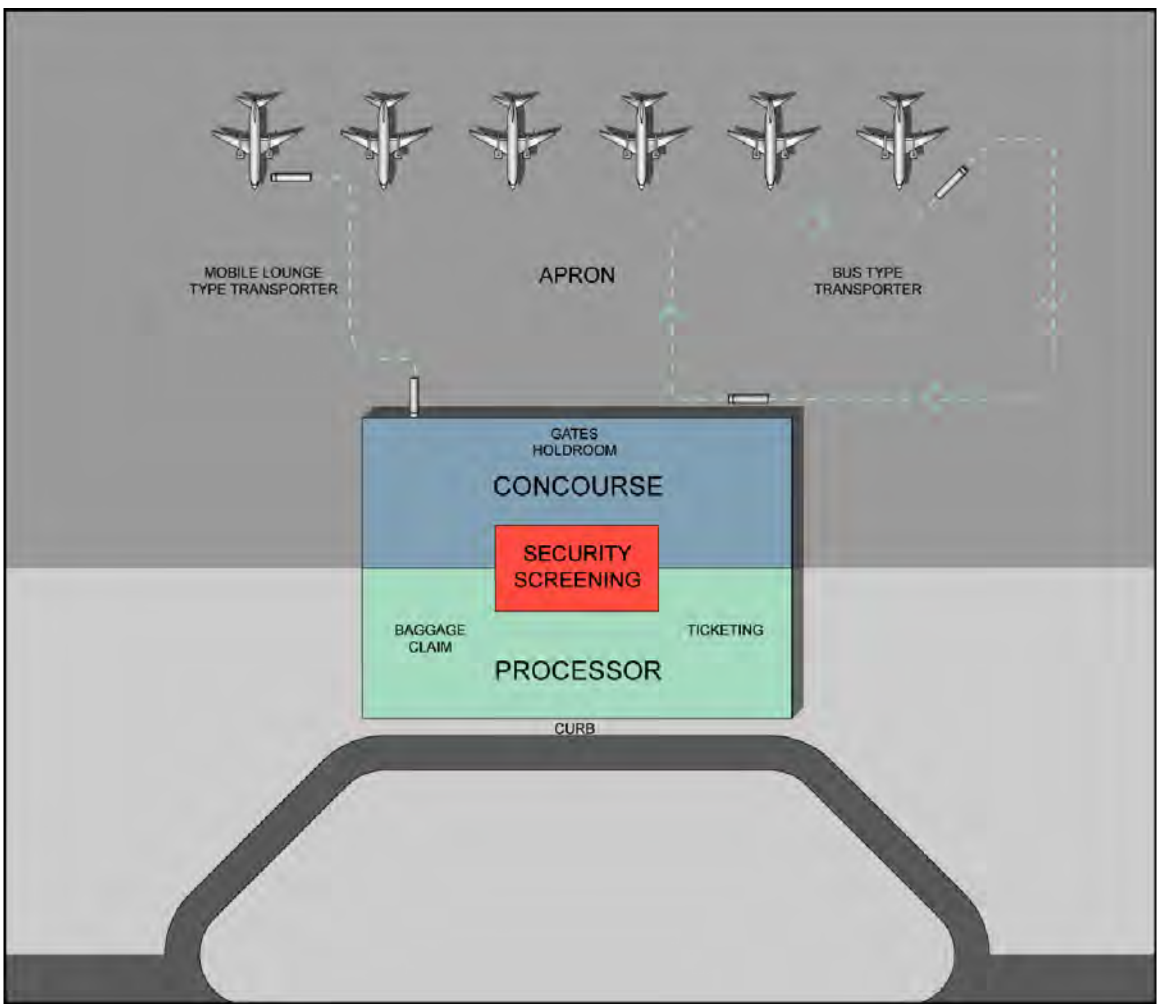
Figure VI-7. Satellite concourse configuration.

advantage especially for business travelers and connecting passengers who may arrive close to the actual aircraft departure time. Additionally, the cost for operating and maintaining the transport vehicles is ongoing and a significant part of the airport's operating costs. And, if a busing system is used, passengers are loaded into the aircraft from the apron and are fully exposed to the weather. Weather exposure can be avoided by the use of mobile lounge–type vehicles; however, the initial cost, as well as operation and maintenance costs, for mobile lounge–type vehicles is quite substantial.

In summary, the original transporter concept envisioned the use of the transporter vehicle as the departure lounge, although a more common application today is simply as a busing operation. Although the transporter concept as a busing operation variant is still somewhat popular in Europe and Asia, the transporter vehicle concept is fading out of existence in the United States. The busing variant is still being used at some airports but primarily as a means of handling peak period traffic without bearing the cost of building additional facilities. This busing transport concept is sometimes used for regional/commuter operations. In the United States, this mode of operations is viewed as a lower level of service than aircraft reached by a passenger loading bridge because of the additional inconvenience of transiting from the terminal to the plane on a bus. Figure VI-8 depicts examples of transporter configurations.

More Complex Designs. With rare exception, airport terminals typically develop as a combination of configuration types. Additionally, because of the availability of land and the desire to make the airport terminal as compact as is practical, elements are often combined in various fashions horizontally, vertically, or both. These combinations open a wide range of variations on the basic configurations, thus offering greater choice when considering terminal configuration options.

Single-Level Terminal. Generally, in smaller, low-activity airports, all of the elements of the terminal are arranged in a single-level building that enables the passenger to move from curb to gate without changing levels. Typically, the only time a passenger has to change levels is for actually boarding the aircraft. For example, the passenger would exit the building and use the aircraft boarding stairs or in some cases go up stairs or a ramp inside the terminal to a passenger loading bridge that docks with the airplane.



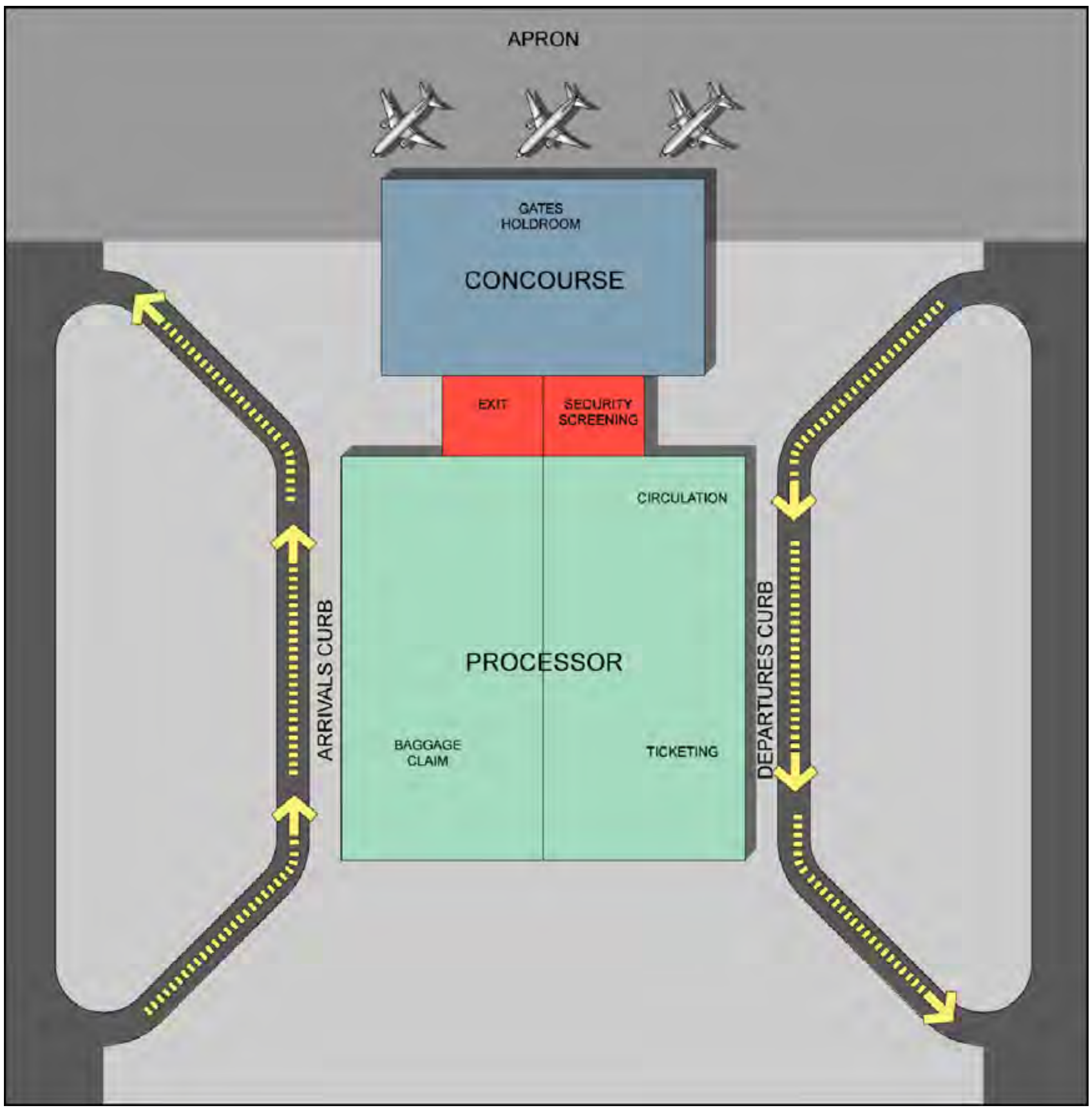
Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-8. Transporter concourse configuration.

For a terminal on one level, the elements of the processor are typically arranged so that departure functions are first on the curb followed by the arrival area, or the departure and arrival functions occur on opposite sides of the terminal with adjacent roadways for each. In either case passenger access to/from the concourse/gate area is through a limited series of monitored screening/exit points. A simple one-level terminal with a single curbfront was previously shown in Figure VI-3, while Figure VI-9 shows a single-level terminal with a dual-curb arrangement.

Two-Level Terminal. With increased activity, in order to make more efficient use of land area and/or to shorten passenger walking distances, terminal elements are often arranged vertically. Typical vertical arrangements include the two-level and the three-level terminal plan.

In the typical two-level terminal, the ticketing activities are located on an upper departures level of the terminal, while baggage claim and ground transportation activities are located on the lower arrivals level. This two-level terminal building configuration should be designed with a two-level



Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-9. Single-level terminal with dual curbs.

curb arrangement with departures on the upper level and the arrivals curb directly underneath in order to minimize passenger's vertical transitions with baggage.

Passengers typically enter and exit the concourse through a screening checkpoint that is located on the upper level. Once arriving passengers exit past security, they take an elevator, escalator, or stairs to the lower arrivals level.

The public concourse elements such as circulation, holdrooms, and gates are typically located on the upper level of the concourse, while airline operations, personnel, and service areas are on the lower level, which is adjacent to the aircraft parking positions on the apron. In this arrangement, passengers board aircraft through loading bridges from the concourse's second level. For aircraft requiring boarding from the apron, such as smaller regional service aircraft, passengers move to the apron level through interior stairs/elevators or via stairs placed at the end of the loading bridge.

Three-Level Terminal. A three-level terminal or concourse is often used at airports handling international flights to provide a separate sterile level to segregate international arriving passengers. This sterile level is located either above the holdroom level or between the holdroom and apron operations level, making the holdroom the third level. Passengers exiting the aircraft use vertical transportation to access the sterile level while maintaining complete separation from departing passengers in the holdrooms or arriving domestic passengers. After entering the sterile corridor system, passengers proceed to CBP inspection areas.

There are many variations possible in the placement of FIS. The FIS may be located above or below the departures level of the terminal, on a single level, or split between two levels. CBP primary inspection (immigration) may be separated from international baggage claim and secondary inspections (customs, wildlife, and agriculture). If primary inspection is on a different level, sterile circulation must be continued between the primary and baggage claim/secondary areas.

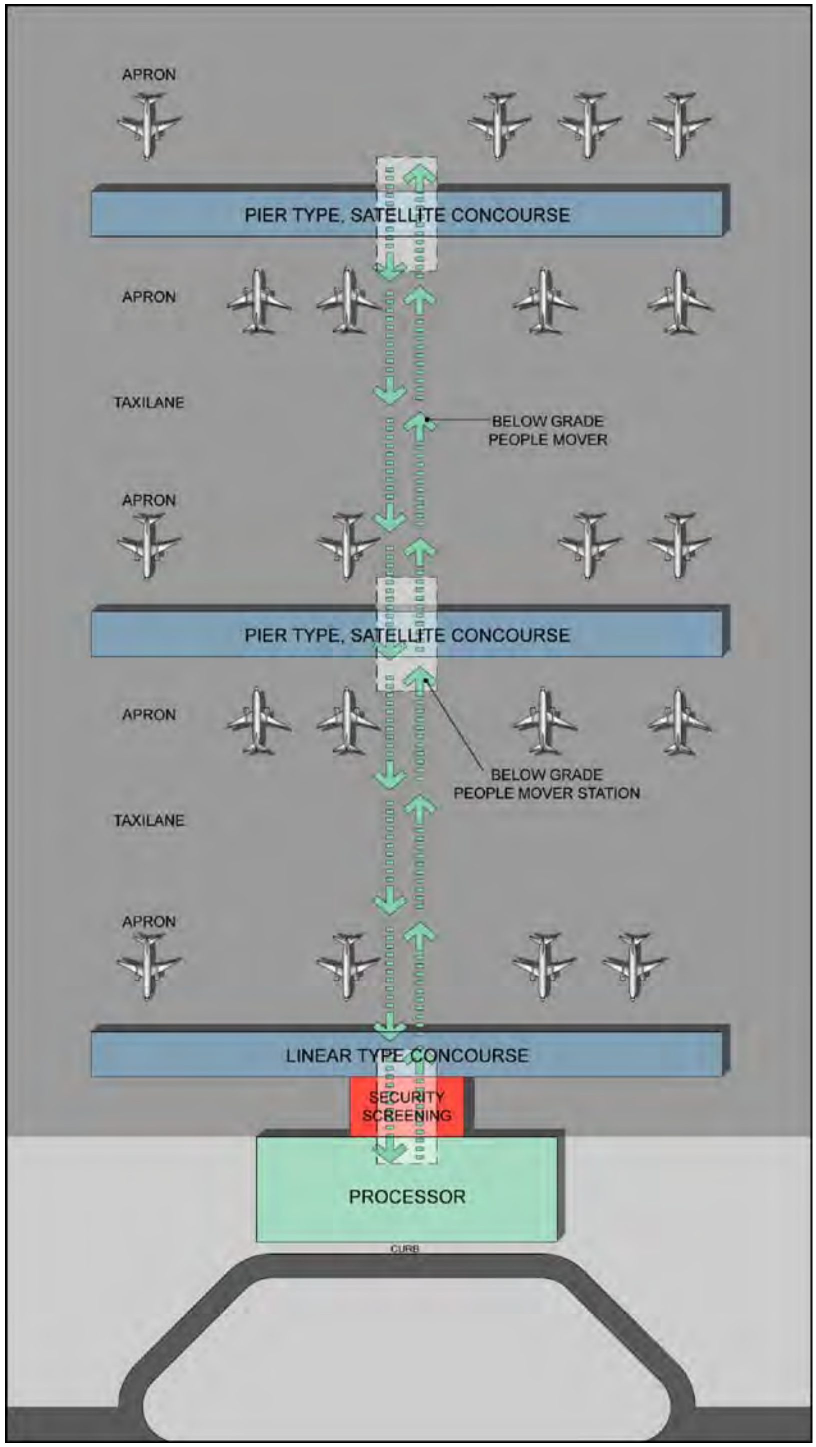
Upon exiting the FIS, passengers pass through a meeter/greeter lobby and arrivals level of the terminal to the adjacent curb. If the FIS is located within a concourse remote from the terminal to primarily serve international to domestic connecting passengers, systems must be in place to transport locally terminating passengers and luggage back to the terminal.

Detached Terminal Elements. Utilizing APM technology, larger airports can develop separate processing and concourse facilities and move passengers between these via specialized passenger transportation systems. This ability enables each of these airport elements to grow and adapt independently, as required, to meet the changing needs of the industry. As the airport grows, new facilities can be added in the appropriate location and the transportation system extended to reach these new additions.

Currently there are two basic types of APM systems in use. The **spine** system transports passengers in two directions along a single spine track system between various areas of the terminal facilities. This system can be completely internal as in the McNamara Terminal of Detroit Metro Airport, run between independent terminal facilities as in Denver International Airport, or connect terminal facilities and other airport facilities such as parking and intermodal facilities as at O'Hare International Airport.

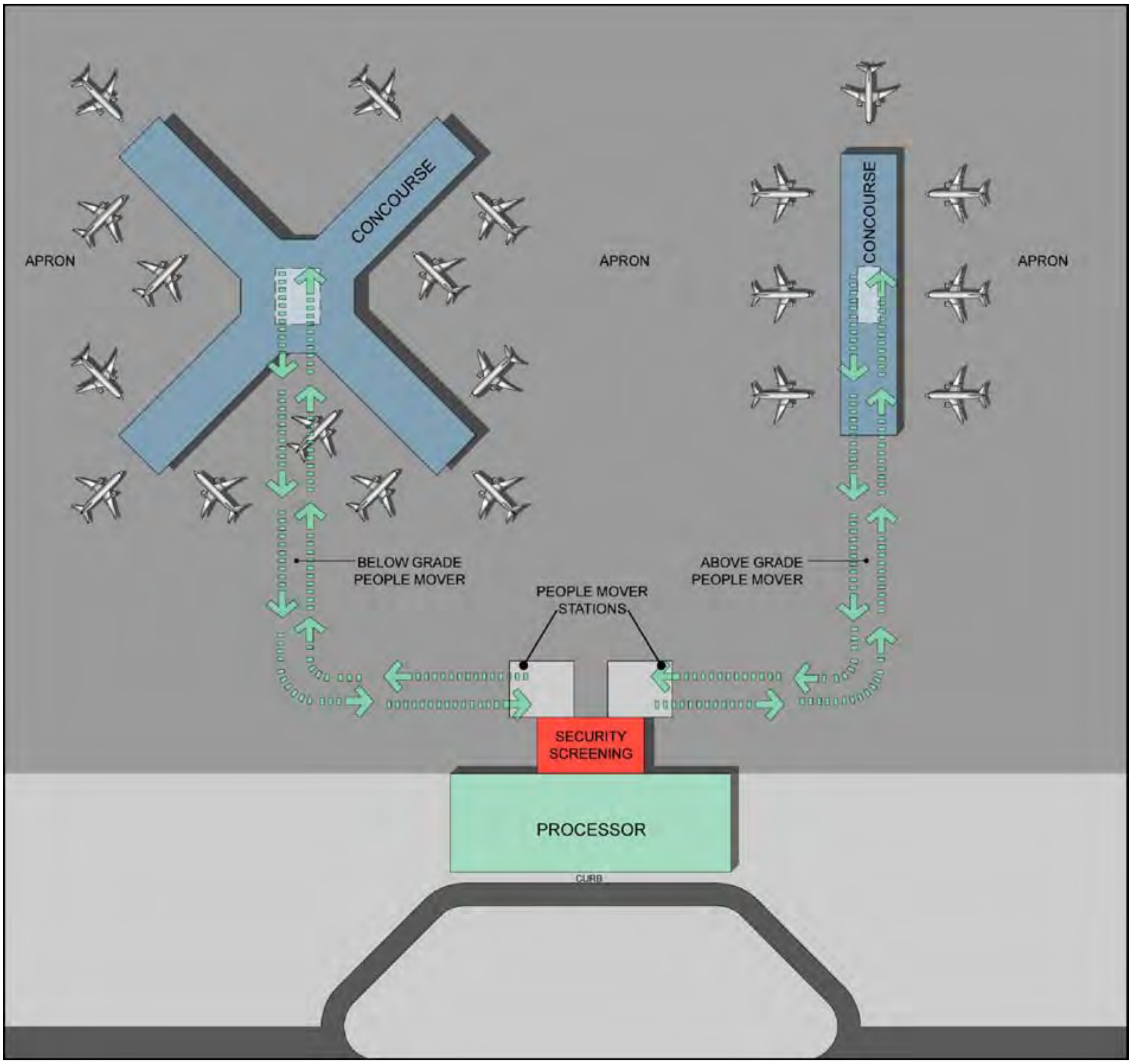
A **loop** system moves passengers in one or two directions around a circular track system between various terminal facilities. A loop system differs from a spine system in that the track circuit is typically longer than a spine system and thus has a larger ultimate capacity than a spine system serving the same facilities. The APM system at Dulles International Airport and the central terminal area portion of the APM at JFK International Airport are examples of a loop system.

A multiple-APM system typically combines a number of individual spine systems that move passengers from the processor area to various concourse areas of the airport. Each system operates independently and is sized and scheduled to meet the needs of the concourse it serves. Tampa and Orlando International airports in Florida utilize a system of spine APMs that transport passengers to and from the central processor to the various concourses as depicted in Figures VI-10, VI-11, and VI-12.



Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-10. Spine automated people mover.



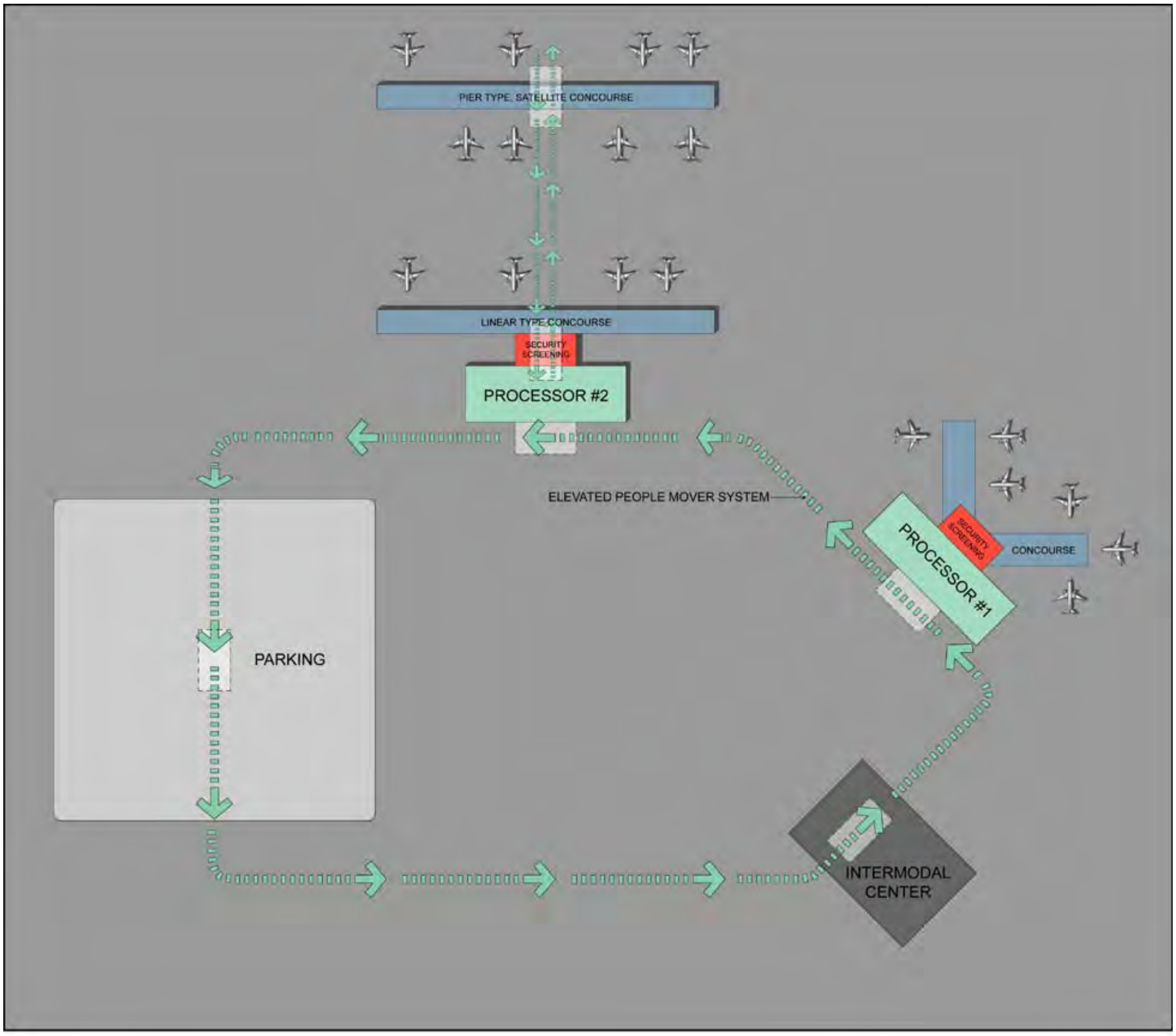
Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-11. Multiple-spine automated people mover.

The primary advantage to this type of system is that each of the elements of the terminal can be developed to meet their own particular needs at the most appropriate location on the airport, while not being limited by passenger walking distances. As the airport evolves, the elements too can evolve to meet the changing requirements. As additional facilities are needed, they can be added to the airport and included in the transportation system. The disadvantages of reliance on APM systems are that they are typically expensive to construct, operate, and maintain and the use of such systems adds to the time required for the passenger to move through the terminal from curb to gate. These disadvantages have to be weighed against the increased capacity and flexibility such systems provide.

VI.2.2 Flow Sequences

This section describes the various paths or flows taken by the different user groups of the terminal and concourse facilities. These groups typically include passengers, visitors, employees, baggage, and deliveries.



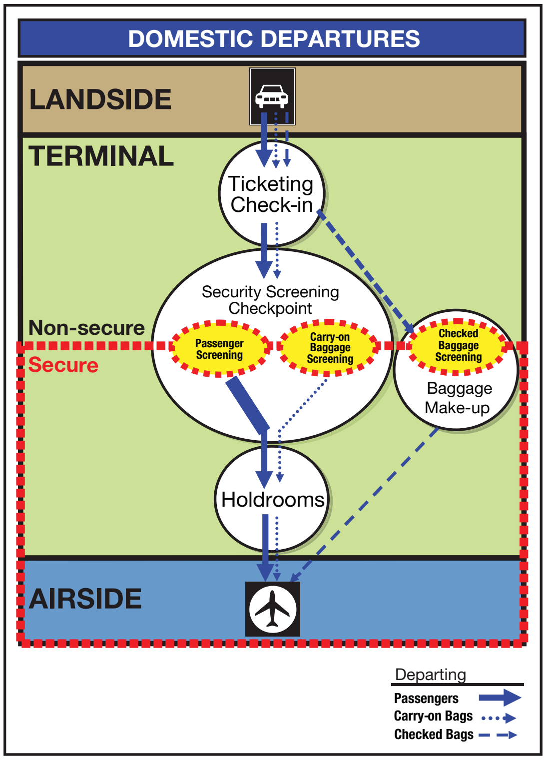
Source: "Considerations for Selecting a Terminal Configuration," David A. Daileda, FAIA, FAA White Paper.

Figure VI-12. One-way or two-way loop automated people movers.

VI.2.2.1 Passengers

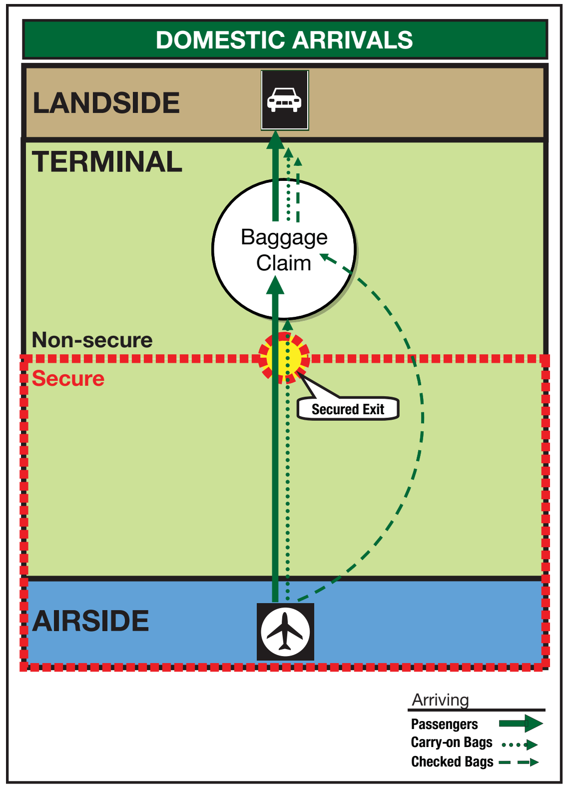
The basic sequence of processing functions for the enplaning and deplaning of passengers has remained fairly constant from the inception of air travel. One of the most recent and significant changes to the air travel experience occurred following the attacks of September 11, 2001. The more stringent TSA security requirements for screening outbound passengers and baggage have had a significant effect on several aspects of today's airport terminals.

The following diagrams represent, in a very simplified manner, the primary passenger processing functions of a U.S. domestic airport terminal complex within the context of its three primary components: airside, terminal, and landside. Figure VI-13 illustrates domestic departures, while Figure VI-14 shows domestic arrivals. A significant function in all U.S. airports is the SSCP, which acts as the control portal between the secure and non-secure portions of the terminal. The SSCP is the location where all passengers and their carry-on luggage, airport employees, and all airside-bound supplies are screened for security purposes. This dividing line within the terminal serves as the demarcation for the SIDA/secured areas (beyond TSA security screening).



Source: Landrum & Brown

Figure VI-13. Passenger flow diagram for domestic departures.



Source: Landrum & Brown

Figure VI-14. Passenger flow diagram for domestic arrivals.

Only ticketed passengers with a current boarding pass and appropriately badged personnel are allowed to proceed past the SSCP. All visitors are currently prohibited from proceeding through the SSCP unless they are escorted by appropriately badged personnel. One reason that visitors are not currently allowed past the SSCP is that this change of policy would increase the number of individuals that would need to be screened during peak periods, which in turn would require additional TSA staffing. At some future date, this SSCP policy concerning visitors may change, which would then affect projected demands on the SSCP, as well as impact the split between airside and landside concessions.

Some of the most significant recent changes in this travel process have evolved out of technological advances, specific security screening changes stemming from the attacks of September 11, and the need to generate more non-aviation revenues from the airport in general.

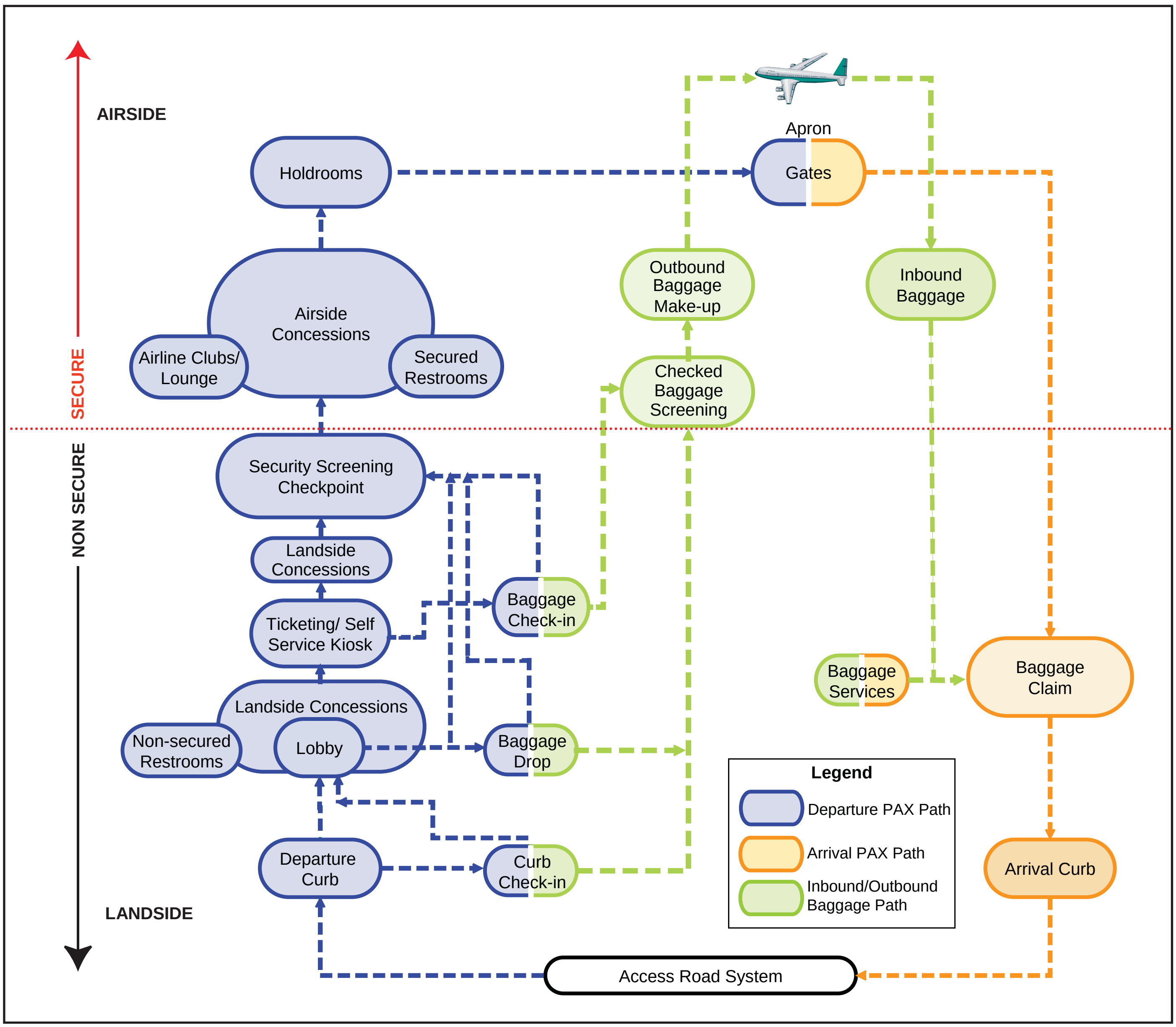
Origin and Destination. O&D passengers are those passengers who begin or end their trip at a particular airport.

Connecting. Connecting passengers are those who change their aircraft between the origin and destination. In nearly all cases, connecting passengers who later connect to another domestic flight are not screened at the connecting airport. Rather, they deplane at the connecting airport at a point that is secure (i.e., behind the screening locations) and then proceed to the gates of their next flight without having to go through another screening process.

Domestic (Arrival/Departures). The domestic departing passengers enter the departure hall or lobby, which is accessible either by car through access road systems or by foot from the parking facilities. The departure hall or lobby also may be accessible by light rail at some airports. Upon entering the departure hall, passengers can check in at their respective airline ticketing areas before proceeding to the security checkpoint. Passengers who have checked in remotely, either at an off-site location or by Internet, can go directly to bag drop locations and then to the security checkpoint. Passengers with no check-in bags can proceed directly to the security checkpoint. Figure VI-15 depicts a typical U.S. domestic arriving and departing passenger flow sequence.

At security, all passengers and carry-on baggage are examined. After going through security, passengers can then shop at the concessions, eat, or continue on to the gate holdrooms. When the flight is called, they will proceed to the holdroom (if not already there) to board the aircraft.

Arriving domestic passengers disembark the aircraft and enter the terminal building on the ground level or departure level depending on the type of aircraft and concourse operations. They are



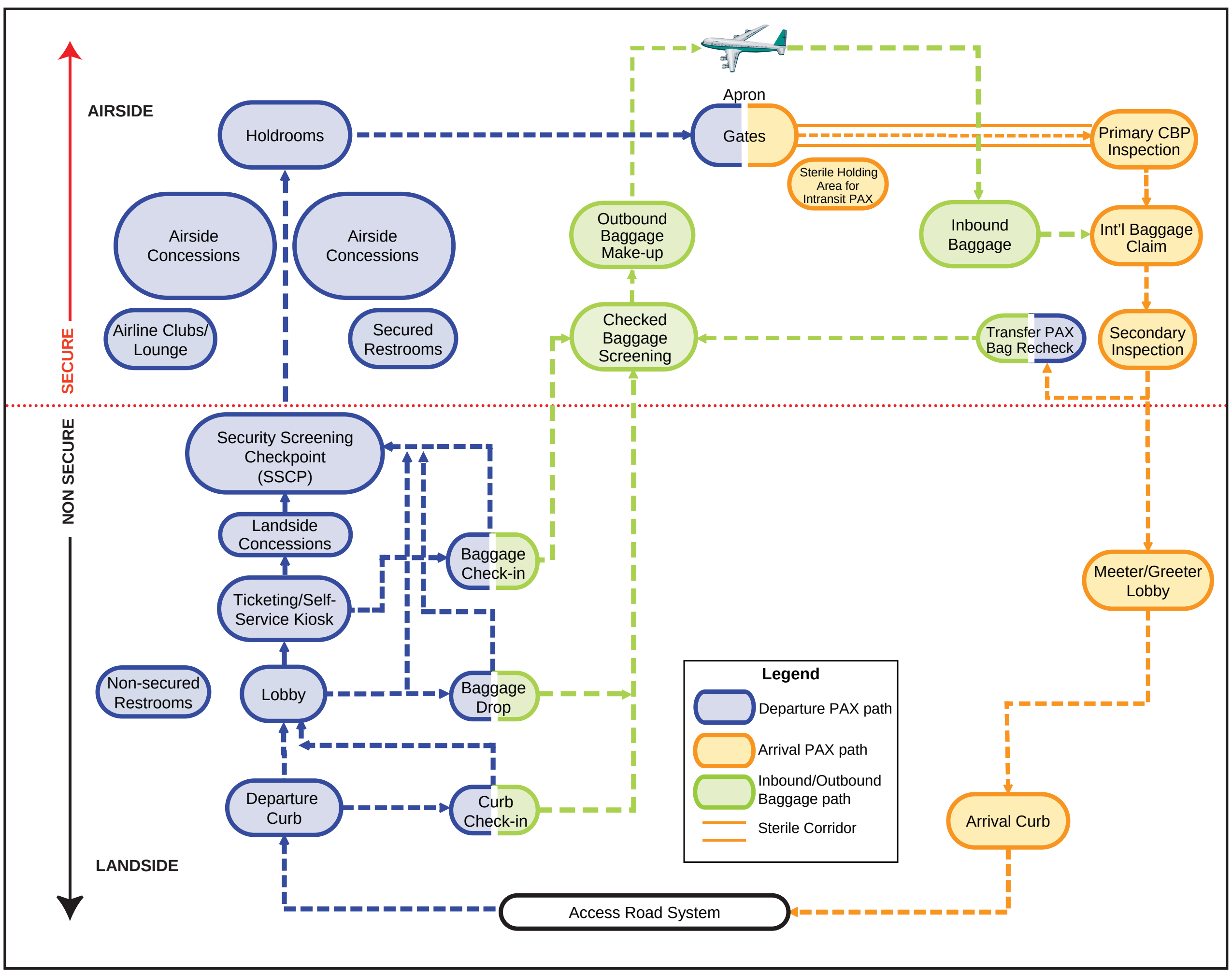
Source: Landrum & Brown

Figure VI-15. Passenger flow diagram for U.S. domestic arrivals and departures.

then directed toward the baggage claim area via concourse signage through the one-way security doors and on to the arrivals hall, where they can claim their baggage and reunite with family and friends. From the arrivals hall, passengers can proceed toward services such as transportation and hotel/accommodation counters, tourist information centers, rail connections, and parking facilities. Depending on the airport, rental car facilities may be located at a remote location on airport property accessed via rental car shuttles operated by each of the rental car companies or a common shuttle bus for consolidated facilities. These buses typically pick up the passenger at a designated area of the inner or outer arrivals curb area depending on the roadway infrastructure of the airport.

International (Arrival/Departures). The departing international passengers follow the same course as the departing domestic passengers mentioned previously. In some cases, depending on the airport, the departing international passenger may enter an international terminal building separate from the domestic terminal. Additional security screening may be required for those traveling overseas to destination cities that have their own strict security guidelines. Figure VI-16 depicts typical flows for U.S. arriving and departing international passengers.

All arriving international passengers disembark the aircraft and proceed through the sterile corridor system toward the immigration hall or CBP primary processing area. In some instances



Source: Landrum & Brown

Figure VI-16. U.S. international arriving and departing passenger flows.

the passenger loading bridge(s) may lead into a "swing gate" vestibule space, which can be used by domestic arrival and departing flights as well as international departure flights during non-peak international arrival times by controlling the door access to the sterile corridor area. Passengers are then processed into the United States by CBP officers at the processing booths. From there passengers are directed to the baggage claim area to claim and retrieve their baggage.

After claiming bags, passengers are directed to exit control points leading to the arrivals hall. Most passengers then proceed to the meeter/greeter lobby or, for connecting passengers, a transfer baggage re-check area.

Arriving passengers, who have been identified by CBP officers for additional screening either at primary processing or at the exit control point, are directed or escorted to CBP secondary processing where further individual screening is conducted. These areas may include baggage and/or agricultural products screening, and passport/visa concerns. From secondary processing, passengers who are cleared are directed to the meeter/greeter and transfer baggage areas.

The meeter/greeter lobby typically includes transportation and hotel/accommodation counters and, in some instances, tourist information centers. All these service counters may be shared by both domestic and international passengers if the CBP area is contained within the main terminal. In some instances there may be a separate international arrivals building. Connecting passengers will then continue on to their gates.

International arrivals facilities that are situated on a concourse on the secured side of passenger screening must have passengers go through an SSCP before entering the secured concourse. Under these circumstances all passengers must recheck their checked baggage either to their connecting flight or, if they have reached their final destination, to a domestic claim device on the non-secured side of the terminal. This procedure is done to ensure the integrity of the U.S. security screening process, because international travelers may not have been appropriately screened to U.S. standards at their point of international origination.

Transiting passengers or "in-transit" international passengers are those who departed from an international location and are traveling to another international destination via the United States. International transiting passengers arriving into the United States are escorted to an in-transit lounge area through a sterile corridor system that keeps passenger(s) from mixing with other inbound and outbound passengers, making it easier and less labor intensive for the escort. Outbound transit passengers would then be escorted back through the sterile corridor system, to their departing aircraft.

Before September 11, 2001, the Transit Without Visa program was available to airlines that had contracts with the United States to transit passengers without them first obtaining a U.S. visa. Many of these passengers would disappear between connecting flights, request asylum upon entering the United States, etc. This program was suspended on August 3, 2003, for posing a risk that could be exploited by terrorist organizations.

As a result, all arriving non-U.S. passengers, whether they are staying in the United States or transiting to another destination, first obtain a U.S. visa. These passengers then have their passports processed by CBP even if they remain in an in-transit lounge. The only exception to this procedure is for citizens from countries in the Visa Waiver Program. Citizens of these countries are considered low risk and may enter the United States for up to 90 days without a visa.

VI.2.2.2 Visitors

Meeters/Greeters. The meeters/greeters of passengers enter the arrivals hall, which is accessible either by car, through the access road system, or by foot, from the parking facilities. The meeters/greeters are bound to the meeter/greeter area in the arrivals hall where they meet their arriving passengers and then depart with them.

Well-Wishers. The well-wishers of departing passengers accompany them to the departure hall in the ticketing lobby. Generally, they enter the terminal with the departing passenger and can accompany them before security checkpoint. Security guidelines after September 11 prohibit any non-ticketed passenger from entering the SSCP area and therefore restrict them to the non-secure areas of the terminal.

VI.2.2.3 Employees

Employees are categorized, from a security perspective, as those who work at the airport and have an operational need for access to various security-related areas. They may be employed by the airport, airlines, concessionaires, the CBP, the TSA, other governmental agencies, or other tenants of airport facilities. Their ability to move around and perform their jobs typically depends on the type and location of their work, and the related permissions designated by the airport on their access badge. These permissions typically provide and/or limit access to security-related areas such as the Airline Operations Areas (AOA), sterile areas, and SIDA/secured areas, each of which is specifically defined in each individual Airport Security Program and are generally the non-public areas beyond TSA security screening. In some airports dedicated "employee-only" lanes near the checkpoint or in designated operational areas can accommodate limited types of access.

VI.2.2.4 Baggage

Domestic (Arrival/Departures). Individuals traveling domestically with baggage to be checked typically check their baggage at the curb or the bag drop locations within the ticket lobby. Depending on the airport, the airlines, and the types of baggage screening being deployed, the bags are either taken to a TSA checked baggage screening point, which is typically located within the ticket lobby; screened in-line behind the ticket counters; or taken to fully integrated in-line screening with the baggage conveyor system. Depending on the size of the airline and/or airport operation, the bags can enter either a baggage pier/carousel make-up area, where bags are sorted by hand and delivered to the aircraft via tug and cart (small operations, single airline), or a sortation pier/carousel make-up area, after which bags are delivered to the aircraft by tug and cart (large operations, multiple airlines).

Those passengers traveling with carry-on baggage that wish to "gate check" will receive a claim ticket at the gate before they proceed to the aircraft. Passengers will typically leave their baggage in the cab of the passenger loading bridge before boarding the aircraft. For apron-loaded aircraft when a passenger loading bridge is not feasible for boarding passengers, baggage carts are typically placed adjacent to the aircraft stairway. Gate-checking typically occurs on regional-type aircraft because overhead bin space is often limited given the size of the aircraft. This type of baggage check is typically preferred by business passengers traveling with smaller sized carry-on luggage and enables quicker baggage retrieval either on the apron adjacent to the aircraft or in the cab of the passenger loading bridge instead of at baggage claim.

Arriving baggage is unloaded by airline ramp personnel and loaded onto baggage carts, which are then off-loaded either onto baggage sortation systems that feed specific claim retrieval devices or onto individual baggage belts that directly feed the claim device through the wall. Arriving gate-checked baggage is unloaded and placed on a cart adjacent to the aircraft stair or in the cab of the passenger loading bridge for claim by deplaning passengers. In some cases where aircraft use a passenger loading bridge for enplaning and deplaning of passengers, the passenger loading bridge itself may have a dedicated luggage elevator in the rotunda area of the bridge. Airline ramp personnel place the baggage in this contained elevator, which then travels up to the departure level of the bridge enabling passengers to claim their baggage just before entering the building.

For airports with a large portion of oversized baggage, separate areas of the terminals are dedicated to its retrieval; for example, ski equipment may have its own dedicated conveyor belt, which should have as straight a run as possible to minimize the potential for jamming.

International (Arrival/Departures). International departing baggage flows in the same manner as domestic departing baggage but may have more scrutinized security screening procedures that are governed by the airline and the security screening guidelines of the international destination city.

International arriving baggage is unloaded by airline ramp personnel onto baggage carts, which deliver the baggage to a sortation system that feeds the CBP international claim devices.

Transfers. Transfer baggage is off-loaded by airline ramp personnel onto baggage carts. Depending on the airline operation, these bags can be transferred "tail to tail" (one aircraft to another) or to a sortation system that directs the baggage to the proper location for transfer onto the connecting aircraft.

International transfer baggage is the responsibility of the connecting international passenger. Once passengers claim their bags and either clear secondary processing or exit the CBP area, they are directed to baggage transfer locations, which feed baggage into the sortation system for delivery to their departing aircraft.

VI.2.2.5 Deliveries

The process or flow by which goods enter the airport complex depends on the area those goods are delivered to. Goods can be delivered at the terminal building via landside loading docks or at secure concourse locations depending on the configuration of the terminal itself. Loading docks and delivery areas at airport terminals offer entry into the building for various vendors and supplies. Deliveries bound for the secure and sterile portions of the terminals and concourse must first pass security inspections or be escorted by individuals with appropriate security clearances to those areas requiring proper security identification. These deliveries may enter the secure portion of the airport via secure checkpoint stations that include either manned guard stations, electronic access points (keypad access) with automatic gates, or a combination of both.

To improve the efficiency of delivering concession goods to airport shops and restaurants, some airports are choosing to develop logistics centers outside of the terminal building to coordinate the arrival of goods at the airport and subsequent delivery to in-terminal facilities. The addition of this middleman facility at large airports can help to reduce overall average stock-keeping costs for the following reasons:

- Acceptance of the concessionaire's merchandise at this centralized facility can reduce the need for concessionaire personnel to accept and process merchandise at the receiving dock.
- Merchandise can be delivered to concessionaire facilities at appropriate times of the day, thereby improving the efficient use of receiving docks and avoiding congestion during peak times.
- Reducing merchandise processing bottlenecks improves the costs associated with security screening of goods, as well as allows the airport operator to better manage the number of trucks on its roads and parked at its terminal building(s).

At several case study airports, the concession logistics centers are noted for the following efficiencies:

- Reducing merchandise delivery times by as much as 80%; delivery personnel can deliver goods in 15 to 45 minutes as opposed to the hours the delivery process could sometimes take without such a center.
- Decreasing the number of duplicate staff hours and equipment needed among concessionaires.
- Increasing the efficiency of staffing levels for TSA, police, and security personnel when incoming merchandise does not have to be processed at multiple, decentralized locations.
- Avoiding the need to break down large packages so they can get through existing X-ray machines and then put them back together for delivery to the stores.

VI.3 Terminal Facility Requirements

The development of a detailed schedule of terminal facilities requirements (the terminal program) is the cornerstone of the process of planning a new, expanded, or renovated passenger terminal. Unless the planning team understands how much space of each type is required to meet targeted levels of activity and desired levels of service, a terminal plan cannot realistically be defined. The program typically does not refer to a specific terminal concept or gate configuration. The programming process can, however, run in parallel with the development of terminal concepts, which may be constrained by the terminal site and/or existing facilities. As the program is developed, especially the number and mix of gates, the terminal concept can be refined and the concept then used to better define certain elements of the program. For example, if multiple unit terminals are being considered, there may be a program for each terminal that reflects the duplication of some concession and support facilities. Thus, programming is, to some extent, an iterative process, but ultimately should drive the size of the terminal building, rather than an architectural concept driving the program.

Terminal facilities are a function of the specific characteristics of the airport they serve. Each airport and each terminal has its own distinct peaking characteristics due to variations in the following:

- Airline schedules
- Proportion of business and leisure travel
- Number of long- and short-haul flights
- Mix of mainline jets and regional/commuter aircraft
- Proportion of originating/terminating passenger activity vs. transfer passenger activity
- International passenger or domestic passenger use

These passenger and peaking characteristics determine the size and type of most terminal facilities. Thus, two airports with similar numbers of annual passengers may have different terminal requirements, even if the design hour passenger volumes are approximately the same. The peak hours for different types of activity (domestic vs. international, etc.), or for different airline groups (hub vs. spoke carriers), may also occur at different times at the same airport. Thus, it is important to determine, as accurately as possible, which types of activity occur at an airport and which individual peaks need to be considered in the terminal planning process. The various requirements can then be consolidated into an overall program that will achieve the primary goal of the terminal, getting passengers and their baggage from ground transportation to aircraft or from aircraft to ground transportation.

As discussed in Section VI.2.1, the concept of LOS also must implicitly, if not explicitly, be incorporated into the assumptions about the areas and dimensions for terminal programming. Unlike many airfield facilities, the capacity of each element of a terminal facility can vary depending on the level of crowding and/or processing time that is considered acceptable. A passenger traveling on business may be less tolerant of congestion or delay than a passenger traveling for pleasure, but in some cases the opposite may be true. In many cases the degree of acceptability also may vary depending on the configuration of the terminal space and the level of amenities provided. Thus, the capacity and LOS of a terminal can vary significantly. Economic considerations, as well as the practical realities of design, dictate that a good LOS must be provided for the design hour passenger volumes. LOS may decline to adequate levels during the "super peaks" of the year, such as during holiday weekends. However, a well-programmed and -designed terminal will not decline to unacceptable LOS, even during these super peaks.

The basic approach taken in developing terminal facilities requirements is to review the plans and areas of the terminals, make observations of passenger activity, discuss with airport and airline staff how well the present facilities are functioning, and then compute the quantitative requirements for current levels of activity. Comparing these to existing facilities is a form of calibration to see if the planning factors and/or models yield a demand consistent with current levels of facility utilization.

The facility requirements described in this section are assumed to be developed using passenger and aircraft activity demand levels produced by one of the methodologies described in Chapter IV, Forecasts. These activity demand levels are then applied to a mathematically based formula that includes generally accepted dimensional criteria for determining the size of the facility. For each major functional area (ticketing, bag claim, etc.), typical configurations and their associated typical dimensions are graphically illustrated and described in the text. Typical dimensions are depicted in both feet and meters on the example drawings and, in some cases, a minimum recommended dimension is suggested. These dimensions are based on multiple sources including current published planning criteria such as IATA and ATA, as well as generally accepted industry planning parameters.

For some of the key facility requirements described in this volume of *ACRP Report 25,* a spreadsheet model is available in *Volume 2* that provides the user with an additional analytical tool. These Spreadsheet Models support the technical analyses mentioned in this volume by providing a quantitative background reference further defining the terminal facility methodology. As with any modeling, judgment as to the validity of the input assumptions is necessary. It is not the intention of either this Guidebook or the analytical modeling tools to provide a "cookie cutter" approach to developing a terminal facilities space program. The planning team should base assumptions and parameters for each terminal on the best locally relevant information, rather than automatically assuming that the typical values are correct. This section also will reference other ACRP studies that provide additional information on identifying and collecting appropriate programmatic parameters; more information on these studies are in Appendix B, Other Pertinent ACRP Studies.

VI.3.1 Level of Service Related to Passenger Flow

Previous sections have characterized LOS as the qualitative experience of passengers using airport terminal buildings and discussed the use of quantitative metrics to determine the amount of space required to provide that experience. Those discussions were based on the space required at a specific point in time, typically the design hour in the design year. However, fluctuations in demand during this design hour can create profoundly different experiences for passengers, not only within the design hour but also beyond.

The basic assumption underlying most space calculations based on a design hour is that the demand rate throughout that hour is constant. While not unreasonable, this assumption is almost always incorrect. Variations in passenger arrival rates during the design hour and variations in both the staffing levels and service rates at facilities during the design hour alter the demand pattern from the uniform distribution implicit in an hourly capacity calculation. In facilities sensitive to the impact of dynamics, using a design hour calculation alone can result in a significant change in the queuing experienced and the LOS provided to a large number of passengers. However, it is often not economical or prudent to plan for a peak condition that is only a few minutes in duration.

This section outlines the key dynamic factors that influence passenger queuing and LOS at processing facilities within airport terminal buildings and the manner by which such factors develop. Applications of these dynamic factors are discussed in the following sections for each relevant terminal element. With this information, planners can determine if adjustments to planning hour calculations are required to achieve target LOS conditions.

VI.3.1.1 Dynamic Factors Influencing Queuing and Level of Service

Passenger Arrival Patterns. Simply knowing how many passengers arrive in a planning period is not sufficient to determine the expected queue, accumulation, or LOS. Instead, a planner needs to know, in smaller time increments, how many passengers are expected to transit the facility. This information may be generated by an arrivals distribution (i.e., for passengers entering the terminal building), output from the previous facility (e.g., the arrival at international baggage claim is directly related to passengers leaving Customs Inspection), flight schedules, on-time performance, walking speeds, etc.

Staffing Level Variation. Both the number of staff provided and the time at which they commence and cease serving passengers have impacts for the LOS at the majority of airport terminal facilities.

Cross Flow or Merge Conditions. It is not economical or sensible to create airport terminals in which each area is only used for one purpose at one time. As such, multi-use spaces must contend with different groups of people attempting to do different things, often at different speeds and/or in conflicting directions. These dynamic factors must be considered in order to design functional facilities providing reasonable LOS.

Facility Location. It is not reasonable to treat each area of an airport as a separate process without regard for the activities that precede it. An airport must be considered as a "system" in which the LOS provided in one facility impacts those that follow. The arrival pattern at downstream facilities, while related to the throughput of predecessor areas, can also be affected by other variables. Thus, two facilities processing the same passengers with the same average processing speed may generate different queues as a result of their relative location in the airport.

Discretionary Time. The way in which passengers spend time in an airport other than in "processing" is discretionary. Variations in the expected use of this time can alter arrival patterns and ultimately the LOS achieved.

Utilization Rates. In a facility where passengers have a choice about the process they utilize (e.g., check-in via self-serve kiosks or full-service counters, with no checked baggage, curbside check-in, or premium check-in), assumptions must be made about the utilization of each of these options. Variations in these utilization rates can have a significant impact both on localized queuing for the various modes and also the total throughput of the facility, which subsequently impacts downstream processes.

Processing Speed. In calculating the throughput and queuing at processing facilities, assumptions have to be made about processing speed. Within a spreadsheet model, an average (such as 2 minutes per passenger) is used, while in a simulation model, distributions are used (such as an Erlang distribution with a minimum of 1 minute, a maximum of 5 minutes, and an average of 2 minutes). Regardless of the type of model used to project the required size of a facility, variations in the expected processing speed can result in significant changes in the LOS achieved.

Passenger–Bag Match. A dynamic factor found in baggage claim relates to the requirement to project not only passenger behavior (number of checked bags, time to arrive at baggage claim, time to find bag, etc.), but also baggage "behavior" (time of first bag, unload rate, etc.), and most importantly the way in which these two factors interrelate. Similarly, security throughput is affected by both the time required to process passengers and the amount of carry-on baggage. As improvements are made to the processing speed of passengers, the ability to process their bags within the same timeframe (i.e., matching the bag processing rate to the passenger processing rate) is becoming the constraining factor.

VI.3.2 Ticket/Check-in Lobby

The departures process has historically begun at the ticket, or check-in counter of the terminal. This has traditionally been referred to as the airport ticket office (ATO) counter. There is also a strong functional relationship between the ticket counter and the administrative offices that support the daily operation of the ticketing and check-in process. It is generally advantageous to have the offices and counters in a contiguous location with a staff only connection which is separate from direct public access. With the increasing use of automated, self-service, and remote check-in systems, the role of the ATO counter and the terminal check-in lobby has changed and continues to evolve.

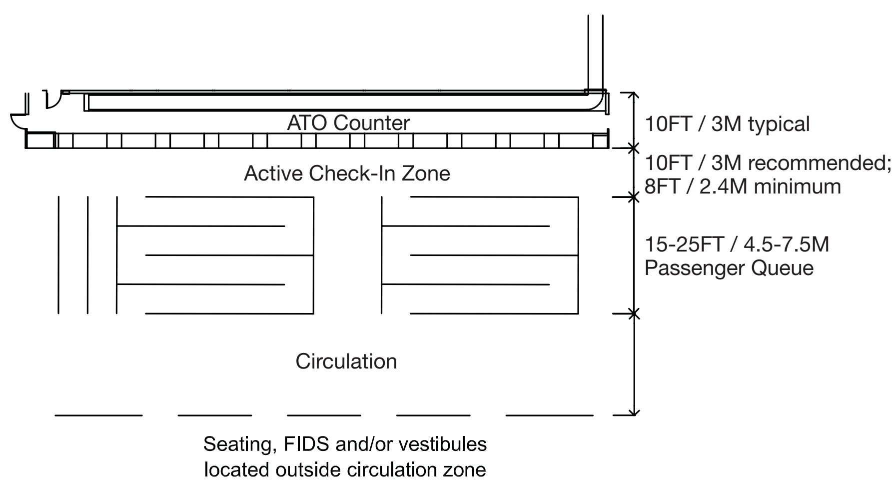
VI.3.2.1 Types of Check-in Facilities

Staffed Check-in Counters. Many legacy carriers, depending on the location of the airport, maintain a certain service level for their customers by requiring staffed counters. These staff members may be divided among dedicated international, first/business class, elite level frequent flyers, and coach domestic ticket counters. Some international carriers may require ticket purchasing positions either at the Airline Ticket Office (ATO) counter or remotely. Figure VI-17 depicts a typical lobby configuration.

Self-Service Check-in Kiosks. Self-service devices are commonly referred to as kiosks and are typically the size of an automated teller machine. Depending on the airline, self-service devices can be designed as stand-alone units that print passenger boarding passes and receipts, and allow the passenger to make changes in their reservations. These types of kiosks can be located away from the ATO counter in the check-in lobby, or distributed throughout the terminal. Because this type of kiosk is not staffed, bag tags usually cannot be printed. When kiosks are located in the ATO counter, counter stations are typically configured in pairs with a bag well weight scale between pairs. This configuration allows for bag acceptance and bag tag printing by agents who can staff multiple counter station positions.

Bag Drop Counters. If passengers checking in remotely have baggage to check and the airline does not allow self-tagging, bag drop counters are typically required. These may be similar to regular ATO counter-located self-service kiosks, but dedicated to the bag drop function.

Self-Tagging Stations. Self-tagging stations can incorporate bag tag printers as well as boarding pass printers into self-service kiosks. Passengers then apply the bag tag to their luggage and



Source: Hirsh Associates

Figure VI-17. Typical linear ticket lobby.

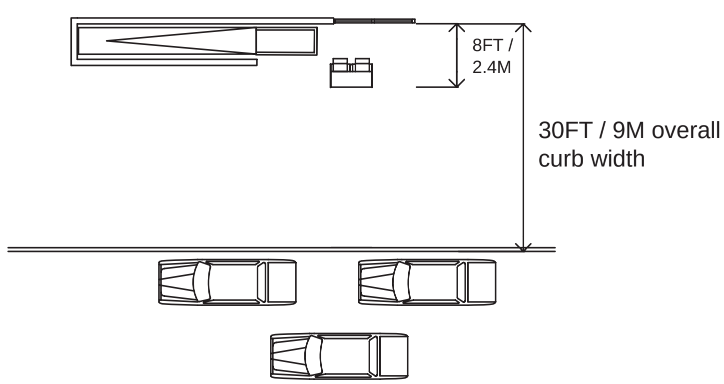
deliver it to an originating input conveyor for loading into the baggage system. A self-tagging station can also be a stand-alone device that only scans the passenger's boarding pass and prints out the number of previously approved bag tags for application. These stations require some minimal staffing support to handle customer issues.

Curbside Check-in. Most airports provide for curbside check-in. Typically curbside check-ins are equipped with conveyor belts located at the check-in podiums for direct input of bags into the outbound baggage system. At smaller airports (or for airlines who do not wish to pay for conveyors), checked bags may be placed on carts and taken into the check-in lobby to be transferred to the ATO counter bag conveyor. Curbside conveyors must either be capable of locking down or include a security door on the conveyor system that separates the public from the non-public side of the facility. These areas can require localized heating or cooling depending on the airport's location or preference. The number of curbside inputs usually depends on the airport's operation, type of airlines served, type of outbound baggage system, and location of baggage system relative to airline ticket counters. Allowing for curbside check-in can improve the LOS for customers and increases the volume of passengers serviced without increasing the size of ticket lobbies. Figure VI-18 depicts a typical curbside check-in layout.

Whether for passenger convenience or airline staffing economics, the proportion of passengers using non-traditional check-in methods has grown significantly and, in the future, such methods are likely to serve the majority of passengers at most airports. Because there are different ways a passenger can check in, or check a bag after checking in remotely (by Internet, remote kiosk, or other means), the ticket lobby may need to accommodate the different types of facilities described previously and possibly others that will be developed in the future.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Check-in/Ticketing model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model allows the user to segment the check-in functions, adjust the number of positions, and see the impact of space inputs on the passenger flow and queue density.

Due to the dynamic nature of these processes and procedures, this Guidebook will focus on requirements of staffed check-in counters, curbside check-in, and self-service check-in kiosks from a physical and functional perspective. The terminal planner should be aware of the various systems and procedures in use, or expected to be used, as the check-in lobby and related spaces are



Source: Hirsh Associates

Figure VI-18. Typical curbside bag check.

planned. Flexibility in configuration and design is especially important for this evolving passenger processing function.

Although demand can be estimated if sufficient information is available, the number of ATO counter positions can often be as much an issue of airline back wall "billboard" space as actual demand, and/or staffing. Thus, some airlines will prefer to locate self-service kiosks in-line with the ATO counter, effectively replacing staffed counters, while others prefer to locate kiosks in free-standing clusters or other configurations away from the ATO counter.

VI.3.2.2 Estimating Demand

Regardless of the mix of facilities, the approach to determining the requirements for check-in requires essentially the same information:

- Number of peak hour enplaning O&D passengers
- Number of airlines
- Time distribution of passengers arriving at the terminal
- Average service times and maximum waiting time targets
- Percentage of passengers using each type of facility in the ticket lobby vs. other locations or going directly to the gate
- Use of curbside bag check-in or fully remote bag check-in

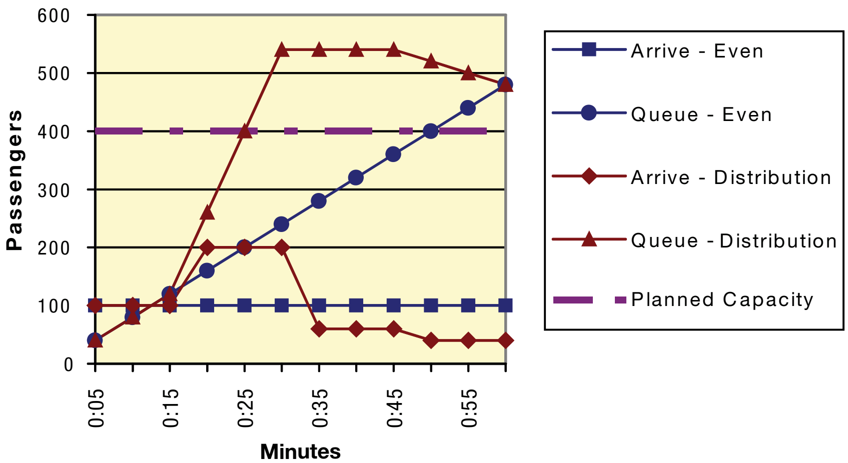
These airline and passenger characteristics can be used together with DDFSs to build queuing models (or input to simulations) to estimate the number of each type of check-in facility for each airline. These models must have all of the above data in order to produce an accurate estimate of check-in facility demand.

However, as noted in Chapter V, DDFSs are often not available. Lacking this specific data for detailed queue modeling, other approaches may be used. Other approaches include using design hour spreadsheet models and using existing ratios of check-in facilities to peak hour passengers and/or gate capacity.

VI.3.2.3 Dynamic Aspects of Check-in

The arrival pattern of passengers at the airport can have a significant impact on the LOS experienced by passengers. As in all queuing facilities, variations in staffing and service rates also affect passenger LOS. Differences in the arrival pattern of passengers at check-in, from a uniform arrival pattern over the design hour to time-dependent arrival patterns during the design hour, result in significantly different queuing patterns and therefore LOS experiences for passengers. Similarly, if staffing levels or service rates vary over the design hour, different queuing and LOS experiences result.

The example in Figure VI-19 illustrates the difference in the passenger queuing between a uniform passenger arrival pattern in the design hour and a variable passenger arrival pattern during the design hour. The basic data used in Figure VI-19 is the same for both sets of lines in the graph and consists of 1,200 design hour passengers, 30 staffed check-in desks, and an average processing rate of 2.5 minutes per passenger. If consideration is limited to a design hour passenger volume, then in a uniform (even) passenger arrival pattern, 100 passengers are assumed to arrive in each 5-minute increment of time. Because only 60 passengers can be served in that time, 40 remain in queue after 5 minutes. At the end of the hour, 480 passengers will be in the queuing area. Without consideration of arrival patterns, a planner might reasonably size the queuing area for this number of people. However, given that the queue of that length only occurs for 5 minutes, it can be argued that targeting a 5-minute increment of time results in providing a larger queuing area than needed thus representing too high a LOS. Accordingly, the 15-minute demand, in this case 400 passengers, is often used.



Source: "Passenger Flow Dynamics and Level of Service in Airport Terminal Buildings," Regine Weston, FAA White Paper, 2004

Figure VI-19. Pattern distribution for check-in arrival.

However, if a simple arrival distribution is applied, the results are quite different. For the arrival distribution shown in Figure VI-19, the passengers are assumed to arrive as follows:

- 25% in the period 60 to 45 minutes before flight close-out (same as uniform)
- 50% in the period 45 to 30 minutes before flight close-out
- 15% in the period 30 to 15 minutes before flight close-out
- 10% in the period 15 to 0 minutes before flight close-out

In this case the arrival pattern has 100 passengers arriving every 5 minutes for the first 15 minutes. Passenger arrival then jumps to 200 every 5 minutes before tapering to 60 and finally 40 passengers in the latter quarter of the hour. Thus, while the hour ends with 480 passengers in the queuing area, this level is exceeded for half of the time and there are 540 passengers, 12.5% more than expected, for a period of 20 minutes. If a 400-passenger peak were used to size the facility, it would equate to being 35% over capacity for that period, which would cause a significant decline in passenger LOS experience.

VI.3.2.4 Check-in Design Hour

The Check-in model considers these dynamic factors and is based on calculating the number of staff needed to check in the originating passengers for the peak 30-minute demand period with a defined maximum waiting time. The basis for this 30-minute methodology assumption is that passengers do not arrive at the terminal in a uniform manner, even within the peak or design hour. It requires data on, or assumptions for, the passenger distribution to estimate the percentage of passengers entering the terminal in a peak 30-minute period, average processing time per passenger, and the maximum waiting time desired. Because the Check-in model is useable for any type of check-in facility, a separate model can be run for each facility to be estimated. The sample arrival distributions that are illustrated in this chapter depend on the type of flight (domestic or international) and time of day (flights departing before or after 9 a.m.), and suggest that the peak 30 minutes of a flight's passengers arriving for check-in can range from 30% to 50% of the design hour total.

An advantage of the Check-in model is that it allows the planner to include LOS assumptions for waiting time. However, it also requires data or estimates for average processing times and the arrival time distribution. This modeling must also be done separately for each airline or group of airlines (assuming the peak hour occurs at a similar time for the airlines, or some type of common use facility). Otherwise adjustments must be made for exclusive-use check-in positions, which may not be in use by airlines during the terminal's peak.

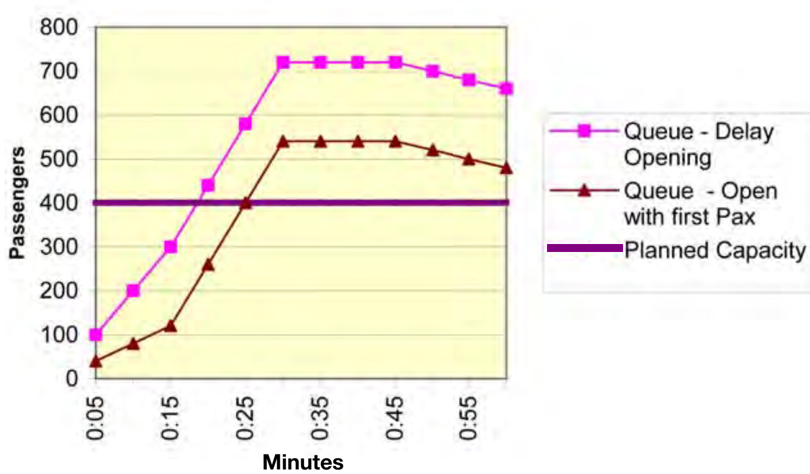
When obtaining data on processing times for staffed or self-service check-in facilities, caution should be used with airline-furnished data. These service times may reflect only the time an agent or kiosk is in use for a transaction (from log-in to delivery of boarding passes) and therefore could underestimate the full time taken by each passenger to complete the check-in process and walk away, making the position available for the next passenger. The planner should confirm airline-furnished data with on-site observation surveys.

The Check-in model assumes a constant number of staffed positions, active kiosks, and so forth. As with passenger arrival patterns, variability in staffing can also affect queue length and waiting times. Continuing with the previous example, and using the distributed arrival pattern as a basis, Figure VI-20 illustrates the impact of staffing on queue length. The base case assumption is that the 30 desks will be fully staffed as soon as the first passenger arrives. Use of this assumption results in a maximum queue of 540 passengers as previously described. If opening the counters is delayed by 15 minutes, the queue at opening will be 300 passengers, which is below the planned capacity of 400 passengers queuing. However, this initial unmet demand drives a peak queue of 720 passengers and an over-capacity condition for 75% of the planning period. This variability should be considered for check-in and other processing-related facilities such as security and international arrivals primary inspection.

VI.3.2.5 Ratio Approaches

Existing ratios of check-in positions to design hour O&D passengers and/or EQA may also be used as a basis for future planning when sufficient detailed data is not available for modeling approaches. These ratios should be based on actual peak period use, staffing of ATO positions rather than leased counters, and numbers of available kiosks; they also should take into account observed levels of service. Examples of this approach are included in the Check-in model.

The ratio approach can combine conventional staffed positions and kiosks as equivalent check-in positions (ECP). Each airline's ECP is the number of conventional positions in use plus the number of kiosks. The current ratio of design hour enplaned passengers per ECP is determined and then either held constant for the forecast years or changed, based on the existing LOS. The



Source: FAA White Paper, *Passenger Flow Dynamics and Level of Service in Airport Terminal Buildings*, Regine Weston, 2004

Figure VI-20. Impact of variable staffing at check-in.

ratio of staffed positions to kiosks can then be varied depending on the current utilization of kiosks at the airport and the trends in kiosk use identified.

An advantage of using a design hour to ECP ratio is that it requires less detailed data than the 30-minute service model. The disadvantage can be that it assumes a continuation of existing staffing assumptions and the approximate number of airlines.

Another variation on this approach is to use a ratio of gate capacity EQA to ECP. This variation may be appropriate when the airport is expecting new airlines and larger increases in gates vs. growth in design hour passengers due to load factors and/or aircraft size growth within an aircraft group.

Other factors that can affect the number of ECPs include the following:

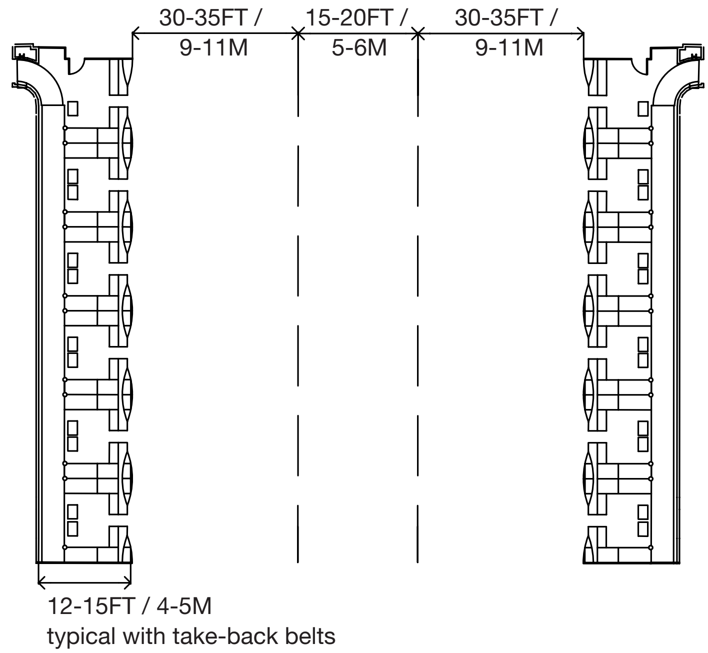
- Curbside check-in: The use of curbside, skycap check-in (although limited to domestic flights) is very popular among many passengers and airlines, especially when skycaps have the ability to issue boarding passes. While removing some passengers with checked bags from the ticket lobby, it relocates the queue to the curb and so has its own facility impacts. Recent changes in charging for use of curbside check-in may reduce utilization unless passengers believe they are getting a higher LOS.
- Common-use counters using Common Use Terminal Equipment: CUTE systems allow airlines to share counters based on schedule compatibility (one airline's schedule peaks coinciding with another's schedule valleys). These types of systems are often administered by airport authorities, or joint airline operating companies. New standards incorporating both CUTE counters and CUSS kiosks are in development by IATA and should be in place in 2009. These CUPPS standards will resolve some commonality issues that have increased the costs and complexity of introducing common-use equipment at many airports.
- Dedicated ticket sales positions for foreign flag carriers: Many foreign carriers require separate counters for ticket sales due to internal training/accounting procedures and/or the use of non-airline personnel (handling agents) for the actual passenger check-in process.

The number of forecast ECPs can be converted to conventional linear positions to establish the length of the ATO counter. As noted, locations for kiosks are determined using a combination of airline preference and the physical constraints of the ticket lobby. To determine the length of an ATO counter for future activity, assumptions are made as to the ratio of in-line kiosks as compared to those located elsewhere in the ticket lobby. The resulting number of in-line kiosks and staffed ATO positions determine the length of the counter.

VI.3.2.6 Typical Dimensions

The ATO counter consists of the actual counter, agent work space, and the baggage conveyors. In most domestic and smaller airports, the conveyor is arranged parallel to the counter and the bags are taken from the counter bag well to the conveyor manually. The overall depth of this configuration is typically 10 feet from back wall to face of counter.

The average width of the ATO counter per agent varies from 4 to 5 feet depending on counter design and whether bag wells or bag scales are shared. Most domestic carriers can use a 6-foot double counter plus a shared 30-inch bag well for an average of 4.25 feet per agent as previously shown in Figure VI-17. In a typical ATO configuration, there are also (1) breaks along the entire counter length to allow personnel access to individual ATO office areas and (2) end counters without bag wells. This increases the average ATO counter length for planning to approximately 5.0 to 5.5 linear feet per position for most terminals. The width of an in-line kiosk can be less than that of a staffed counter but is dependent on individual airlines' equipment. For planning, all in-line positions are often assumed to require the same width.



Source: Hirsh Associates

Figure VI-21. Typical island ticket counter lobby.

In many international terminals, where bags are heavier, powered take-back belts (typically 24 inches wide) for each agent are used. The overall depth of this configuration is typically 12 to 15 feet including a parallel baggage conveyor. The average width per agent varies from 6 to 7 feet depending on counter design. Figure VI-21 depicts a typical island ticket counter lobby. This configuration has also been required by some larger domestic airlines.

VI.3.2.7 Ticket Lobby Dimensions

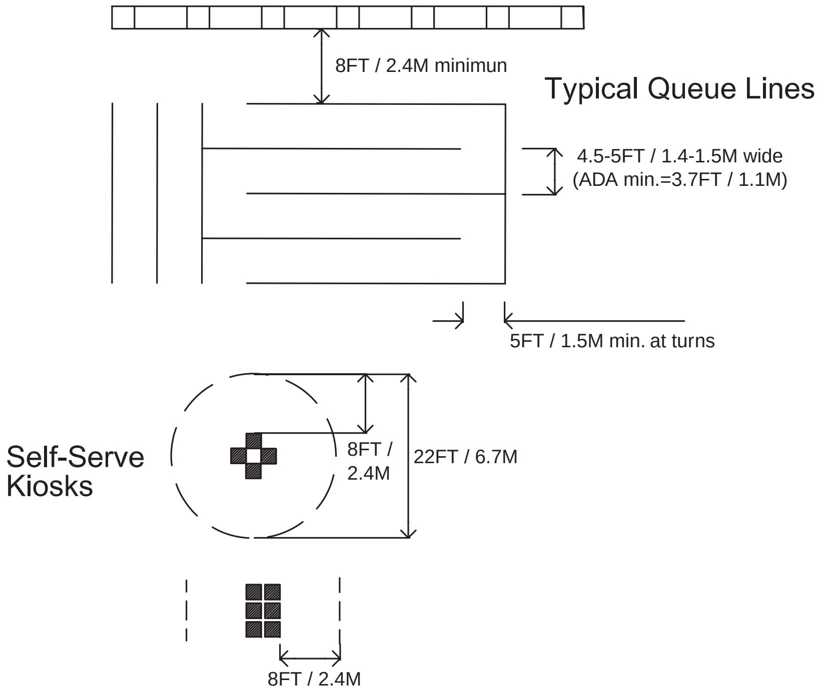
The ticket lobby includes ATO counter passenger queuing area and cross circulation at the main entrance of the terminal building. Self-service kiosks can also be located within the passenger queuing area.

Active Check-in Zone. In front of the counter is space for the passengers who are being checked in and for circulation to and from the check-in positions. This space is recommended to be 10 feet deep, with 8 feet as a minimum.

Passenger Queuing Area. The total amount of passenger queuing area is ultimately determined by the number of passengers expected to be in the queue and the width of the ticket lobby (number of check-in positions). It has been found that 15 feet is typically the minimum depth for passenger queuing and is adequate for lower activity terminals. Medium and higher activity terminals typically require 20 to 25 feet for queuing, respectively.

Queues may be a combination of single queues (one per check-in position) or multi-server serpentine queues. The minimum width of a queue is recommended to be 4.5 to 5.0 feet. At terminals with larger checked bags, heavy use of bag carts, and/or larger traveling parties, wider queues are appropriate. Queue ropes should be spaced to provide more space at turns, with 5 feet as the minimum and 6 feet recommended when bag carts are used. Figure VI-22 depicts typical queue dimensions.

For stand-alone kiosks, 8 feet for the passengers and circulation is recommended. Figure VI-22 depicts kiosk area dimensions as well.



Source: Hirsh Associates

Figure VI-22. Typical queue dimensions.

Cross-Circulation Zone. A cross-circulation zone is needed behind the passenger queue. This zone should be free of obstructions and separate from seating areas, FIDS, advertising displays, and/or entrance vestibules. The width of this zone is recommended to be a minimum of 10 feet at lower activity terminals, increasing to 20 feet at higher activity terminals.

Total Dimensions. The combination of these three functions results in the following typical dimensions for the depth of the ticket lobby:

- Low-activity terminals—35 feet
- Medium-activity terminals—45 feet
- High-activity domestic terminals (minimum)—55 feet
- High-activity international terminals—50 to 70 feet

Seating areas, entrance vestibules, and other functions would be in addition to these and typically add a minimum of 5 feet to the overall depth of most lobbies.

Terminals with unusual conditions that result in large surges of passengers, such as charters, cruise ship activity, and so forth, may require deeper lobbies. In all cases the ticket lobby should be as barrier free as possible, and enough space provided for cross-circulation flows so they do not trigger automatic openers for curbfront doors.

There are also two fundamental check-in counter configurations: linear/frontal and island. These are illustrated in previously shown Figures VI-17 and VI-21, respectively.

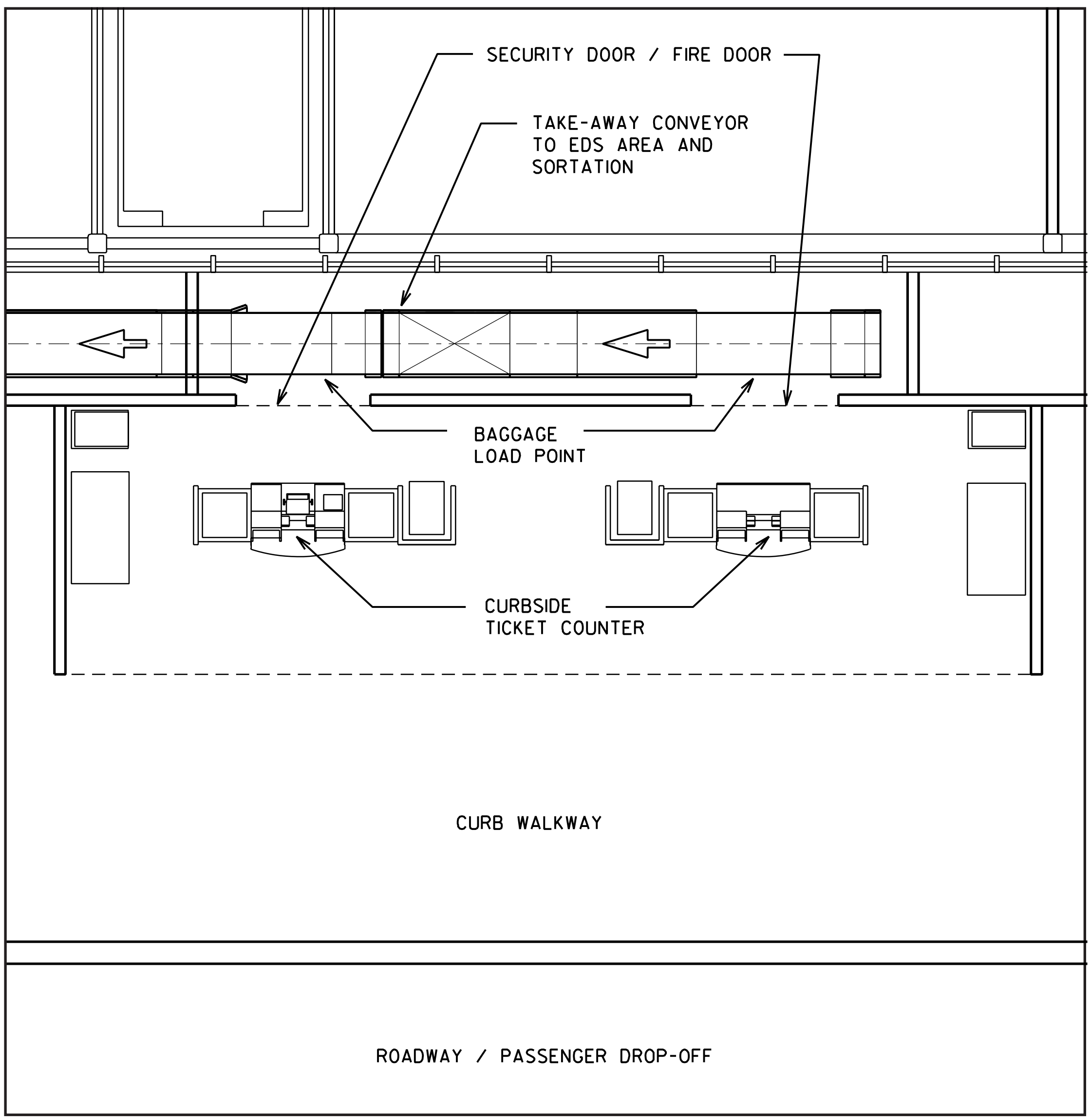
The linear/frontal configuration is the most common for domestic terminals as well as many terminals handling international passengers with limited numbers of airlines. This configuration provides the most frontage as compared to the number of check-in positions.

The island configuration is more common at larger international terminals because the number of check-in positions requires more length than frontage. The dimensions shown in Figure VI-21 are applicable to medium to higher capacity terminals.

VI.3.2.8 Curbside Check-in Dimensions

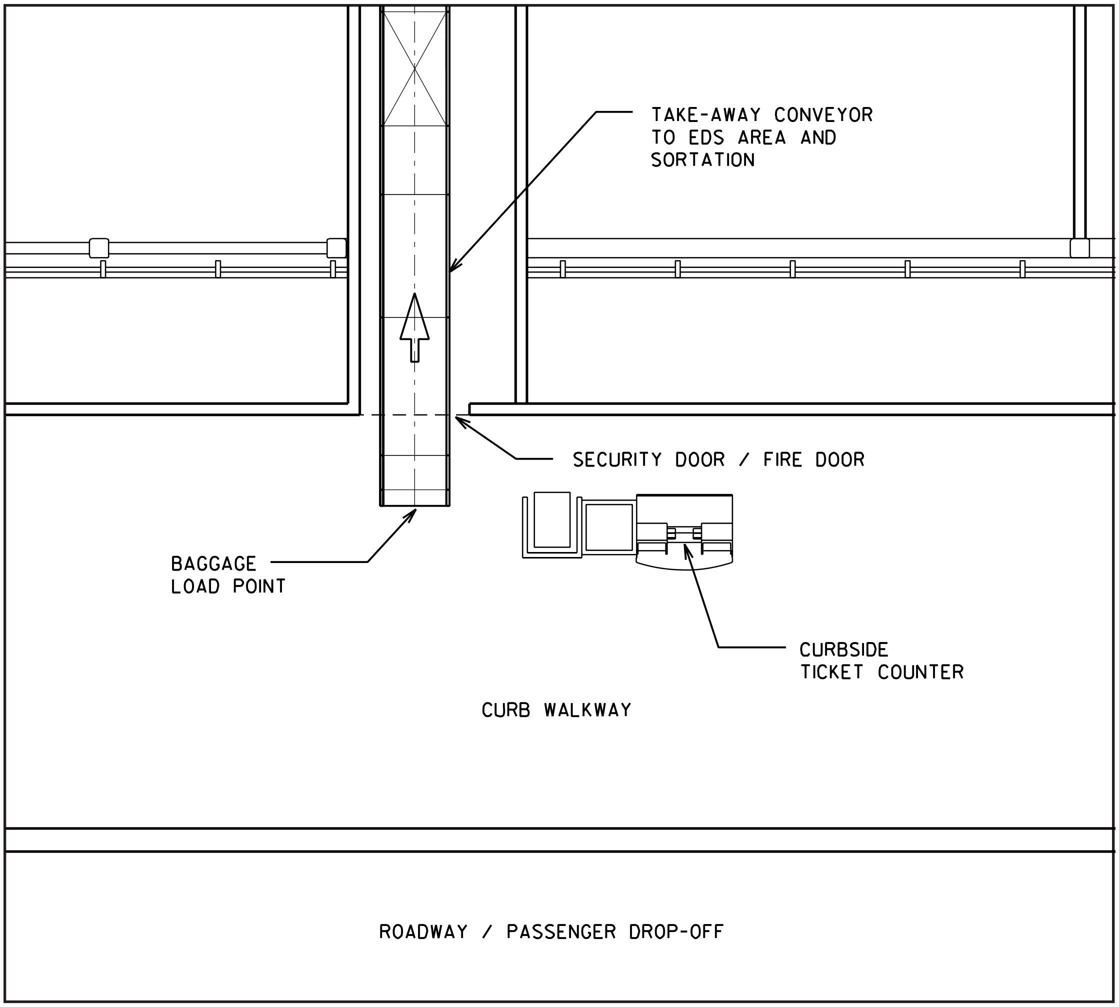
Curbside baggage check-in is popular at many airports. The dimensions for these facilities are similar to that of typical check-in counters. Figure VI-18 illustrates a two-position check-in podium with a bag belt to the side. This configuration minimizes the depth of the podium (8 feet). Depth can also be limited by locating the bag conveyor within the terminal front wall to allow a more conventional counter configuration. Figures VI-23 through VI-25 illustrate other typical curbside check-in configurations.

Passenger queuing and cross circulation space is recommended to be a minimum of 12 feet, with greater depth for higher activity terminals where there may be more circulation along the curb edge. It is normally anticipated that queues will form parallel to the curb rather than toward the vehicle lanes. This results in a 30-foot recommended minimum depth.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-23. Typical curbside ticket check-in counter with take-away conveyor and two load points.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-24. Typical curbside ticket check-in counter with take-away conveyor and one load point.

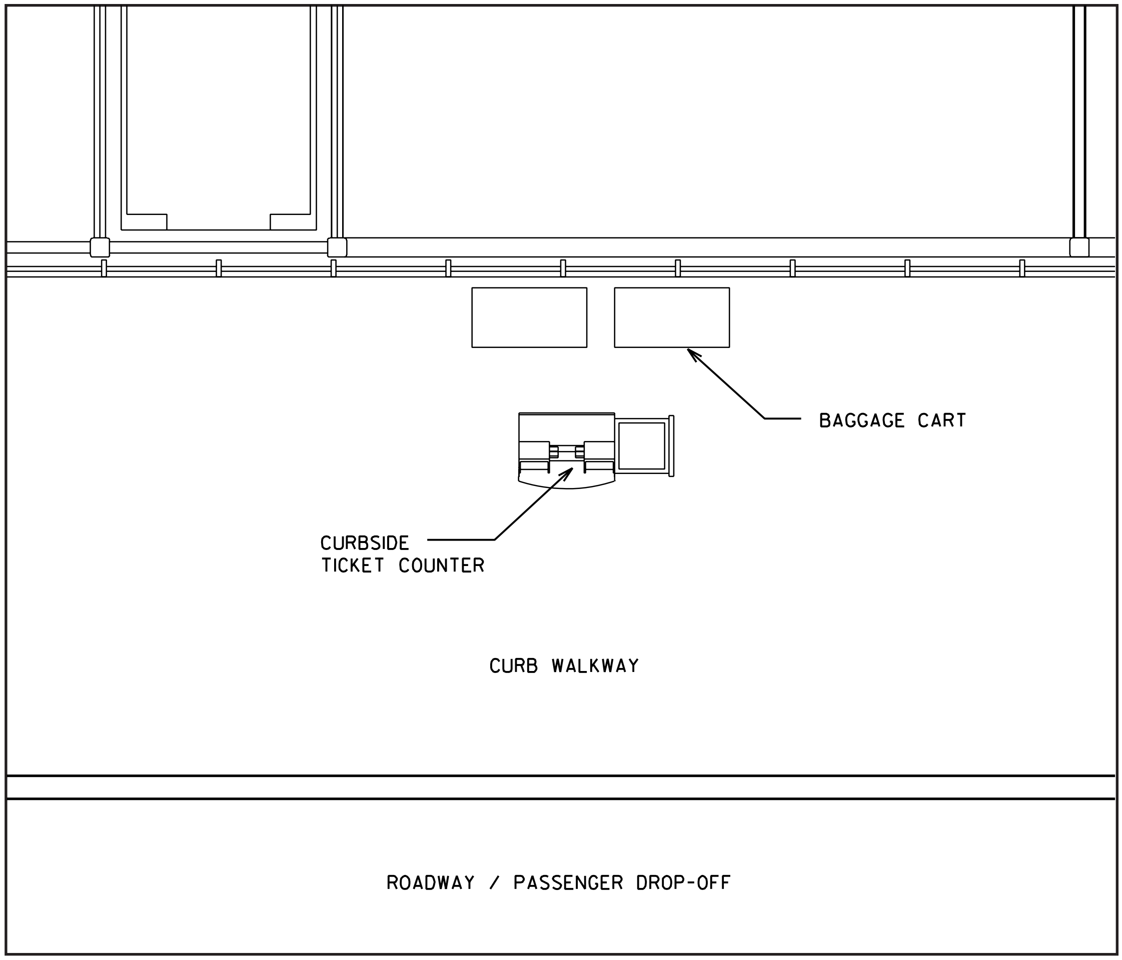
The curb depth is also influenced by the presence of vehicle barricades that may be required at some airports for blast protection considerations unrelated to passenger processing.

VI.3.3 Passenger Screening

Security screening requirements are subject to TSA regulations and the level of security may be changed by TSA security directive if unusual levels of threat are perceived. Please see Section VI.1.6, Terminal Security, for a more complete discussion of passenger and baggage security considerations.

VI.3.3.1 Estimating Demand

Processing rates for SSCPs have been observed to vary significantly at different sized airports, with rates ranging from approximately 100 passengers/hour/lane to over 200 passengers/hour/lane. A lane contains typically an X-ray unit for carry-on bags, plus a walk-through metal detector (WTMD). Based on current TSA procedures that require passengers to remove computers and some other electronics from passenger bags, to remove their shoes, and so forth, the X-ray unit determines the capacity of the SSCP. Some airports have installed a combination of two X-ray units paired with a single WTMD for better TSA staff utilization, which also results in a reduction



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-25. Typical curbside ticket check-in counter with baggage carts.

of the width of the checkpoint. This configuration is typically referred to as the "2 to 1" combination and is currently considered the preferable configuration.

Passenger characteristics typically determine the SSCP throughput, with less frequent travelers (who are unfamiliar with TSA rules and procedures) taking longer than frequent flyers. Changing TSA rules, such as the ban on liquids and gels, can also slow down processing rates until all passengers become familiar with the new procedures. It is very important that each airport measure its average processing rates during different seasons and times of day to determine a reasonable range of processing rates to use for planning. It is also recommended that actual throughputs be observed rather than relying on TSA hourly WTMD counts. These counts can overstate the passenger throughput because the WTMD counts include each person who passes through, including TSA officers and passengers who trigger the alarm and are allowed to take off probable trigger items and walk through again.

Processing speed for the SSCP actually consists of the time required to perform a number of different activities such as divestiture, WTMD, X-ray, and referral to trace detection, each with its own individual processing speed. Variation in the time to complete any of these can have significant impact on the overall processing rate. As an example, one major airport found their security processing speed significantly diminished when dealing with participants from a large computer conference in which a high percentage of the passengers had increased quantities of electronics. Although the number of passengers processed was comparable to other peak days, the average wait time increased to 1 hour from the typical 20 minutes as a result of increased trace utilization and reduced processing speed. Increased queue length and wait time can occur as a result of increased processing time in any type of queuing facility, although variations tend to be more extreme where multiple processes are involved, as in the case of security.

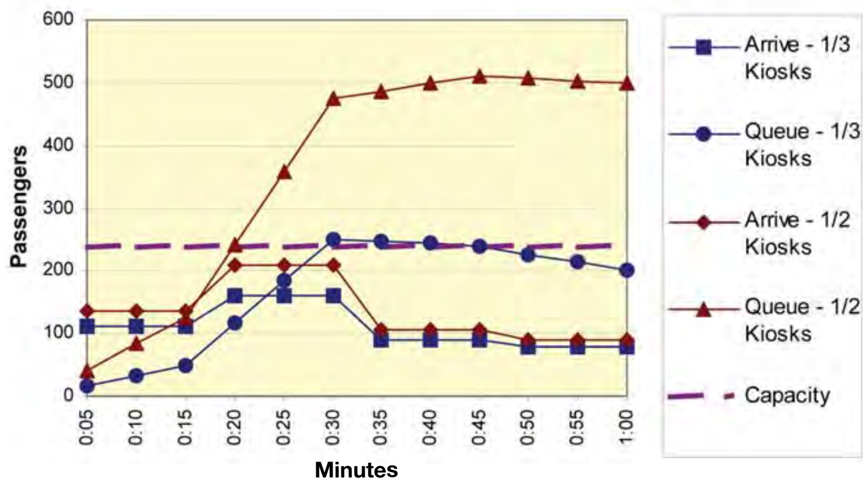
As discussed in Section VI.3.2, Ticket/Check-in Lobby, queues at check-in are affected by the rate of arrival for passengers entering the terminal building. If all passengers use the check-in facility immediately in advance of security, then the volume of passengers entering security has a known maximum, which is equal to the throughput capacity of the check-in counters. However, a number of dynamic factors can cause demand to exceed this "known" maximum. One of the most difficult to assess is the impact of passenger discretionary time. After check-in, some passengers may not proceed directly to security. The factors considered in making this decision include the amount of time before flight departure, security queue length, previous experience using the airport terminal, availability of concessions in the non-secure area of the terminal, and whether the passenger is accompanied by a well-wisher. There are too many variables to reasonably consider in a simple mathematical formula. For simulation modeling, significant data collection is required to develop reasonable test scenarios.

The Security Screening model assumes that passengers do not have significant delay between check-in and security; however, the peaking factor can be varied to test the sensitivity of this assumption as discussed in the following paragraphs.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Security Screening model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model allows the user to see the effect of the number of screening lanes and passenger processing rates on passenger flow and the queue density.

Notwithstanding, if all passengers proceed directly to security as early as possible, other dynamic factors can still impact LOS. For example, if self-service kiosks are provided, then some passengers will arrive at security in much the same pattern as they arrive at the terminal. (Note: This scenario assumes little or no queuing at kiosks, which is frequently the objective for this type of facility.) The use of staffed check-in by some passengers and kiosks by others can easily be considered in calculating demand at security. However, the percentage utilization of either method is a dynamic variable.

Returning to the example previously used in Section VI.3.2.1 for staffed check-in, assume the base case of 1,200 passengers using staffed check-in related to 1,800 design hour passengers, but with one-third using kiosks. Figure VI-26 illustrates the base conditions at security using this assumption and the distributed arrival pattern used for the staffed check-in example. Passengers are arriving from two sources: metered through staffed check-in and un-metered having used kiosks. The number of passengers processed through staffed check-in every 5 minutes is 60 (30 counters × 5 minutes ÷ 2.5 minutes per passenger). In this example, there are always passengers queuing at check-in, so this number is constant and equates to 720 passengers within an hour. For the kiosk-using passengers, arrival at security is based on the distributed arrival pattern used previously in the check-in example. With the base assumption of one-third kiosk use, 600 kiosk-using passengers will arrive at security in the planning hour, varying between 20 and 100 passengers every 5 minutes. Assuming eight security units with a processing rate of 140 passengers per hour



Source: FAA White Paper, *Passenger Flow Dynamics and Level of Service in Airport Terminal Buildings*, Regine Weston, 2004

Figure VI-26. Impact of arrival pattern on security.

for each unit, the throughput capacity of the security facility is 1,120 passengers per hour. In the base case, the queue at the end of the hour will be 200, having peaked at 250 passengers. A reasonable queue space allowance on this basis would be in the range of 240 passengers.

However, if kiosk use increased to half of all passengers, a very different condition would result. With only half of the passengers using staffed check-in, there is still a constant throughput of 60 passengers every 5 minutes from this source. In addition, assuming that sufficient kiosks have been provided, the passenger demand from this process will increase by 50% to between 30 and 150 every 5 minutes. If the capacity was set at 240 passengers as previously suggested, this scenario would result in a peak of more than twice that amount for over half of the planning period, as illustrated in Figure VI-26.

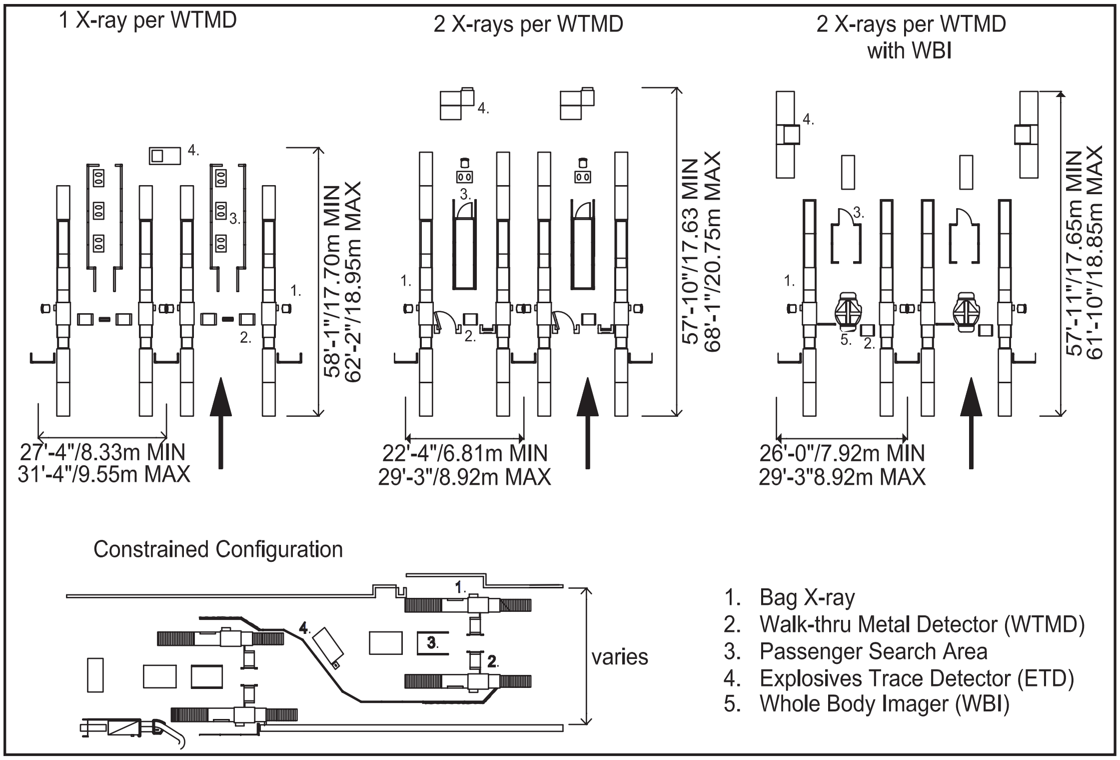
VI.3.3.2 Typical Dimensions

Passenger checkpoints have changed since the attacks of September 11, 2001, and the establishment of the TSA, becoming larger than previous installations. As TSA procedures and equipment continue to evolve, the configuration and size of the SSCPs are expected to change as well. Currently (2009), a standard SSCP contains four major components (See Figure VI-27):

- X-ray unit for carry-on bags
- WTMD
- A search area for passengers who set off the WTMD
- ETD for checking bags

Additional equipment that has been installed in some airports includes whole body image technology, a separate X-ray unit for shoes, booths for TSA supervisors and law enforcement officers, and other equipment currently undergoing testing. The TSA's ultimate goal is to have fewer pieces of equipment with better capabilities to speed up passenger processing. However, it is also likely that checkpoints will become larger and slower, before they reduce in size and become faster.

Typical configuration with one X-ray unit for each WTMD varies from approximately 27 to 31 feet wide for a pair of lanes, depending on the type of baggage X-ray unit used. If a "2 to 1" configuration of two X-rays for one WTMD has been installed, a slightly narrower footprint of approximately 22 to 29 feet can be assumed. Non-standard configurations are also used when



Source: *Checkpoint Design Guide (CDG)*, Revision 1, February 11, 2009, Transportation Security Administration

Figure VI-27. SSCP equipment configurations.

physical constraints do not allow a typical line of inspection lanes. Additional width may be associated with ADA accessible lanes.

The length of the SSCP varies depending on a number of factors but is primarily related to the length of the tables placed before the X-ray unit for passengers to unpack laptop computers, take off jackets and shoes, and remove metal objects from pockets. Similarly, the length of roller beds and/or tables, and seats after the SSCP for passengers to put clothing back on and repack bags, can vary. Airports are experimenting with these functions, and standards for these tables are evolving. The length for an SSCP can vary from 57 to 68 feet. The variability in both SSCP width and length is a function of the type of baggage X-ray unit, the type of passenger holding and/or wanding stations, and other screening equipment.

It is recommended that planners coordinate with the TSA on current equipment and procedures at the time of design. However, flexibility to reconfigure SSCPs should always be a goal in case of future changes in equipment and/or procedures.

The size of the passenger queue area before the inspection lanes will be determined by the number of passengers anticipated to be in the queue at peak times. Serpentine queues are recommended. The width of the queue lines is recommended to be a minimum of 4 feet, with 5 feet preferable, if possible, to allow travelling parties to stand next to each other.

VI.3.4 Holdrooms

Holdrooms or departure lounges are provided at each gate or group of gates. A typical holdroom contains seating and standing areas for passengers, an airline agent check-in podium to handle passenger service issues (such as standby seat assignments), space for a boarding/deplaning queue, space for circulation within the holdroom, and other amenities that the airport or airline may wish to provide.

VI.3.4.1 Estimating Demand

Holdroom sizing is typically based on the average seating capacity of the largest aircraft expected to use each gate or group of gates. Holdrooms are typically sized for LOS C with some airports choosing to provide a higher LOS. LOS in holdrooms does not, at this time, have a formally accepted industry-wide definition. Previous guidelines on space per passenger (as discussed in Section VI.1.3, Level of Service) lacked specificity as to whether the area per passenger applied to all the passengers on the aircraft, or just those in the holdroom at a given time, and aspects such as how much circulation was included.

The following LOS parameters have been derived from generally accepted industry practices:

- Load factor for the aircraft typically expected to use the gate: Typical ranges are for 80% (LOS B/C) to 90% (LOS A) for terminals with consistently high loads. The design load factor may be reduced however if it is expected that a significant number of passengers will be using close-by concessions, or waiting in airline clubs and/or premium class lounges (international flights). Thus, an international airport may provide seating for only a 70% to 80% load factor, but still consider this to be LOS A.
- Percentage of these passengers to be seated in the holdroom vs. standing: This percentage can range from 50% seated (LOS C) to 80% (LOS B), or even 100% LOS A. Again, these are typical ranges and should take into consideration the same factors as the load factor discussed above.
- Area per seated and standing passenger: This area should take into consideration the extent of carry-on baggage. The resulting area must account for both the bags and adequate circulation for passengers with baggage to maneuver around other waiting passengers and their bags. Area per passenger is typically 15 square feet seated and 10 square feet standing (LOS B/C). This guideline can be increased to 17 square feet seated and 12 square feet standing (LOS A) to provide wider aisles and/or more flexible seating configurations.

These factors determine the total seating/standing lounge area of the holdroom.

Area for the gate check-in podium(s) and its queue(s) should be added to the passenger seating area. The gate podium provides facilities for airline agents to check passengers in, change seat assignments, and provide other passenger services. The number of agent positions is a function of aircraft size and airline staffing policies but are typically as follows: one for commuter aircraft, two for narrowbody (up to 150 seats), three for widebody and B757 aircraft, and four for jumbo aircraft (over 300 seats).

In addition to the passenger seating area and check-in area, a boarding/deplaning corridor should be added to the lounge area which effectively acts as an extension of the loading bridge door. If a gate has multiple loading bridges, each bridge should have a separate boarding corridor. Similarly, if a holdroom serves multiple gates, each gate should typically have its own boarding/deplaning corridor. Depending on the configuration of the holdroom and the proximity of the check-in podium queue to the loading bridge entrance, some additional queuing may be provided for the boarding process. However, few airports or airlines have seen a need for this additional queuing area.

Holdrooms are recommended to be paired or grouped to allow greater flexibility of use. Grouping makes it is possible to reduce the total amount of holdroom space at many airports. One rule of thumb is to reduce the holdroom seating area by 5% for each gate in a common group. The amount of area reduction (for the passenger seating/standing area only) should be related to differences in departure times for adjacent gates, the estimated passenger arrival time distribution at the holdroom, and boarding time prior to departure. Thus, a reduction in seating area might not be recommended when there are expected to be near-simultaneous departures. Examples would include a connecting hub airport, and some spoke airports, when all of the carriers schedule departures at the same time. If departure times are typically well spaced, the area reduction may be greater than the rule of thumb.

VI.3.4.2 Other Functions

In addition to passenger seating and departure processing, some airports and airlines have added other amenities to holdrooms. These amenities have included work counters or desks, laptop/cell phone recharging areas, and play areas for children. Providing these amenities can take varying amounts of space and must be planned on a case-by-case basis.

The Holdrooms spreadsheet model allows the user to vary all of the parameters as well as consider consolidated holdrooms serving multiple gates.

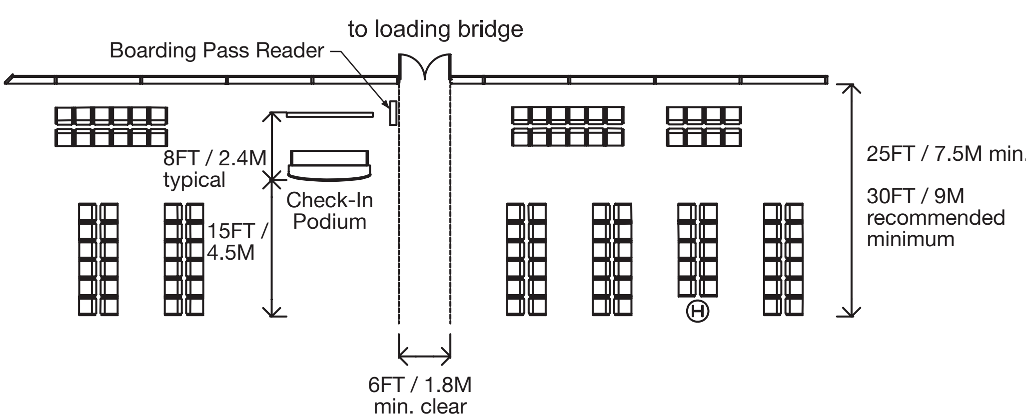
For additional insight and practical help in performing the determinations and methods described in this section, go to the **Holdrooms model** provided in *Volume 2: Spreadsheet Models and User's Guide*. By adjusting usage factors, this model allows the user to determine if a holdroom is sized appropriately to a level of service and what true capacity the holdroom maintains.

VI.3.4.3 Typical Dimensions

Seating Areas and Holdroom Depth. Figure VI-28 illustrates a typical holdroom in a linear configuration along a concourse. The depth of the holdroom should be a minimum of 25 feet to allow some flexibility in seating arrangements. However, a 30-foot depth is recommended for most terminals to increase this flexibility and to allow circulation between seating and the loading bridge boarding corridor. For holdrooms serving multiple gates located in a "corner" or at the end of a concourse, additional depth is recommended.

Seating configurations are driven by LOS factors discussed above, as well as the overall proportions of the holdroom. The distance between rows of seats is recommended to be a minimum of 5 feet to allow free movement of passengers when seats are occupied. The separation can be increased for higher levels of service and/or when large numbers of carry-on bags are expected.

Gate Podiums. A typical two-position gate podium is 8 to 10 feet wide. The depth of the podium counter and back wall is typically 8 feet but can be deeper if storage or other equipment is housed in the back wall. An area should be provided in front of the podium to contain the queue within the holdroom and not block the adjacent corridor. A 15-foot depth is generally adequate.



Source: Hirsh Associates

Figure VI-28. Typical holdroom.

Boarding/Deplaning Corridor. The corridor should provide as direct a path as possible from the loading bridge to the main concourse corridor. A minimum 6-foot width is recommended for deplaning.

Most airlines have installed boarding pass readers at the entry to the loading bridge, which increases the required width at the loading bridge door. These readers can either be a simple stand-alone reader (as shown in Figure VI-28) or can include a small work podium for agents. A wider area or multiple queue paths are generally required for enplaning due to the crowd of passengers that usually forms when an aircraft boards. For example, in Figure VI-28 the check-in podium queue and the internal circulation aisles supplement the boarding/deplaning corridor for enplaning activity. If the configuration does not allow such shared use of circulation, an 8-foot-wide boarding/deplaning corridor is recommended.

Holdroom layouts should be designed to minimize cross-flows (e.g., queuing of departing passengers for information should not interfere with routing of arriving passengers). Airline or ground handler staffing and operational decisions (such as how passengers are called for boarding) can also affect queuing and resulting LOS.

VI.3.5 Concessions

Terminal concessions include all of the commercial, revenue-producing functions that serve the traveling public. However, most concession development is associated with departing passengers.

The split between secure and non-secure concessions is a function of terminal configurations and operating policies. Following the attacks of September 11, only ticketed passengers are allowed past security screening, thereby eliminating well-wishers and meeters/greeters from walking onto non-secured portions of terminals and concourses. At many older airports, space for concessions was an afterthought, with little attention paid to either the amount or location of concessions. Often concessions were concentrated in the non-secure portions of the terminal, where today a better balance between secure and non-secure concessions is desirable. Passengers are more inclined to use concessions if they are relaxed and assured they will not miss their flight's departure. In particular, most passengers proceed through security screening prior to shopping or dining and will typically not subject themselves to rescreening in order to reach concessions. In terminals with a high percentage of connecting passengers, such as hub airports, almost all of the concessions should be in secure areas.

Because concessions can be a major component of the airport's revenue stream, it is recommended that airports consider undertaking a concessions study to better determine market potential. For additional information on maximizing concession financial performance, please refer to Section III.9.3, Concessions Planning.

As discussed in Chapter III, concessions generally fall into six main categories:

- News/gift—including newspapers, magazines, convenience items, etc.
- Specialty retail—including apparel, souvenirs, jewelry, etc.
- Food and beverage—including sit down, food court, and take-away food services of various types; cocktail lounges; etc.
- Duty-free shops—with sales limited to passengers departing on international flights. At most U.S. airports, duty-free merchandise must be delivered to the passenger at the boarding gate, although limited "take-away" purchases are allowed in some terminals.
- Services—including a wide range of functions such as automated teller machines (ATMs) and other vending machines, full-service travel agencies, shoe shine and barber shops, rental offices and business services, currency exchange, baggage cart rentals, and so forth.
- Advertising.

Although most concessions are associated with departing passengers, some are related to arriving passengers:

- Ground transportation concessions mostly consist of rental car counters but can also include commercial ground transportation services counters. At some airports, staffed rental car counters have been removed from the terminal and replaced by telephone banks. These decisions are largely based on local market conditions, the number of terminals at an airport, and other leasing/financial considerations.
- Counters for hotels and other visitor services may not necessarily be revenue producing but are necessary passenger services. At most airports, these may take the form of telephone boards rather than staffed counters.
- Other services for arriving passengers typically include ATMs and currency exchange for international arrivals.
- Food/beverage and retail concessions in arrivals areas are typically small and are more often provided for meeter/greeters waiting for international arrivals rather than domestic flights.

In addition to the passenger service side, a significant amount of back-of-house space is necessary to support a concessions program. Concession support consists of storage areas, preparation kitchens, employee lockers, loading docks, trash compactors, and administrative offices. A percentage of the public serving areas (typically 25% to 35%) is generally used. This percentage depends on the mix of smaller concessionaires and larger operators with multiple locations served from central storage/preparation areas. Depending on the types of concessions and the number of concessionaires, some support space needs to be integrated into the back-of-house area adjacent to the customer serving spaces, rather than located remotely.

In planning a terminal, consideration should also be given to providing non-public circulation for each major concession area, to allow deliveries and trash removal outside of public view. (See Section VI.3.10.5, Non-public Circulation.)

VI.3.6 Passenger Amenities

Passenger amenities include the following services that may not be revenue-producing concessions but provide the passenger with services that improve the travel experience:

- Airport information centers, counters, and kiosks: In the increasingly competitive world of air travel, airports are using every marketing and public relations tool available to build a positive customer service image and make a favorable impression on travelers and visitors as they pass through their facilities. The customer service centers, information counters, and kiosks strategically located in the terminal assist passengers and visitors by addressing their questions, comments, or concerns. The range of services offered at such information centers might include flight, airport, and city information; directions; lost and found; local phone calls; in-terminal paging services; valet and ground transportation coordination; etc.
- Paging systems and courtesy phones: A paging/phone service is used primarily to locate persons within the terminal complex. Audio/visual paging systems allow both visually and hearing impaired passengers to send and receive pages. The names of those being paged are both announced through speakers inside the terminal and displayed on monitors throughout the airport.
- Wi-Fi: Many airports have added free Wi-Fi high-speed Internet access as an amenity for travelers. Some offer Wi-Fi access throughout the entire airport, while others may limit access to specified areas of the terminal complex or waiting areas. In addition, many airline club lounges offer their own free or fee-based Wi-Fi access.
- Computer recharging stations: The convenience of charging a computer or a phone at the airport adds to customer satisfaction. These services offer passengers a way to stay connected and remain

productive while traveling through the airport. The recharging stations are most conveniently located in waiting areas and holdrooms of the terminal. Providing convenient electrical outlets is a trend that is increasing in popularity at airports and has more recently been recognized by some airlines as a potential LOS enhancement to be associated with their particular airline brand.

- Wheelchair storage: Airlines provide escorts and wheelchairs to passengers transferring between flights if they request wheelchair assistance. All elevators, concessions, and restrooms in the terminal building must accommodate wheelchair users to meet ADA requirements. Wheelchair storage should be located to minimize the average amount of time needed to reach any gate in a single concourse.
- Electric passenger carts: Electric carts (typically referred to as golf carts) are used at many larger airports to supplement wheelchairs, especially when long distances are involved and an APM system is not used. These carts can range in capacity from 3 to 10 passengers, with larger carts at major connecting hubs. Airlines may also use electric carts to expedite connecting passengers who would not normally require assistance when flights are late. As noted in Section VI.3.10, corridors should be wider when electric carts are in use and passenger volumes are high to avoid accidents and injuries. Storage areas for carts must include adequate electric power for recharging batteries and be located so as not to interfere with passenger flow when parked.
- Passenger luggage carts or trolleys: Luggage carts can be considered both an amenity and a revenue source. Whether provided free as a passenger service or for a fee, the following factors should be considered when planning the terminal:
  - Location and distance: The further a passenger needs to move his checked baggage, and the more bags there are, the more likely a passenger will want to use a cart. Thus, typically parking garages will generate more demand than curbside locations for departing passengers, and international baggage claims will generate more than domestic baggage claims.
  - Space: Although carts are nested for storage, the area can become significant if demand is high and there are large surges of demand such as a peak arrivals bank of flights. Locating cart racks or staging areas should be considered in the planning process to avoid the carts becoming choke points in baggage claim areas and circulation corridors.
  - Cart management: Typically, a third party will be responsible for cart operations. This responsibility includes picking up carts from around the terminal and adjacent parking areas and redistributing them to the locations where passengers need them. Terminal plans need to consider that long strings of carts will be moving to these locations and that ramps, doors, and other access points need to be planned to minimize conflicts with people and vehicles.

VI.3.7 Domestic Baggage Claim

Baggage claim facilities are required for both domestic and international passengers. The following discussion and methodology is primarily focused on domestic passengers; however, many of the principles and systems characteristics apply to international baggage claim as well. See Section VI.3.8.3 for more information on international baggage claim.

Baggage claim planning is one of the most complex areas of terminal design. It is necessary to consider both the passenger flow and the baggage flow and predict their interface in order to adequately size the facility. In addition, there are multiple components to the facility requirements: exposed length of device (for passenger access to claim bags), off-load space (to allow baggage carts to be pulled adjacent and handlers to load bags onto the claim device), total claim unit length (based on the expected number of bags to be accommodated), and baggage hall space (which relates to the total number of people to be accommodated and claim unit layout, and circulation).

Utilizing only the design hour demand, it is difficult to assess the impact of these various factors. For instance, a design hour demand of 600 passengers could consist of 3 flights of 200 passengers or 12 flights of 50 passengers. Assuming that each flight is handled independently, the length of claim unit required would vary significantly. Often with smaller aircraft, multiple flights share one claim device, which drives a different requirement for off-load space. An analysis of the characteristics of the design hour is necessary to determine the peaks of demand to be accommodated. The full planning day schedule should also be analyzed, because the peak period for baggage claim may not always coincide with the peak hour for deplaned passengers.

Perhaps the most challenging aspect is the interface between the bags and passengers. In a domestic facility, it is possible to arrive at a reasonable estimate of when the first and last passenger will arrive at baggage claim, based on their arrival gate and average walking speed. Baggage delivery is also affected by the distance between the gate and the off-load area but more significantly by the efficiency of airline or ground-handler staffing. Variables include how quickly the off-load crew is available after chocks-on, the number of baggage handlers off-loading the aircraft, the number of carts per baggage train (and therefore the number of trains per flight and amount of space at off-load), as well as the number of handlers off-loading bags onto the claim device.

The reality at most domestic airports is that passengers will be in the claim area by, or before, the time the first bags are unloaded. At very large airports, planners need to work with the airport, airlines, and handlers involved to form a view on the likelihood of the first bag being delivered before passengers arrive, in order to calculate the maximum accumulation of passengers in or bags on the claim unit. When those factors are considered (passengers before bags, or bags before passengers and passenger–bag match), a wide range of accumulations can be experienced.

VI.3.7.1 Estimating Demand

As noted above, the pattern of activity within a design hour (or another peak arrivals period) must be considered for sizing the baggage claim. Most domestic flights can be unloaded and thus all bags claimed within a 20-minute period. This has led to the industry using the peak 20-minute period within the design hour as the basis for planning. Therefore, the claim unit frontage should be sized for the estimated number of passengers waiting for baggage, because most bags are claimed on the first revolution of the claim unit. The number of passengers actively engaged in claiming bags is also related to the average traveling party size, because with larger family groups, not all of the party will actually be at the claim unit picking off bags.

Domestic baggage claim requirements are based on the following:

- Design hour deplaned terminating passengers
- Concentration of passengers arriving within a 20-minute period
- Percentage of passengers checking bags
- Average traveling party size, bearing in mind that not all members of a traveling party (especially families with children) will actually stand at the claim unit, but rather one member will claim the bags with most of the other members waiting in the peripheral area
- Checked baggage per passenger ratios, which is less of a factor for domestic baggage claims, because bags typically do not accumulate waiting for passengers to claim them
- Active claim frontage per passenger to achieve the desired LOS

Industry consensus is that all passengers actively claiming bags should be either adjacent to the claim unit (LOS A and B) or no more than one person away from the claim and able to reach in/around to the claim unit when his/her bag is presented (LOS C). This guideline results in a claim frontage of 2 to 3 feet per person (LOS A and B) to 1.0 to 1.5 feet per person (LOS C) for those actively claiming bags.

The factors contributing to estimating the size of a claim unit for an individual flight are the same as for the total demand, except that aircraft seating capacity and design hour load factor substitute for the peak 20-minute deplaned passenger volume.

The Baggage Claim model estimates the number of passengers within the active claim area by calculating the number of traveling parties, taking one member to actively claim bags and then adding in a percentage of the "extra" passengers who may accompany the active claimer at the claim unit. These factors would be based on passenger survey data (party size) and observations.

The Baggage Claim model is in two parts. The first part uses the 20-minute peak period to estimate the total amount of baggage claim frontage required to accommodate the total number of arriving passengers. This part uses the input assumptions listed above. The second part uses a similar methodology to calculate the size of a claim unit for an individual flight. Once the total frontage is estimated, the size and number of claim units should be determined based on the expected number of flights and aircraft sizes during the design hour(s), and airport operating policies regarding exclusive or preferential use of claim units.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Baggage Claim model** provided in *Volume 2: Spreadsheet Models and User's Guide.* This model allows the user to either size the total claim frontage required during the peak period of arrivals or to size an individual claim device for one or more aircraft.

The time that a claim unit is in use for an individual flight helps establish the turnover of claim units. This time is more significant for flights on widebody aircraft.

The following factors are required for estimating the time that a claim unit is in use for an individual flight:

- Aircraft seating capacity
- Design hour load factor
- Percentage of passengers terminating at this airport
- Percentage of passengers with checked bags
- Average number of bags/passenger
- Average bag unloading rate, which will vary depending on the size of the bags and the number of feed conveyors per claim unit

The above factors will determine the time needed to unload a flight's bags. In addition to the time needed to unload the checked bags, additional time should be added for bags that are not claimed on the first rotation of the claim unit because passengers arrive late or fail to identify their bags (typically up to 10 minutes should be added, unless there are unusual conditions). In cases where passengers arrive significantly earlier than the first bag is delivered, planners may want to consider the claim unit "in use" for that additional time if the airport or airlines do not want to have passengers from multiple flights at the claim unit simultaneously.

As shown in the example in the Baggage Claim model, narrowbody domestic flights typically occupy a claim unit for 20 minutes or less (which results in the typical approach of sizing domestic baggage claim units for a peak 20-minute period). Widebody flights can occupy a claim unit for significantly longer periods, which is why units sized for large aircraft typically are often configured with two feed conveyors.

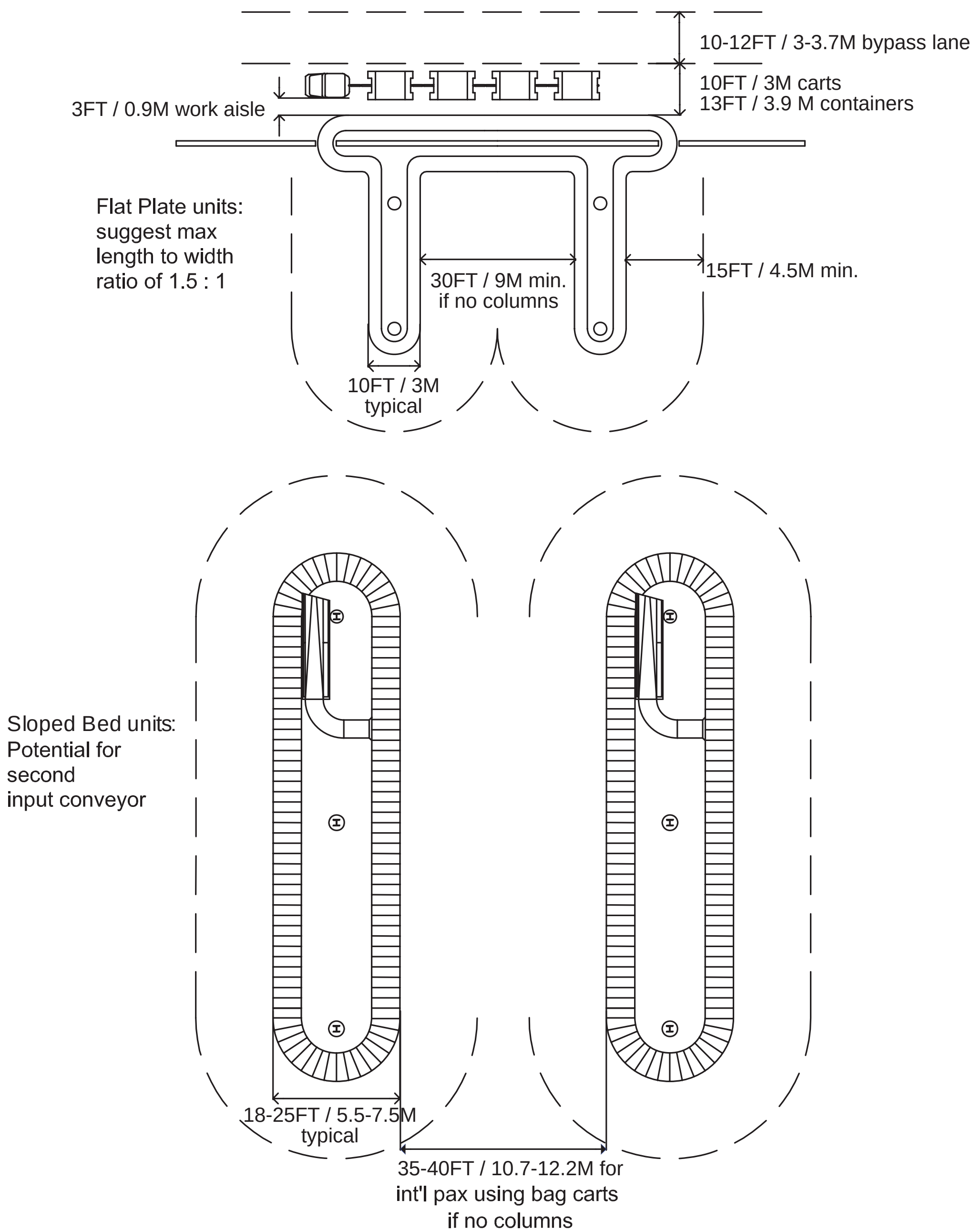
VI.3.7.2 Typical Dimensions

The baggage claim area consists of the baggage claim units, active retrieval and peripheral waiting/circulation zones around the claim units, additional passenger circulation, and baggage off-load area (baggage handling systems are described in additional detail in Section VI.4.1).

VI.3.7.3 Baggage Claim Unit Types

There are three basic types of claim units: flat plate, sloped bed, and simple claim shelves. Figure VI-29 depicts typical flat plate and sloped bed baggage claim units.

Flat Plate. Flat plate units can be designed in various configurations, with "L," "T," "U," and variations on these most common. Because they are direct feed, flat plate units are simpler to



Source: Hirsh Associates

Figure VI-29. Typical baggage claim units.

maintain and are generally preferred if the baggage off-load area is on the same level as the claim area. Bags are loaded on the secure side, pass though fire/security shutters (which are closed when the claim unit is not in use), and are claimed by passengers in the (typically) non-secure baggage claim lobby. Unclaimed bags will circulate back through the loading area.

The minimum outside radius is typically 5 feet, which results in a 10-foot-wide unit. It is recommended that the ratio of clear length of the "arms" to the width of the unit be no greater than 1.5:1. This ratio will limit deep, narrow bays, which can cause passenger congestion.

Sloped Bed. Sloped bed units (often referred to generically as "carousels") are almost always configured as ovals. Sloped bed units are fed from one or two conveyors, with larger international terminals typically preferring two conveyors due to the time required to deliver the larger number of bags. Feed conveyors can be located on a different floor level, or from some distance, and may feed the claim unit from either above or below. This capability provides flexibility in location, but with separate feed conveyors, there is the possibility of jams if oversized bags or bags with loose straps are accidentally loaded.

The minimum width of these units is 18 to 20 feet, depending on the manufacturer, but is often wider due to the location of structures and the feed conveyors. Sloped bed units can also be configured to allow flow-through passenger circulation, which may be advantageous in some terminal configurations, especially for larger claim units. Although sloped bed units have more baggage storage capacity, the effective amount of this capacity is often less than expected unless airline/airport personnel manually reposition bags to optimize bag capacity.

Simple Claim Shelves. Simple claim shelves can be used at very low-activity airports. Claim shelves are typically 3- to 4-foot-wide, sloping stainless steel shelves. They are loaded directly from the baggage carts through roll-up doors. As compared to mechanical claim units, the passenger moves along the claim shelf looking for his/her bag, which can cause congestion and confusion when large numbers of passengers are claiming bags. Typically, claim shelves do not exceed 35 to 45 feet in length (three baggage carts) and are most commonly used for oversized baggage.

VI.3.7.4 Odd-Sized or Oversized Baggage

Facilities should also be provided for odd-sized or oversized baggage, such as golf clubs, skis, and packages that are too large to fit on the baggage claim units or may cause jams on feed conveyors. Odd-sized (sometimes called out-of-gauge) baggage is usually handled in one of three ways:

- Oversized belt: An extra wide conveyor, anywhere from 45 to 65 inches wide, transports these bags from the baggage off-load area to the baggage claim hall, generally between two claim units or against an exterior wall of the claim area. This conveyor system can be flat, incline, or decline before entering the claim area, but it is recommended that no bends occur in the system.
- Oversized slide: Roll-up doors, from 6 to 10 feet wide and at least 5 feet high with a stainless steel slide, can be used to deliver oversized bags to the claim area. This system usually only functions effectively when the cart is off-loaded at the same level as the claim area, as with a flat plate claim arrangement.
- Manual laydown: When it is not practical to include either a slide or belt system, airline employees can take oversized bags from the secured side to the non-secured side for passenger retrieval, by using an airport access door usually adjacent to the claim area, or an elevator if the off-load area is on a different level than the claim area. This process would also apply to special handling items such as pet carriers.

VI.3.7.5 Retrieval/Peripheral Areas and Claim Unit Separation

The total amount of this area is ultimately determined by the number of passengers expected to be near the claim unit and the desired LOS. This area includes the active claim depth along the unit (retrieval area), depth for others in the traveling party, plus a circulation zone to and away from the claim unit (peripheral area). It has been found, however, that 15 feet is typically the minimum recommended depth for the retrieval and adjacent peripheral areas at all but the smallest airports.

This depth results in a minimum separation of 30 feet between adjacent claim units or the "arms" of a flat plate claim. For international claim areas where there is a high percentage of passengers using bag trolleys, a 35- to 40-foot minimum separation is recommended. These dimensions assume an obstruction-free area to allow ease of circulation. Columns, bag cart racks, and other structures should not be within the retrieval area. Objects located within the peripheral area usually will require additional separation. A minimum separation between the claim unit and walls or bag trolley racks is recommended to be 15 to 20 feet for domestic claim units, and 20 to 25 feet for international claim units.

Airports having "positive claim," that is, a railing or wall around the claim units so that a security guard can check if a person has the correct bag, may require additional circulation for queuing at the controlled claim area exits.

Additional area, outside of the peripheral claim area, needs to be provided for access to the claim area, circulation to ground transportation counters (rental cars, public transportation, commercial vans, etc.), seating for meeters/greeters and passengers waiting for transportation pick-up, etc. The dimensions of this circulation zone are dependent on projected passenger volumes and functions adjacent to the claim units, such as rental car counters.

VI.3.8 International Arrivals Facilities—Federal Inspection Services

FIS facilities are required at all airports with international flights. The exception is most flights from Canada, and a limited number of other airports with U.S. pre-clearance facilities. These passengers are treated the same as domestic arrivals.

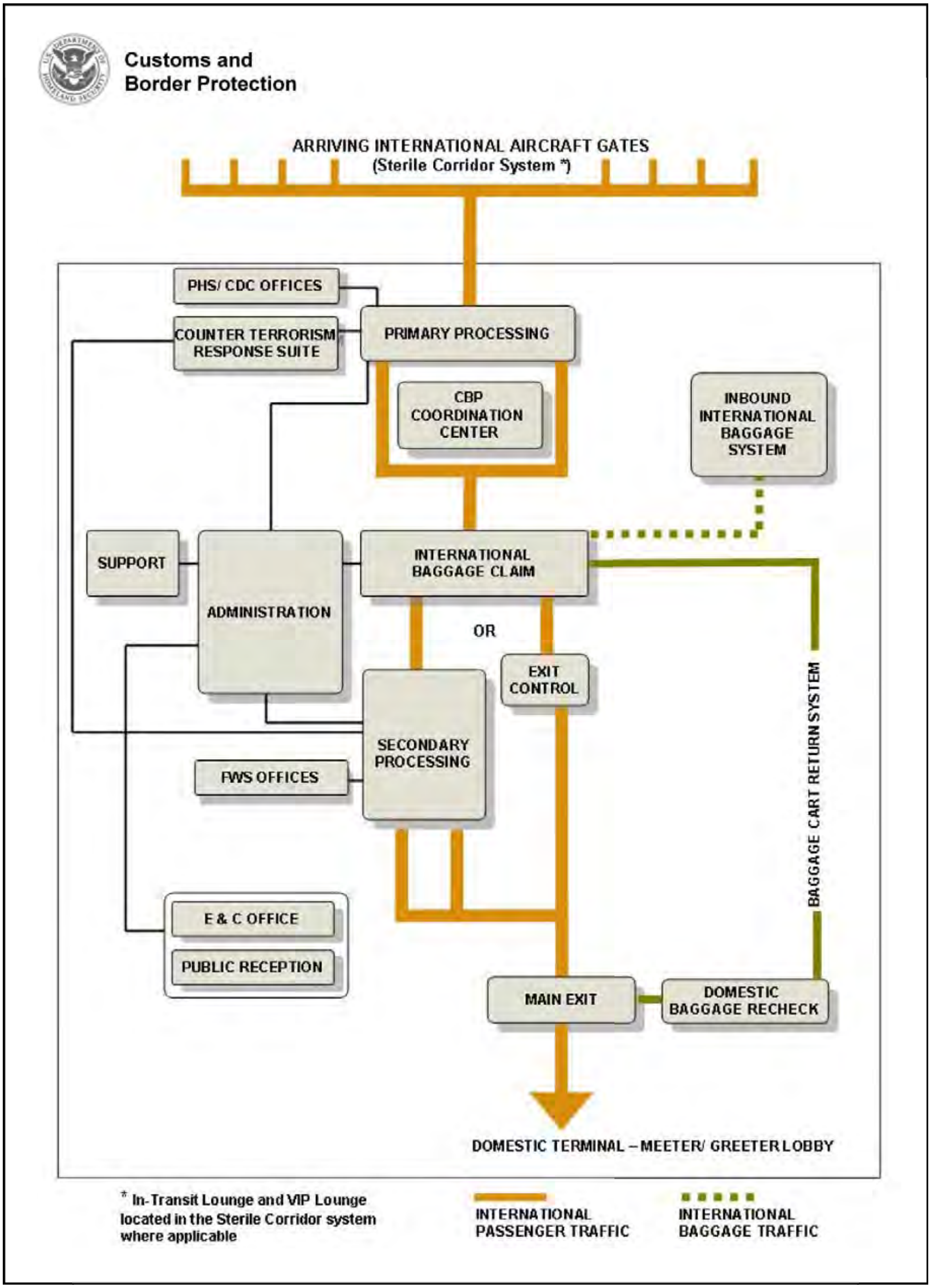
On March 1, 2003, the Immigration and Naturalization Service (INS), the U.S. Customs Service, and the Agricultural and Plant Health Inspection Service were consolidated to establish U.S. Customs and Border Protection. The CBP is responsible for inspecting all passengers, baggage, and air cargo. By consolidating the three major agencies, the CBP has unified the inspection procedures. At some airports, the Public Health Service (PHS) and/or U.S. Fish and Wildlife Service (USFWS) may also have offices.

Although the inspection process has varied over time, FIS procedures now call for all passengers to be processed through the primary inspection counters (formerly operated by INS). There are also a limited number of foreign airports that have U.S. personnel to conduct pre-inspection. Passengers from these airports (Ireland and some Caribbean islands) bypass local CBP primary inspection but are still subject to baggage inspection. It is anticipated that these locations will eventually have full CBP pre-clearance facilities.

Secondary passenger and baggage inspection is based on more selective procedures using computer-based lists of passengers, roving agents, designations of "high-risk" and "low-risk" flights, and other selection techniques. CBP procedures and facility requirements are described in *Airport Technical Design Standards—Passenger Processing Facilities* (*12*). Although there is a national policy, implementation may vary at each gateway based on local conditions, and coordination is required with the CBP for reviews and approvals of plans. Thus, it is essential to involve the FIS agencies in the planning process early. Planners should also request updates to standards from the CBP during the planning process, as these are likely to change and evolve over time. A terminal for international arrivals also has facilities in addition to the actual FIS processing areas.

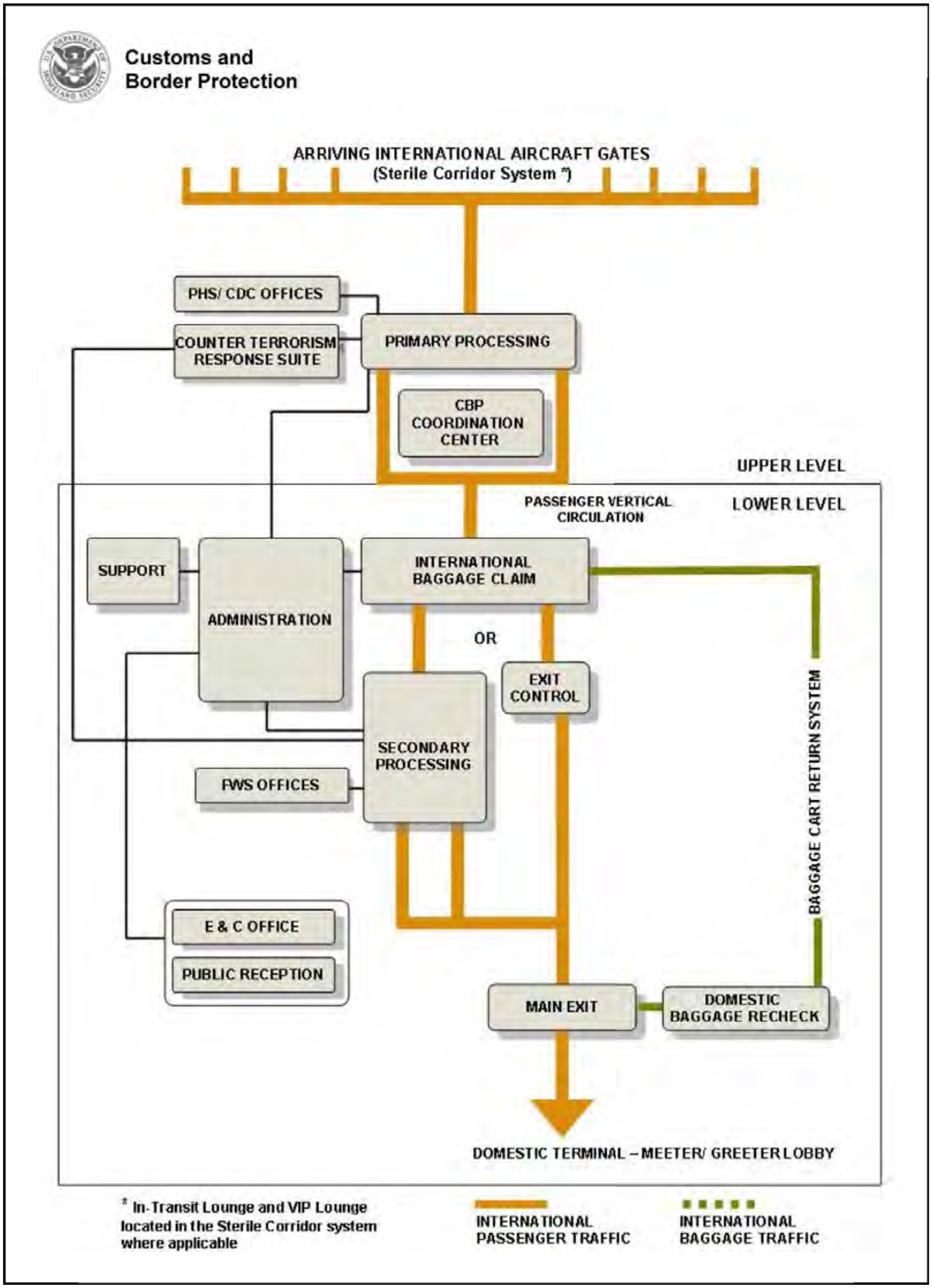
Figures VI-30, VI-31, and VI-32 illustrate the international arrivals flow process for single- and two-level facilities, as well as a preclearance facility such as those found in Canada.

An international arrivals terminal consists of the following major elements.



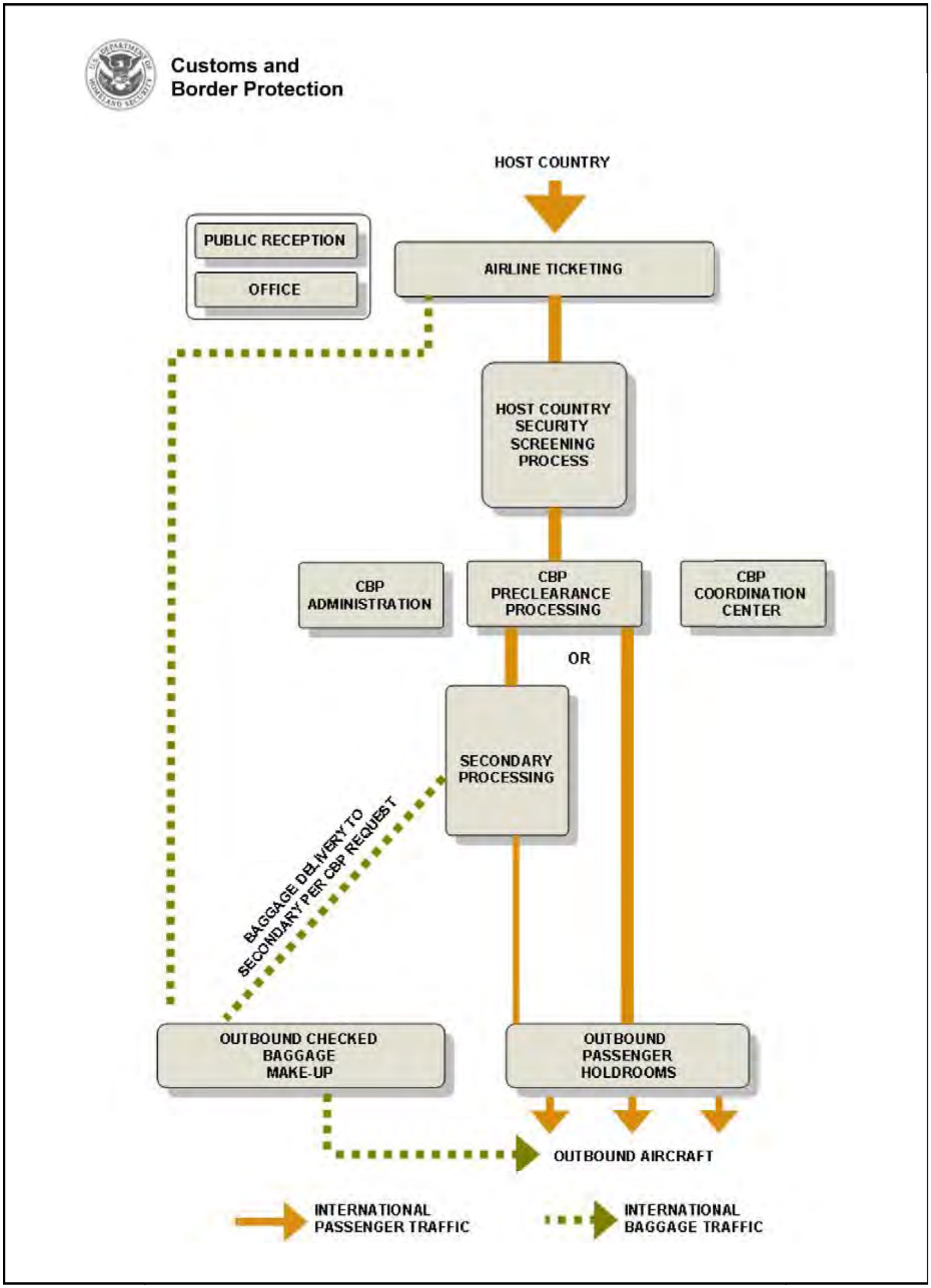
Source: *Airport Technical Design Standards—Passenger Processing Facilities*, U.S. Customs & Border Protection, Washington D.C., August 2006, pg. 2-15

Figure VI-30. Single-level passenger processing facility.



Source: *Airport Technical Design Standards—Passenger Processing Facilities*, U.S. Customs & Border Protection, Washington D.C., August 2006, pg. 2-16

Figure VI-31. Two-level passenger processing facility.



Source: *Airport Technical Design Standards—Passenger Processing Facilities*, U.S. Customs & Border Protection, Washington D.C., August 2006, pg. 2-17

Figure VI-32. Preclearance passenger processing facility.

VI.3.8.1 Sterile Corridor System

Arriving international passengers must be kept separate from other passengers, visitors, or unauthorized airline employees until they have cleared all FIS inspections. Therefore, a separate corridor system from the aircraft gate to primary inspection is required. The corridors should be sized for single-direction passenger flow. Depending on the distance from gate to primary inspection, moving walkways or APMs may be appropriate. Because departing passengers can use the same gates as international arrivals, control doors and monitoring of the corridor system is required to prevent mixing of arriving and departing passengers. See Section VI.3.4.3, Typical Dimensions, for guidance on corridor sizes.

VI.3.8.2 CBP Primary

Because all passengers are subject to CBP primary inspection, the capacity of primary inspection generally dictates the overall capacity of the FIS. Under current guidelines, one double primary inspection booth (two agents; also referred to as a "piggy back counter") is officially rated at an average of 100 passengers per hour. There are usually separate queues for U.S. citizens and foreign nationals, each of which will have a different average processing rate.

CBP primary facilities are sized for a capacity stated in terms of passengers per hour. This rating is "steady state," assuming a relatively well-distributed pattern of arriving flights. For that assumption to be correct and target waiting times to be maintained, a peak hour volume of 900 passengers, for example, would need to consist of six flights, arriving every 10 minutes, with 150 passengers each, rather than two flights of 450 passengers arriving within a few minutes of one another. Even in airports that have shorter-haul international flights, the idea that they will be of uniform size and evenly spaced is difficult to accept as a typical or reasonable planning standard.

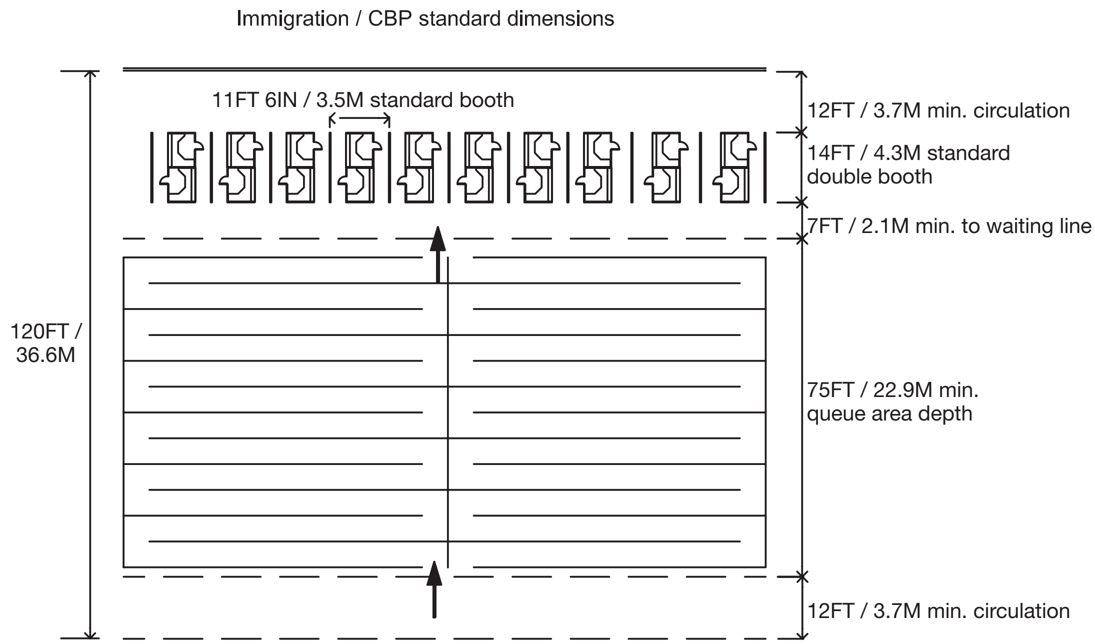
However, there are factors which "spread" or dilute the impact of arriving passengers, notably the distance between aircraft gate and the government inspection booths, combined with the metering of passengers out of aircraft and variations in the speed they walk. It should be noted that speeds are more divergent in terminals where moving walkways are provided.

The number of booths required for primary inspection is typically prescribed by the CBP based on the design hour passenger volume and, as such, consideration of dynamic issues will not usually impact that aspect of the facility. However, while agencies may specify minimum queue depths, they may be insufficient depending on the likely distribution of peak hour passengers amongst flights and the relative timing of those flights. Examining demand in a smaller time frame, 15 or 30 minutes, is often helpful in understanding the maximum length of queue to be accommodated. One other key area to consider in arrivals facilities is the impact of off-time (i.e., early or late) flights. In addition to a base analysis, if off-time data is available, a number of sensitivity tests should be performed to fully understand the dynamics of the facility.

> For additional insight and practical help in performing the determinations and methods described in this section, go to the **FIS/CBP model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model allows the user to size the CBP primary inspection area.

The spreadsheet model for primary inspection has a tool for illustrating how variable arrival times for the same number and size of flights can impact passenger arrival rates and queue sizes in the primary area.

Figure VI-33 illustrates a typical primary inspection area with the standard dimensions as published by the CBP.



Source: Hirsh Associates

Figure VI-33. Primary inspection lanes.

The standard double inspector "piggyback" booth is approximately 14 feet deep and, with the passenger standing areas on either side, 11 feet 6 inches wide. The CBP requires a 7-foot minimum distance from the booths to the holding line for waiting passengers. The CBP recommends a 50-foot minimum queue depth for smaller airports and a 75-foot queue depth for larger airports, but the actual depth should be a function of the peak number of passengers forecast to be in the queue and the LOS assumed. Separate queues are required for U.S. residents and for foreign citizens.

Although Figure VI-33 shows equal queuing areas, the division of the queues would be determined by the nationality mix of the passengers. The width of the queue lines is recommended to be 5 feet because most international passengers are traveling with others.

VI.3.8.3 Baggage Claim

After primary inspection, passengers proceed to international baggage claim. The approach in sizing a baggage claim for an FIS is similar to that of a domestic baggage claim; see Section VI.3.7. However, the time a claim unit is in use is typically longer for two reasons:

- Checked baggage ratios and the percentage of passengers with checked bags are typically higher than for domestic flights, thus requiring more time to unload. All passengers entering the United States must also have CBP baggage inspection at the first point of entry (except those in-transit). Connecting passengers then re-check bags to their final destination.
- Because passengers must clear the CBP primary area before entering the baggage claim area, bags may be on the claim unit before passengers are present. This delay can require a claim unit with greater capacity for baggage storage than is required for domestic flights. Thus, an international claim unit may be sized more for baggage storage than for active claim frontage, although both aspects should be considered. If sufficient storage isn't available (or passengers are delayed at the CBP primary area longer than anticipated), airline employees may have to unload bags from the claim unit and place them on the floor for passengers to pick up.

VI.3.8.4 CBP Secondary Inspection and Processing

The CBP is planning to institute a new unified secondary inspection procedure that will affect the configuration of FIS facilities. Under previous procedures, passport, visa, and other documentation concerns were handled in a secondary inspection area immediately adjacent to the primary (immigration) booths. Under the new unified concept, a single secondary inspection area will be located after baggage claim and contain both passenger (document) and baggage inspection facilities. This change can have significant impacts on existing facilities. In FIS facilities located on two levels (primary separated from baggage claim), some secondary passenger inspection facilities may continue to be located adjacent to the primary booths. These decisions would be made by the CBP and the airport on a case-by-case basis.

After claiming their baggage, passengers proceed to an exit control to surrender their CBP declarations. Most passengers are instructed by exit control officers to exit the facility. If a passenger has been identified for additional inspection/processing at the primary area, or by any CBP officer while in the sterile area, he or she will be directed to proceed to the CBP secondary area for further processing. The secondary area can be configured with either a single entrance or separate entrances for document and baggage inspection. Within the secondary processing area, there are additional requirements for interview rooms, search rooms, and detention holdrooms. Facility requirements for these spaces are defined in *Airport Technical Design Standards—Passenger Processing Facilities* (*12*) but may vary given local airport conditions.

VI.3.8.5 Transfer Passenger Re-check

International passengers connecting to a domestic flight must clear all CBP inspections at their first point of arrival in the United States. Thus, after completing all the FIS procedures, connecting/transfer passengers must re-check their baggage. The re-check counters should be located between the FIS exit and the meeter/greeter lobby so that the connecting passenger does not have to transit the meeter/greeter lobby with bags. This process is similar to an originating passenger and can be sized in a manner similar to a kiosk bag drop because the bags should be tagged to their final destination. Some staffed counters should also be provided to accommodate flight re-bookings or to issue new bag tags if the original tags are damaged. Queues for transfer passengers are typically shorter than queues for originating passengers due to relatively short processing times.

From a security perspective, arriving transfer passengers are considered "dirty" because they have had access to checked bags that may contain items not allowed in the aircraft cabin. Thus, transfer passengers must go though an SSCP before entering the gate areas. In addition, the TSA does not accept the level of checked baggage security provided by most originating international airports and requires connecting baggage to be subject to the same security screening process as originating bags. This may, or may not, require a separate checked baggage screening system depending on the volume of transfer bags and the overall design of the terminal checked baggage screening system.

VI.3.8.6 Meeter/Greeter Lobby

After exiting the FIS, locally terminating passengers enter a meeter/greeter lobby, which will also provide access to ground transportation and other arriving passenger services. The meeter/greeter lobby should have seating for a proportion of the meeters/greeters. However, seating may account for a smaller portion of the area with greeter standees and passenger circulation through the space making up the bulk of the area. The number of meeters/greeters will depend not only on local passenger characteristics but also on how long prior to scheduled arrival times the meeters/greeters enter the terminal. This information should be determined by survey.

VI.3.8.7 CBP Administrative and Support Areas

The total amount of space, as specified in *Airport Technical Design Standards—Passenger Processing Facilities* (*12*) is based on the rated capacity of the FIS. As with all FIS facility requirements, local airport conditions may result in different requirements and evolving CBP procedures may change support space requirements; therefore, planners need to work with the CBP at an early stage of planning. A number of support spaces are related to CBP staffing, which must be considered on both a shift and total staffing basis. Staffing can vary considerably depending on whether the FIS is a 24-hour facility or only open for a single shift. Consolidation of the three former main inspection services has resulted in generally less duplication of support and administrative office spaces than previously required.

The CBP administrative and support spaces should be located within the sterile perimeter and accessible from the primary and secondary processing areas. FIS facilities may also include a public reception room and an adjacent Entrance and Clearance (E&C) office. The office is required to be accessible to CBP officers from within the secured facility and to the general public from the domestic side of the terminal.

As noted in the beginning of this section, other government agencies may have offices within the FIS.

- The PHS enforces regulations to prevent the introduction, transmission, or spread of communicable diseases from foreign countries into the United States. The PHS usually requires an examination and isolation room suite even if it is not staffed on a full-time basis. This suite is approximately 900 square feet and should be located near CBP primary inspection.
- The USFWS is responsible for preventing illegal trafficking of protected fish, wildlife, and plants. The USFWS may have an office for an inspector at some larger ports of entry. This office is usually located near secondary baggage inspection and may range in size from 200 to 900 square feet depending on the number of officers assigned and whether the USFWS requires examination and storage areas separate from the CBP.
- Immigration and Customs Enforcement (ICE) is the investigative arm of the Department of Homeland Security and is responsible for enforcing immigration and customs laws. The ICE typically has at least one agent office at an FIS but may have a larger presence at some ports of entry.

VI.3.9 Public Spaces

Public spaces include most of the non-revenue-producing areas of the terminal including queuing areas, seating and waiting areas, restrooms, and circulation corridors (see Section VI.3.10). Some of the public space elements are directly related to peak hour passenger volumes, whereas others are functions of adjacent facilities. Some of these areas (such as check-in lobbies) have been described under the departures and arrivals processes in previous sections of this chapter.

VI.3.9.1 Restrooms

Public restrooms should be provided in the main terminal locations (ticketing, baggage claim, and central concession areas) and the concourses. Observations of passenger activity indicate that deplaning passengers are the principal demand driver for concourse restrooms. Short-haul flights will also generally produce a greater demand for restrooms on arrival than long-haul flights. It has also been observed that most passengers will use the first restroom they pass between their arrival gate and either the baggage claim or a connecting gate, even if it is crowded and there is another restroom a short distance away. Thus, to reduce queues, it is better to have a smaller number of higher capacity restrooms than a greater number of relatively smaller restrooms.

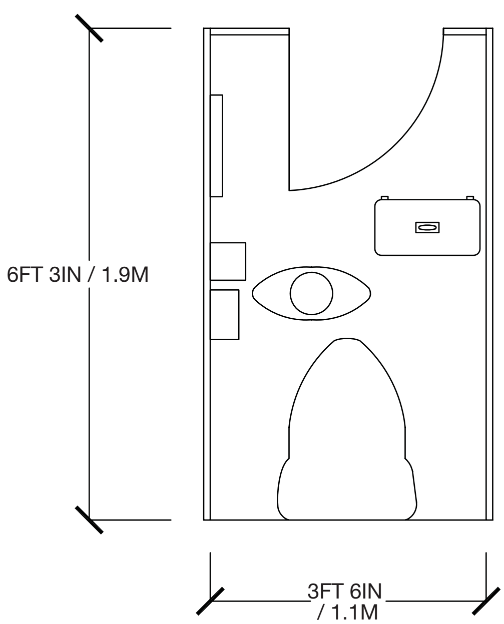
Restrooms should have at least as many fixtures for women as for men. A restroom fixture is a toilet or a urinal. Sinks are in addition and not included in a restroom's fixture count. In some jurisdictions, new building codes for public buildings are mandating 25% to 50% more fixtures for women than for men. These higher ratios are appropriate for airports when the passenger gender mix approaches 50% female. In heavily business-dominated airport markets, with a typically lower female population, an even fixture ratio will provide a good LOS. However, if the gender mix is not known, it should be assumed to be 50%/50%.

Restroom requirements are developed separately for the terminal and concourse locations to meet the demand profiles:

- The terminal factor should be based on design hour total O&D passengers and their well-wishers. One approach is to provide a minimum of one fixture per sex for each 100 people. However, the configuration of the terminal may require more total restroom capacity due to the number of restroom locations and reasonable minimum sizes. This requirement often equates to 2.0 to 2.5 square feet/person based on design hour passengers.
- For the concourses, it is recommended that a restroom module be provided for every eight EQA in order to provide reasonable walking distances. For most domestic O&D airports, the minimum number would be 10 to 12 fixtures/sex in each restroom location. For concourses with domestic hubbing, a larger restroom module (15 to 20 fixtures/sex) is recommended. This recommendation recognizes the more concentrated arrivals pattern and typically shorter flight times of hubbing airlines.

Airport restrooms should be designed with more space than restrooms in typical commercial or public buildings because of the amount of carry-on baggage typically associated with airline passengers. For example, toilet stalls are recommended to be wider and deep enough to allow a passenger to close the door while keeping his/her carry-on bags in the stall. Shelves for smaller bags are recommended over urinals and sinks. More floor area is required for carry-on bags near sinks and urinals to avoid congestion and tripping hazards. Figure VI-34 depicts an oversized restroom stall.

In addition to code-required handicapped access toilets, sinks, and urinals, it is recommended in transportation facilities such as airports that companion care restrooms be provided. These unisex restrooms allow an elderly or disabled person to be accompanied into a restroom by



Source: Hirsh Associates

Figure VI-34. Oversized airport restroom stall.

another person who assists the disabled person. Although these companion care facilities are not very large (typically 70 to 100 square feet), retrofitting them can be difficult.

If possible, restrooms should be designed so that part of the restroom can be closed for cleaning or maintenance while another part remains in operation. It is also desirable to have wide enough plumbing chase access for maintenance personnel.

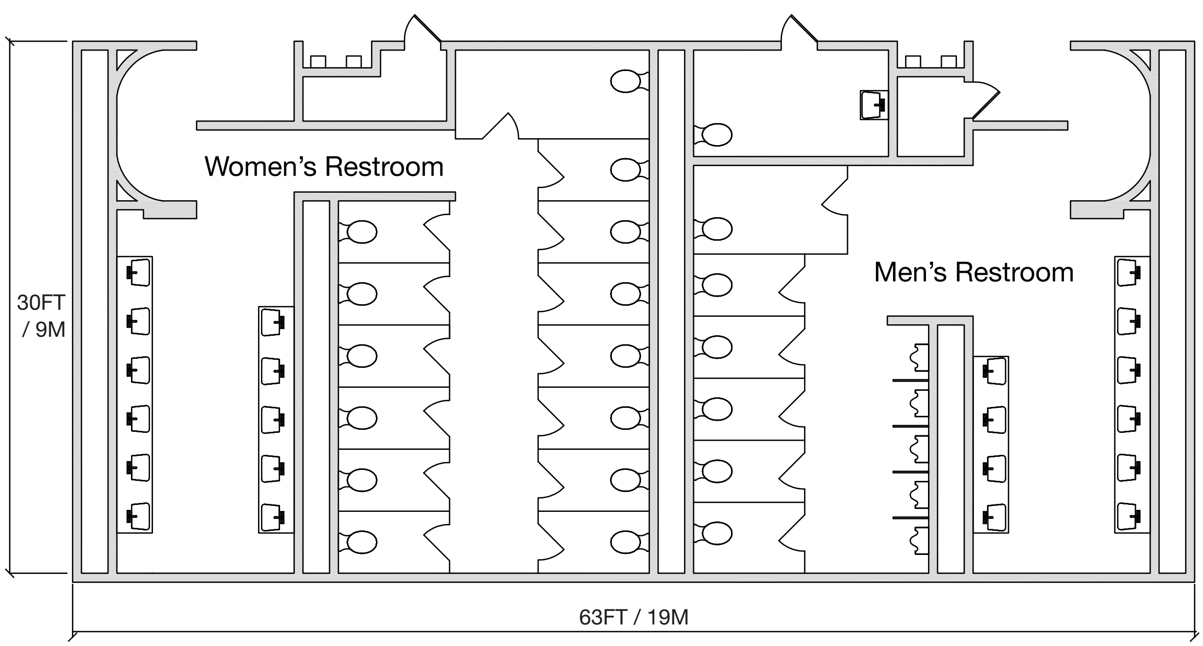
A typical restroom module of 10 to 12 fixtures/sex (including a companion care restroom and janitor closet) will average 60 to 70 square feet per fixture if all of these considerations are taken into account. Figure VI-35 depicts an example of an airport restroom.

VI.3.9.2 Public Seating and Domestic Meeter/Greeter Areas

Public seating areas include general waiting areas near the ticket lobby, baggage claim areas, and concessions. These are typically in non-secure areas of the terminal, but a portion of the area should be in close proximity to concessions regardless of concession location. Because security regulations now prohibit visitors from going beyond security, there is a need for domestic meeter/greeter areas located at concourse exits and the baggage claim area, in addition to the traditional international meeter/greeter lobbies.

Prior to 2001, most airports had traditionally provided seating for approximately 15% of the design hour originating passengers and their visitors, plus visitors for the terminating passengers. Because enplaning passenger well-wishers have been reduced to smaller numbers in most domestic terminals, less seating for enplaning passengers is typically needed. In international terminals, however, some airlines tend to generate large numbers of both well-wishers and meeters/greeters. Because security regulations now prohibit visitors from going beyond security, there is a need for domestic meeter/greeter areas located at concourse exits and the baggage claim area, in addition to the traditional international meeter/greeter lobbies.

In estimating the demand for public seating, the number of well-wishers and the location of concessions should be considered, as well as the number of peak hour originating passengers. For



Source: Hirsh Associates

Figure VI-35. Sample airport restroom configuration.

example, if an airport is in a destination city for most of its passengers, the number of well-wishers would probably be low. If most of the concessions are also in the secure area of the terminal, there would be a low demand for seating in the check-in lobby or non-secure areas for departing passengers. In contrast, if an airport serves a large proportion of locally originating passengers, and there are concessions before security, there will likely be more well-wishers who stay with the departing passengers until closer to departure time and require more public seating. General public seating is recommended to be sized in a similar manner as holdroom seating, with adequate space for carry-on bags.

Similar sizing logic applies to the domestic or international meeter/greeter lobby. In the case of a meeter/greeter lobby, seating may account for a smaller portion of the area with greeter standees and passenger circulation through the space making up the bulk of the area. The number of meeters/greeters depends not only on local passenger characteristics, but also on how long prior to scheduled arrival times the meeters/greeters enter the terminal.

VI.3.10 Circulation

Circulation elements provide the necessary public, non-public, and sterile links to tie the functional elements of the terminal together.

VI.3.10.1 Secure Circulation

Secure circulation typically consists of the main corridor of the concourses, plus the security checkpoints (see Section VI.3.3, Passenger Screening). Concourses are typically either single loaded (gates on one side) or double loaded (gates on both sides). Single-loaded concourses can also have concessions and other uses on the non-gate side that may cause them to function more like double-loaded concourses. Corridor width is a function of single/double loading, the presence of moving walkways, passenger volumes, and hubbing activity.

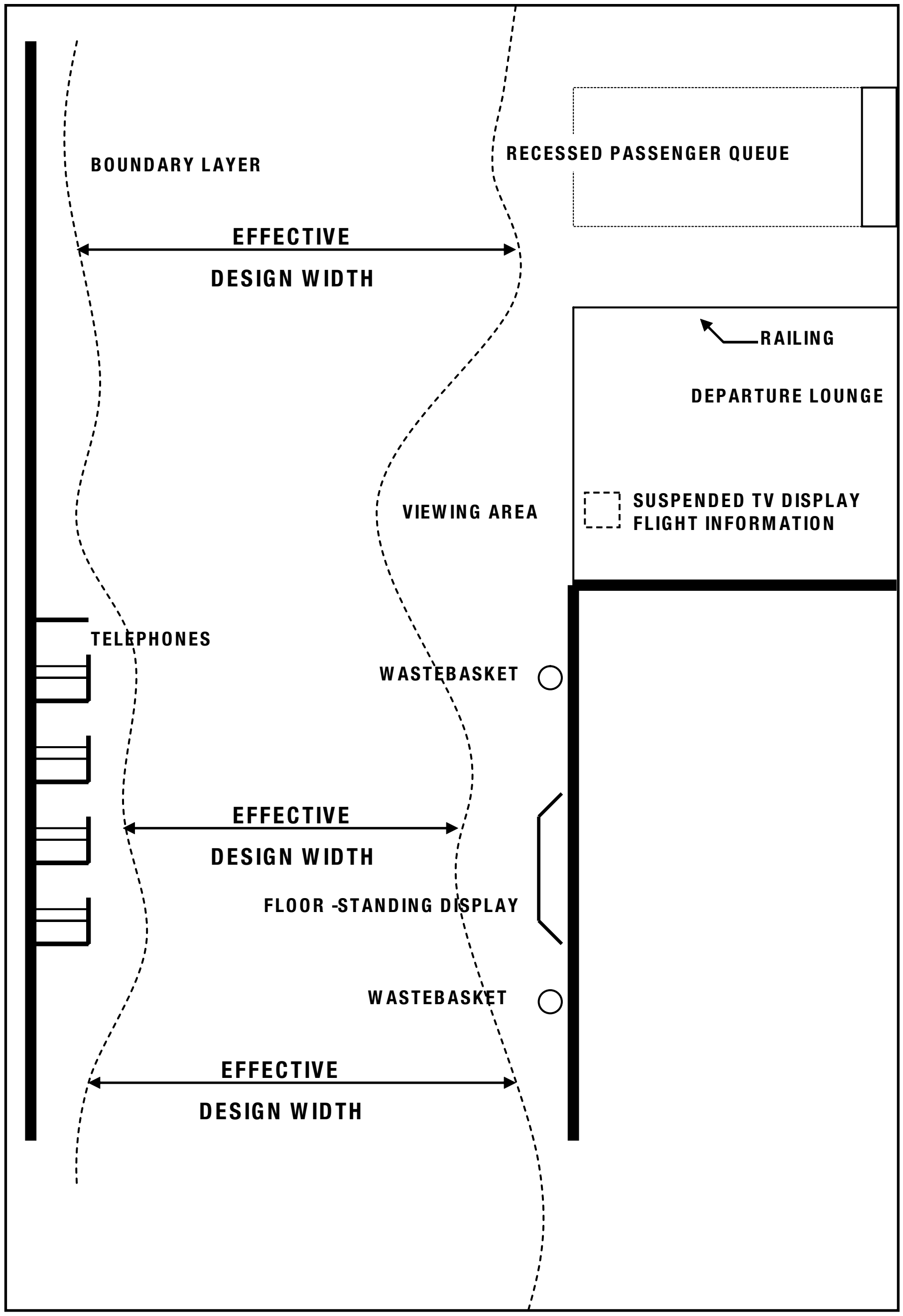
As shown in Figure VI-36, ancillary uses (such as telephones, water fountains, vending machines, or advertising displays), and some adjacent activities (FIDS monitors), can effectively reduce the width of a corridor. It is recommended that these uses be recessed into an alcove in the corridor walls as shown in Figure VI-37 to minimize the impact on passenger flow, or their presence taken into account when programming circulation space.

The following are recommended minimum clear circulation widths:

- For concourses without moving walkways, a corridor 20 feet wide for single-loaded concourses and 30 feet wide for double-loaded concourses is recommended. This width is generally adequate for most medium- to high-volume concourses used primarily for O&D flights, or for shorter hub concourses.
- For concourses with moving walkways, a 15-foot corridor is recommended on each side of the moving walkway as depicted in Figure VI-38. This width generally allows for bidirectional movement on both sides. Wider corridors may be required for high-volume hubbing terminals. A significant number of electric carts in use would also require a wider clear circulation aisle.

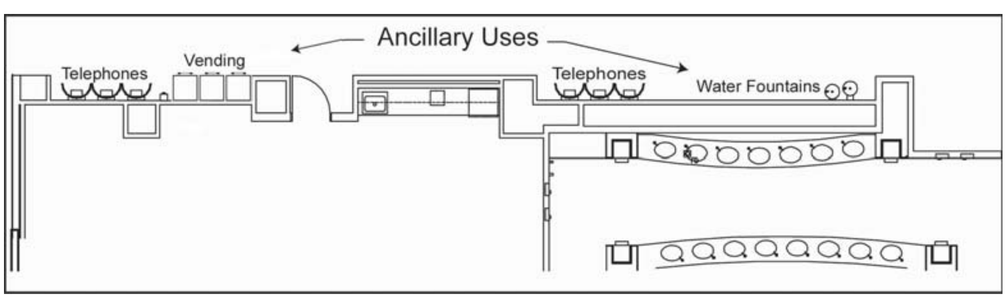
Moving walkways are available in different widths, designated by the width of the pallet passengers stand on. The minimum pallet width for an airport is 40 inches, but 56-inch pallets allow passengers with roller cases to easily pass other passengers without interference. Depending on the manufacturer, a 40-inch walkway is approximately 5 feet 6 inches in overall width and a 56-inch walkway is approximately 7 feet wide as seen in Figure VI-38.

The total program area can be based on an area per equivalent concourse length. This length is determined by gates expressed as NBEG. The actual amount of secure circulation required will depend on the terminal configuration and should consider whether gates are



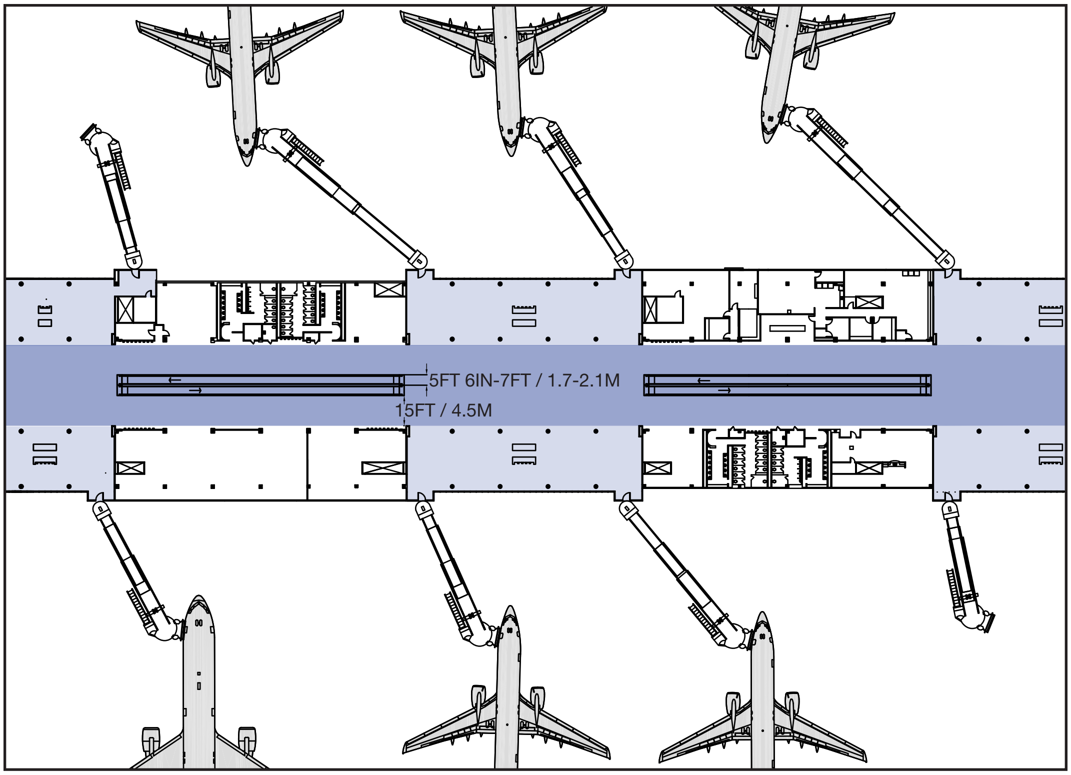
Source: *The Apron & Terminal Building Planning Manual*, The Ralph M. Parsons Company, pg. 3-17

Figure VI-36. Effects of ancillary uses on effective concourse width.



Source: Hirsh Associates

Figure VI-37. Maintaining effective circulation width.



Source: Landrum & Brown

Figure VI-38. Typical double-loaded concourse with moving walkways.

single or double loaded. Exit and service stairs to the apron level should be included in the secure circulation area.

The Concourse Circulation model will develop an estimate for secure circulation of a single concourse using this NBEG approach.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Concourse Circulation model** provided in *Volume 2: Spreadsheet Models and User's Guide.* This model allows the user to analyze the existing dimensions of a single concourse based on suggested corridor width and overall frontage based on the NBEG.

VI.3.10.2 FIS Sterile Arrivals Circulation

As noted in Section VI.3.8, a sterile arrivals corridor system is required consisting of the corridors and vertical circulation elements that connect the international arrivals gates to the FIS facilities. In some terminals a portion of the sterile corridor system may involve "edge" corridors, which connect multiple gates to a vertical circulation core or directly to the FIS. These edge corridors must have controlled isolation doors to prevent international arriving passengers from mixing with departing passengers.

Because sterile corridors have single-direction passenger flow, they can be narrower than the main concourse corridors. Typically, a 15- to 20-foot-wide corridor will allow a single-direction moving walkway for most terminals depending on the number of gates and peak period arrivals.

Edge sterile corridors are typically 8 to 10 feet wide (clear width). The program area must also include vertical circulation from the holdroom level to the sterile corridor, if it is on a separate level.

VI.3.10.3 Connectors

Connectors can include (1) above-grade connector corridors between piers/concourses or between the landside of a terminal and a satellite concourse and (2) below-grade corridors to remote concourses and corridors, which supplement an APM system. The area for these elements is highly concept-specific and the width is dependent on the expected level of utilization, and provision for moving walkways, if applicable. Depending on the terminal concept, connectors may be secure or non-secure.

VI.3.10.4 General Public Circulation

General public circulation includes the vertical circulation elements of all of the corridors and other architectural spaces, which tie the public functional elements of the terminal together. The program area is usually based on a percentage of the other public areas of the terminal and typically ranges from 15% to 30% of these areas. The percentage is a first approximation and will also vary with the terminal configuration and gross size of the terminal. The split between secure and non-secure (public) circulation is also a function of the terminal concept.

Terminals that will have an APM system will usually require additional circulation space beyond what would typically be required, in addition to the actual area for stations, system maintenance, etc. This space needs to be considered at the programming stage.

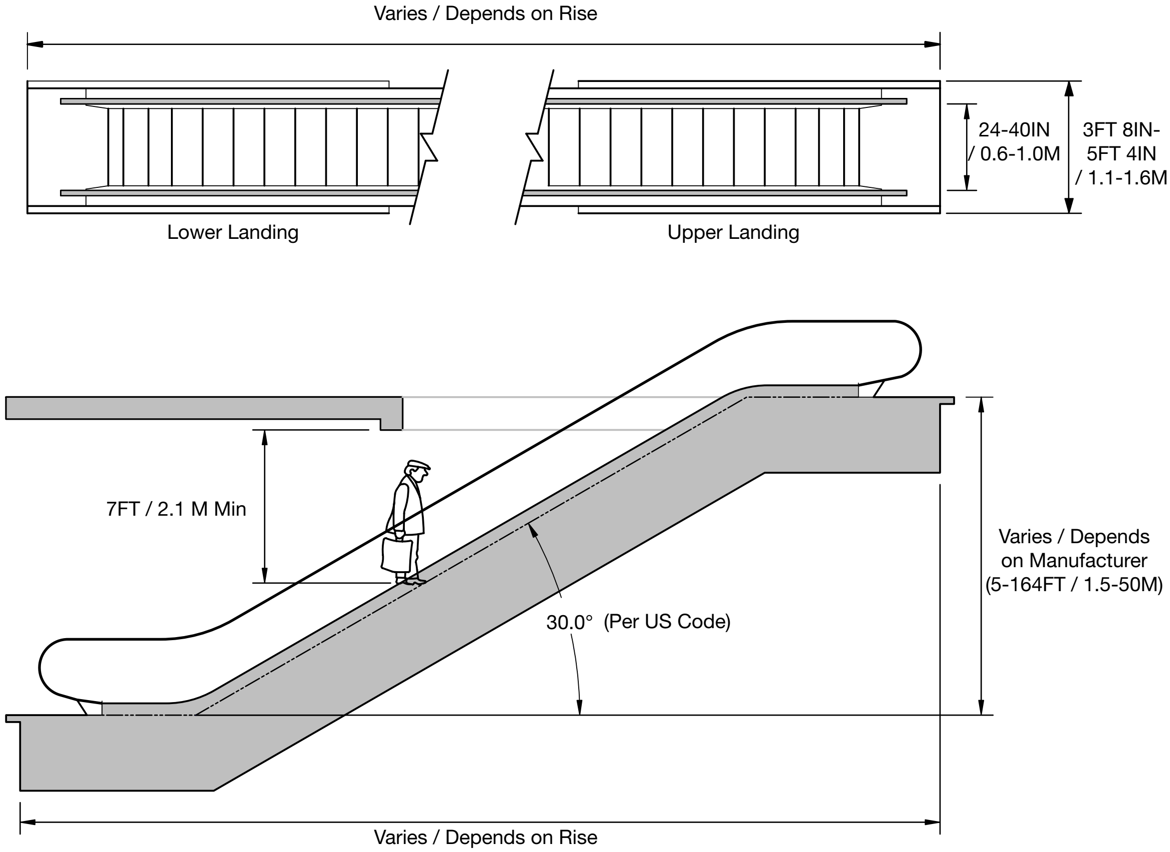
VI.3.10.5 Non-public Circulation

Non-public circulation provides access to airline operations, airport administration areas, concession support (and back-of-house access), and other areas typically not used by the traveling public. Non-public circulation can take many forms, especially when serving back-of-house concessions functions including food/retail delivery and trash removal. These spaces may include dedicated service corridors and elevators directly adjacent to the concessions, and tunnels under concourses to provide access to more distant concessions nodes and loading docks. The width of these corridors and/or tunnels should accommodate two-way movement of the types of delivery pallets and trash containers expected to be used. It is often a matter of interpretation as to whether existing spaces should be included in the public or non-public category. Non-public circulation typically is based on a percentage (10% to 15% is a common range) of these non-public functional areas. Evolving security protocols may require screening checkpoints for employees and concession deliveries that could increase the amount of non-public circulation space required beyond these percentages.

VI.3.10.6 Horizontal and Vertical Transportation Systems

People mover systems are critical in moving passengers between terminal buildings and transferring them between their associated concourses and satellite or remote gates. These systems, which aid in the movement of passengers, include moving walkways, APM, escalators, and elevators. All but the smallest terminals require level changes for passengers and/or employees at some point; to provide a higher level of passenger service, to meet ADA code requirements and/or to allow the movement of goods and supplies, mechanical assistance is needed. The location and size of these systems will depend on terminal configuration and passenger traffic flow patterns, the goal being to move passengers efficiently to and from the gates and between major terminal facilities.

Escalators. Typically escalators provide the primary means of transport for large numbers of people between floors. When available, the majority of passengers will use escalators (up to 90%) as compared to stairs or elevators. Escalators should be sized to handle peak surge loads (5-minute periods) without excessive queuing. Escalators should be located such that if queues do develop, they will not interfere with other functions. More important, there must be adequate



Source: *Escalator & Moving Walks Planning Guide*, V.06, Thyssen Krupp Elevator, 2006

Figure VI-39. Typical escalator.

space at the exit from escalators (or moving walks) so that passengers do not "back-up" on an escalator, which is a safety hazard. An example would be locating an SSCP or CBP primary queue such that it does not have sufficient separation from the exit of an escalator. Figure VI-39 represents a typical floor-to-floor arrangement with common dimensional criteria.

Experience has shown that in an airport or other transit environment, 40-inch-wide (step width) escalators are preferred. The wider step allows sufficient space for passengers to stand on one side of the step and pass on the other side. Additionally, passengers with baggage can be accommodated with minimal disruption to others.

Table VI-5 shows capacities of 40-inch-wide escalators operating at 100 feet/minute (typical speed). Numerous studies have shown that 100% step use is never attained even under the heaviest

Table VI-5. Capacity comparisons for an escalator 40 inches wide.

Capacity*	Persons/Hour
Maximum	8,160
75%	6,120
60%	4,900

*Assumes 2 persons/step moving 100 feet/minute.
Source: Hirsh Associates

traffic pressure. Utilization of 75% may be realized; however, under normal use, 60% capacity is a more realistic utilization and is recommended for planning and design.

Forty-inch step escalators are typically 5 feet 6 inches wide and require a pit at each end approximately 15 feet long and 4 feet deep. These dimensions will allow the escalator to have three flat steps at the top and bottom landings, which is recommended when passengers have baggage.

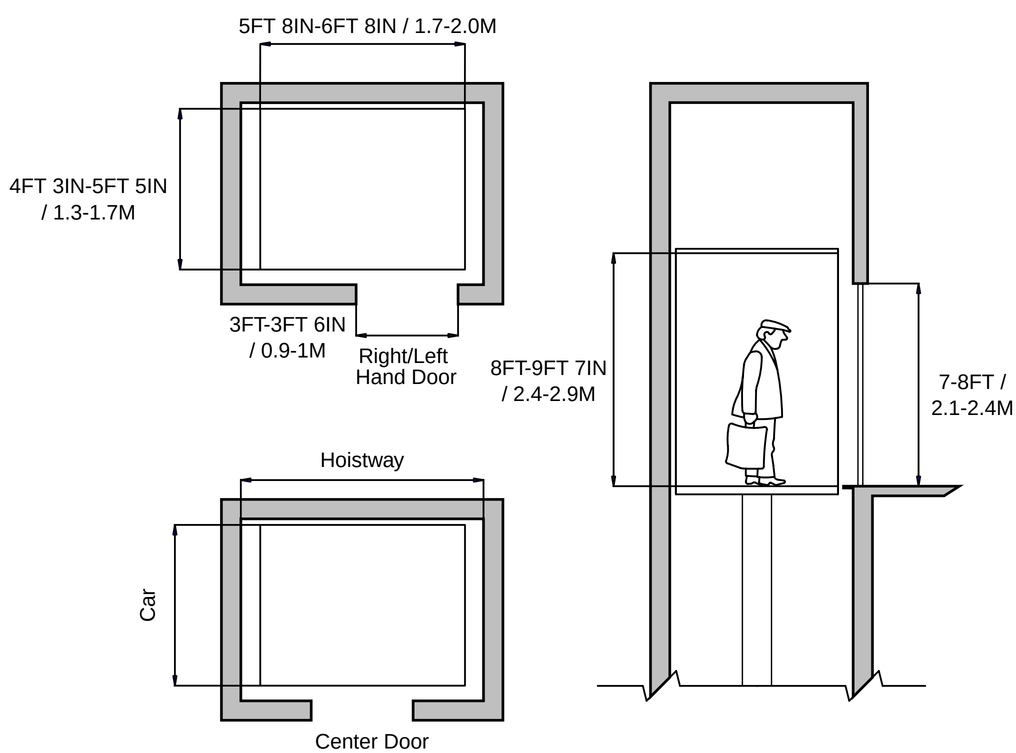
Moving Walkways. Moving walkways are recommended when passenger walking distances are long (exceeding 1,000 feet) or when a higher LOS is desired. Moving walkways should also be located to allow access to gates and concessions.

Moving walkways typically operate at 120 feet/minute and are rated at approximately 9,600 passengers/hour. However, as with escalators, practical capacity is much less, and 4,800 passengers/hour is recommended for planning and design.

Elevators. Passenger elevators are required for handicapped travelers and others who either cannot or will not use escalators or stairs. The size and number of elevators at a given location will depend on the expected use. They can either be pushed (hydraulic) or pulled (traction), and each use depends on the number of floors being served. Because most passengers will use escalators, waiting time and speed are often not as important as providing a minimum size for wheelchairs and attendants.

Dedicated service elevators, which can access non-public service corridors, are also preferred if possible, but most terminals have some form of dual use for elevators. Figure VI-40 depicts a typical single-car/hoistway arrangement with common dimensional criteria.

Automated People Mover Systems. As airports are expanded and the distances passengers must travel increases, conventional modes such as moving walkways may not provide an adequate



Source: *Escalator & Moving Walks Planning Guide, V.06*, Thyssen Krupp Elevator, 2006

Figure VI-40. Typical elevator.

LOS. An APM is basically an automated, driverless train in which individual vehicles or trains operate at frequent intervals on dedicated guideways. Capacities can range from small vehicles holding 8 to 12 passengers to higher-capacity trains accommodating 75 to 100 people per car. APMs typically have maximum cruise speeds of as little as 15 mph to over 50 mph. However, effective travel speeds are highly dependent on the acceleration that can be obtained, the number of curves, guideway gradients, etc. (*3*). If properly planned and designed, an APM can carry large numbers of passengers rapidly between major activity nodes such as concourses and terminal facilities.

Key criteria affecting decisions to utilize an APM include maximum walking distances, minimum connection times for hub airlines, and passenger types (domestic vs. international) and volumes. International arriving passengers who are transferred from gate areas to FIS facilities, via an APM system, will need to be segregated from the rest of the traveling public.

The two general types of APM systems are based on the type of propulsion system: self propelled and cable propelled. Self-propelled systems are typically powered by conventional or linear induction motors. These types of systems are the most flexible and can be run as shuttle, loop, or pinched loop systems depending on the configuration and capacity required.

Cable-propelled systems (sometimes referred to as “horizontal elevators”) have vehicles attached to a cable that is powered by a drive motor located at a single point along the guideway. Cable systems are limited to shuttle configurations with typically two or three stations. Most systems run on rubber tires or steel wheels. Magnetic and air levitation systems have also been developed.

A new, developing type of APM system is the Personal Rapid Transit, which uses small three- to four-passenger vehicles to transport passengers and their luggage along designated guideways to their destination. Currently, this type of system is being implemented at London’s Heathrow Airport. Please see the research from ACRP Projects 03-06, “Guidebook for Planning and Implementing Automated People Mover Systems at Airports,” and 03-07, “Guidebook for Measuring Performance of Automated People Mover Systems at Airports,” for a full analysis of APM systems and their application to terminal planning. Figure VI-41 shows a type of APM single car and guideway system.

VI.3.11 Airline Areas

Airline areas include offices to support check-in functions, passenger services, and aircraft operations.

VI.3.11.1 Airline Administrative Offices

Airline offices include the Airport (or Airline) Ticket Office (ATO) and other airline administrative spaces.

The ATO is usually located immediately behind, or in proximity to, the check-in counter to provide support functions for the airline staff handling check-in and ticketing. Typically these offices are 25 to 30 feet deep along the length of the counter. As airlines move to more automation at the check-in counter, the number of passenger service agents working at the counters has tended to decrease, which may result in less demand for offices near the check-in counters.

Other offices may include space such as the airline station manager office or a sales office. The amount of these office spaces and locations (ATO, operations area, office location on a terminal upper level, etc.) are dependent on individual airline requirements and preferences, and space availability. At hub airports, the amount of airline office space required can greatly exceed that which local traffic, and thus ATO counters, could be expected to require for support. At non-hubbing airports, other offices are typically provided for the equivalent of 10 to 25 square feet/linear foot of ATO counter, but requirements can vary greatly.

Figure VI-41. Miami Metromover.

International terminals served by foreign flag carriers may have special office or counter requirements for ticket sales. As with domestic airlines, the number of passengers purchasing or changing tickets at the terminal has been decreasing through the use of on-line ticketing. Thus, the need for ticket sales offices is likely to be reduced substantially over time.

VI.3.11.2 Baggage Service Offices

Baggage service offices (BSO) include both passenger service counters and waiting areas, as well as storage for late or unclaimed bags. Full baggage offices are typically required only by airlines with sufficient activity to warrant staffing. Other airlines often will request baggage lock-up areas to store late or unclaimed baggage and will handle passenger claims at their ATO counters. Area requirements are highly airport specific but should be based on the number and market share of airlines and O&D passengers.

VI.3.11.3 Airline Operations Offices

Operations include all of the apron-level support spaces for aircraft servicing and aircraft crew–related support spaces, typically located on the apron level. The demand for operations areas is a function of the size and types of aircraft being operated and individual airline operating policies. A planning-level program area for operations can be based on the number of gates (as expressed in EQA) and airlines at an airport.

At airports with a large number of small domestic, international, and/or charter airlines, many of these carriers may use ground handling services provided by third parties. These third parties may include one or more ground handling companies, or other airlines. Typically, this use of third-party ground handling service providers will reduce the amount of operations space in a terminal; however, ground handler support space must still be provided elsewhere on the airport. It should be noted that some larger airlines will also use third parties at their smaller stations.

Hub airlines, in contrast, may require a significantly larger amount of operations space due to locating some functions at the hub airport that serve smaller spoke airports in the region. These support functions may include space for crew-based (flight deck and/or cabin staff) offices and lounges, aircraft parts storage, larger storage areas for passenger cabin stores, etc.

Operations areas may range from less than 1,000 square feet/EQA, to well over 2,000 square feet/EQA at hub locations.

VI.3.11.4 Airline Clubs and Premium Class Lounges

These areas include exclusive-use membership clubs run by individual airlines (American's Admirals Club, Delta's Crown Room, United's Red Carpet Lounge, etc.), international premium class lounges, and special services facilities.

Airlines provide club facilities based on their individual criteria for level of passenger activity, type of market (business vs. leisure), the number of club members in a given airport market area, and so forth. The size of these clubs can vary significantly and, at hub locations, can be quite large.

Airlines with international departures may also provide lounges for their first and/or business class passengers. U.S. airlines with membership clubs at an airport may extend day of departure club privileges to their international passengers rather than providing a separate premium class lounge. As with membership clubs, the size and number of lounges at an airport is highly dependent on the airline mix and passenger volume. Airlines within alliances have joined together at some airports to provide a single lounge for all of the alliance's passengers. This consolidation has reduced, in some cases, the total lounge area that would be required by the individual airlines, while providing their passengers with more services. At a limited number of international airports, a few airlines are also providing arrivals lounges with showers and other amenities for premium class passengers. These lounges are located after FIS inspection.

Some airports have also developed membership clubs or lounges run by the airport or a concessionaire. These function in a manner similar to airline clubs and provide similar amenities. Airlines that do not have clubs (or international airlines without premium class lounges) may also contract to allow their members use of other airlines' airport clubs.

Group rooms are provided by some airlines at hubs and larger spoke cities to accommodate larger traveling parties. Group rooms allow such groups to get together prior to a flight and may include provision for catering. Another type of special service room can be a waiting area for unaccompanied minors.

VI.3.11.5 Ramp Control Tower

The FAA ATCT does not typically take control of aircraft until they enter the main taxiway system. At smaller airports with lower numbers of gates, aircraft can push back and otherwise maneuver on the terminal ramp with minimal control. At larger airports, especially with the potential for aircraft to simultaneously push back into the same taxilane area, a ramp control tower is typically required. This tower can be staffed by either the airport's operations department or an airline if it controls a large proportion of gates. While not a large area per se, the siting of a ramp control tower is important so that the ramp controllers can see directly as much as possible and only use CCTV as a back-up.

VI.3.12 Baggage Handling

Baggage handling includes outbound baggage (baggage make-up), inbound baggage (baggage claim), transfer baggage, and related support areas. Section VI.3.7 discusses the domestic baggage claim area and Section VI.3.8.3 discusses the international baggage claim area for the passengers. Section VI.4.1 provides a more detailed discussion of baggage handling systems and equipment.

VI.3.12.1 Baggage Make-up

Baggage make-up includes manual or automated make-up units, the cart/container staging areas, and baggage tug/cart (baggage train) maneuvering lanes. The type of system selected for a terminal depends on a number of factors including the number of airlines, the terminal configuration, operating policies (common use or exclusive use), and the size of the terminal complex.

Manual baggage make-up systems are characterized by direct feeds from the ATO, curbside, or other input locations to a make-up unit. Make-up units include straight (index) belts, and recirculating units similar to baggage claim units (usually sloped bed).

Automated systems are characterized by some type of sortation system, which accepts bags from numerous locations and directs the bag to a specific make-up unit depending on the airline and/or flight number. The location of the make-up unit may be close to the landside portion of the terminal, in a centralized location, or at the gate areas. Bag transportation can be via conveyor belt, tilt-tray, or destination-coded vehicle, and the amount of space is highly dependent on system design.

Although checked baggage ratios are a consideration, especially when designing more complicated automated sortation systems, these ratios generally affect the total number of baggage carts/containers in use rather than the size of the make-up area. The number of carts/containers per flight, staged at any one time, are generally based on the size of the aircraft. For most terminals, one cart or container is typically staged for each 50 to 75 seats of aircraft capacity; this would be equivalent to approximately two to three carts/containers per EQA (1 EQA = 145 seats). A cart or LD3 container is usually assumed to have the capacity for 40 to 50 bags. The number of staged carts/containers can also vary based on individual airline policies for pre-sorting baggage at the spoke airport for more efficient transfer at their hub. An airline may start moving carts/containers to the gate as they fill up when more than two or three are used for a flight.

The total number of staged carts or containers also is related to the passenger arrival time distributions and how early an airline staffs the make-up area. Typically, domestic flights begin staging carts 2 hours before scheduled time of departure (STD). International flights typically begin 3 hours for early departing flights (between 4 a.m. and 9 a.m.), and 4 hours for other departure times. For passengers who check in before these normal time periods, some type of early baggage storage may be required. For additional information on early baggage storage, please see Section VI.4.1.2. The baggage make-up process is typically finished 30 minutes prior to scheduled time of departure (STD) but can extend closer to STD at smaller airports.

To determine the required number of staged carts or containers, the planner should estimate the peak number of departures during the 2-, 3-, or 4-hour make-up period (as appropriate for the terminal's type of service) and apply the appropriate aircraft sizes. This estimate can be done either for a specific schedule and fleet mix or based on the gate mix as expressed as EQA.

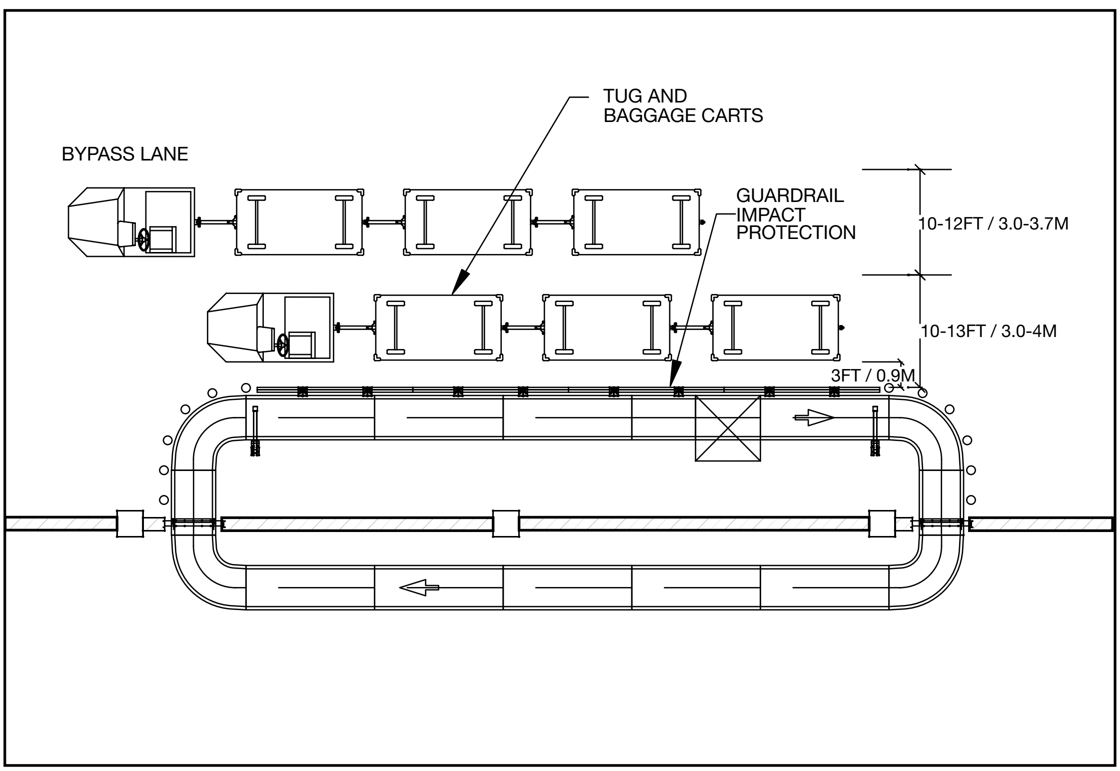
For additional insight and practical help in performing the determinations and methods described in this section, go to the **Baggage Make-up Model** provided in *Volume 2: Spreadsheet Models and User's Guide.* This model allows the user to estimate the necessary baggage make-up area based on the equivalent EQA and space factors relating cart space to EQA.

The size of the baggage make-up area will vary depending on the type of make-up units (index belts, recirculating make-up units, sort piers, etc.) and whether the systems are exclusive or common use. See Section VI.4 for typical configurations and dimensions. For preliminary planning purposes, the area per staged cart/container typically varies from 600 square feet/cart for individual airline make-up areas with recirculating make-up units to 300 square feet/cart for larger pier make-up areas. These areas exclude conveyor tunnels or sortation systems.

VI.3.12.2 Baggage Off-Load Area

The baggage off-load area consists of the portion of a flat plate unit where bags can be loaded or the remote conveyor feeding a sloped bed unit, a work aisle for ramp workers, space for the baggage train being off-loaded, and a bypass lane. Figure VI-42 illustrates a typical configuration.

A work aisle 3-feet wide is recommended. An additional 7 feet for the baggage train is recommended where bag carts are used. When containers (typically LD3s) on single dollies are used, 10 feet is recommended to allow the containers to be rotated on the dolly. A bypass lane that is 10- to 12-feet wide for single-direction traffic flow is also typical.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-42. Typical baggage off-load area.

The program area should typically provide adequate space for the off-loading of a baggage train of four carts or single-container dollies when handling larger flights. This required space will result in an area of 2,000 to 2,200 square feet per off-load area. Depending on the number of flights likely to be using a claim unit at any given time, space may be provided to off-load multiple baggage trains simultaneously, usually less than four carts per flight. For flat plate units, this simultaneous off-loading may require a longer section of the claim unit to extend along the wall dividing the off-load area from the baggage claim. For sloped bed units, simultaneous off-loading may involve multiple feed conveyors. The total length and/or number of off-load conveyors are related to both the number of flights and the typical number of carts or containers in a baggage train.

In terminals where baggage sortation systems are used for connecting bags, additional off-load belts are required for them. The number and length of such transfer input belts is highly dependent on the size and design of the baggage sortation system.

VI.3.12.3 Baggage Train Circulation

In addition to the areas for baggage make-up and baggage claim off-loading, most terminals need additional lanes and other common-use maneuvering areas, which link the inbound and outbound baggage handling areas to the apron. For programming, typically, a 10% to 15% allowance of all baggage handling areas will generally be sufficient for tug circulation in a two-level terminal, provided the terminal configuration is reasonably efficient.

VI.3.13 Checked Baggage Screening

As a result of the Aviation and Transportation Security Act, all checked baggage is subject to screening for explosives. Depending on the size of the airport, available space, and budget, four types of systems may be deployed.

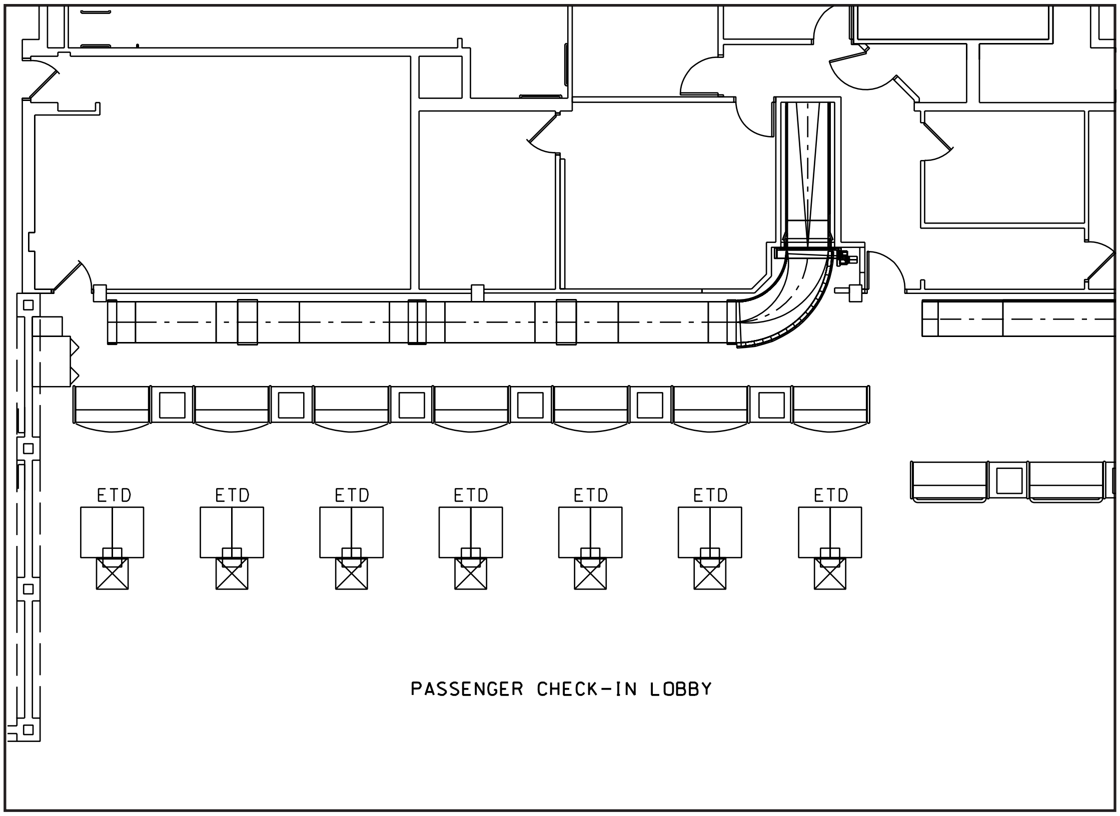
VI.3.13.1 Explosives Trace Detection Units

Typically, ETD units are used by the smallest airports and located in the check-in lobby as the primary form of baggage screening as depicted in Figure VI-43. These units are fully manual systems with the slowest throughput rate. Typically, a single ETD unit shared by two screeners can process up to 66 bags/hour. ETD units also are used for checking oversized bags that cannot fit though EDS equipment and for examining in more detail bags alarmed by EDS units.

VI.3.13.2 Explosives Detection Systems

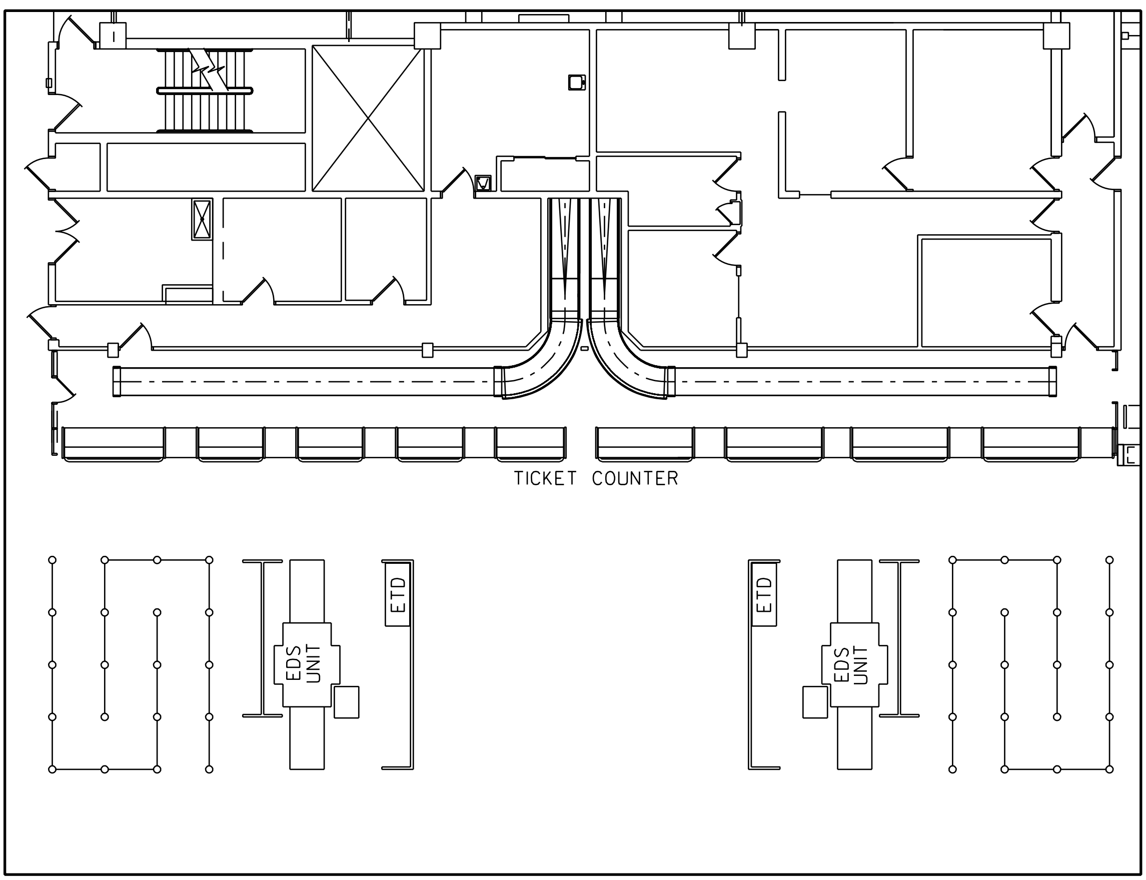
EDS units are capable of automatically detecting explosives and then providing a 3D view of the bag's contents to TSA screeners for further analysis. Most of the currently deployed EDS technology was developed prior to the passage of the Aviation and Transportation Security Act, based on standards set forth by Congress in the Aviation Security Improvement Act of 1990. After large-scale deployment of EDS equipment in 2002 and 2003, equipment manufacturers have incrementally improved performance in terms of reducing false alarm rates and improving throughput capabilities. In addition, new EDS equipment has been certified. Many of the currently deployed EDS machines operate with throughput rates between 100 and 550 bags/hour. EDS units have widely varying capacities and may be configured in different ways:

- Stand-alone EDS units are the simplest EDS installations, typically located in the check-in lobby (as depicted in Figure VI-44) or immediately behind the ATO counter. Screeners manually load the bags into the EDS unit and then the screened bags are moved to a bag conveyor that transports the bags to baggage make-up. Typical throughput rates are in the range of 100 to 200 bags/hour.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-43. ETD units in lobby before ticket counters.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-44. EDS units in lobby before ticket counters.

- Mini in-line systems have a single (or possibly two) EDS unit(s) on a feed conveyor from the ATO counter to the make-up area. This configuration requires the least in the way of bag sortation. EDS units for these simple in-line systems typically have capacities of 100 to 400 bags/hour.
- Medium- and high-volume systems are highly integrated, highly automated, and low labor-intensive systems with multiple EDS units arranged in a screening matrix that requires sophisticated baggage sortation and tracking. Current EDS units for these systems have capacities of 400 bags/hour. Expected upgrades to these EDS units are estimated to increase throughput to the range of 500 to 700 bags/hour. Future EDS units in development are expected to have capacities of up to 1,000 bags/hour. Thus, the baggage handling systems supporting the EDS screening matrix should consider possible increases in EDS capacity during the life of the system. More detailed information can be found in the TSA's *Planning Guidelines and Design Standards for Checked Baggage Inspection Systems* (*41*), released October 10, 2007. (Planners should check for updates).

A full analysis methodology for sizing a checked baggage screening system is beyond the scope of this planning guide. However, an initial estimate of baggage volumes and EDS equipment can be made given certain basic assumptions and design hour passenger volumes. The Baggage Screening model allows for preliminary estimates of the major equipment necessary for EDS system programming. The Baggage Screening model follows the standard three-level TSA protocols for checked baggage inspection systems (CBIS) and assumes an in-line system. The same principles can be applied to stand-alone systems.

In an in-line CBIS, screening operations are integrated with the outbound baggage handling system. The process involves three different screening levels. Level 1 screening is performed with EDS units. All bags that can physically fit in an EDS unit are directed to Level 1 and scanned with EDS. All bags that automatically alarm at Level 1 are subject to Level 2 screening. During Level 2 screening, TSA personnel view bag images captured during the Level 1 EDS scan and clear any bags whose status can be resolved visually. This process is referred to as on-screen resolution (OSR), which for in-line systems allows the continuous flow of bags through the system until a decision is made. Although OSR typically occurs remotely, it may occur locally at the individual units, but this is not usually recommended. All bags that cannot be resolved at Level 2, and all bags that cannot be directed to Level 1 EDS units because of size restrictions, are sent to Level 3. Level 3 screening is performed manually and involves opening the bag and use of ETD technology. The small percentage of bags that do not pass Level 3 screening are either resolved, or disposed of by a local law enforcement officer.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Baggage Screening model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model allows the user to estimate the necessary baggage screening equipment based on checked baggage volumes.

VI.3.14 Support Areas

VI.3.14.1 Mechanical, Electrical, and Plumbing Areas

At the planning and programming stage, utilities areas are typically estimated as a percentage of the enclosed functional areas of a terminal. This percentage will vary with the geographic location of the terminal, the provision of central plant functions either within the terminal or remotely and, in some cases, architectural design considerations that may limit the use of roof-top equipment.

Most newer terminals allocate space to utilities in the range of 10% to 12% of functional areas if the terminal has its own heating/cooling plant, but many terminals are outside of this range. The existing percentage should be calculated and adjusted for expansions based on the adequacy of existing facilities.

Recent trends in computer systems, telecommunications, and other building systems have increased the demand for utility space in many terminals. Some of this increased demand may be accommodated in the airline operations areas, whereas common-use systems need to be accommodated in airport-controlled areas.

Airline mechanical systems may include centralized ground power and preconditioned air. Engineering studies should be done to determine if centralized vs. individual gate systems are preferred. These areas (if centralized) should be considered as a supplement to the overall building mechanical/electrical systems area for the terminal.

VI.3.14.2 Maintenance, Janitorial, and Storage Areas

Maintenance, janitorial, and storage space includes the building maintenance functions that are required to be within the terminal building. In addition to typical janitorial and supplies storage, areas may be required for hoists (cherry-pickers) and other specialized equipment needed to clean and maintain high-ceiling areas or certain types of window walls. Additional maintenance support may also be provided by facilities outside the terminal complex. A percentage of the functional areas (1% to 2%) is generally used in the absence of specific airport requirements.

VI.3.14.3 Receiving Areas and Loading Docks

Receiving areas and loading docks can serve both terminal maintenance and concessions. It is generally recommended that loading docks should be provided for concession deliveries to avoid clogging the terminal curbs with delivery vehicles. When loading docks are used for concession receiving, provisions may need to be made for security screening of food and retail merchandise before it can be moved to a secure area of the terminal. Trash compactors are also typically co-located with loading docks, and multiple compactors may be required depending on the volume and types of trash generated in the terminal.

Estimating the number and size of loading docks involves many factors: the location (landside or airside); the relative size of the terminal; whether concessions have a central receiving area separate from the terminal; the number of individual concessions that may get separate deliveries; the average size of delivery trucks (vans, larger straight trucks, or semi-trailers); and airport policies with regard to operating hours.

VI.3.14.4 Airport Administration

Management and Airport Operations Offices. In addition to offices for airport staff, many airports have a communication/incident control center that can often double as a meeting room or for other functions that are required on a more day-to-day basis. There is no rule of thumb for sizing airport offices because each airport has different staffing requirements and management structures. Planning for these facilities should be considered early in the programming process with input from the airport operator.

Some airports prefer to locate management offices within the terminal while others prefer a location in a separate building. Such location decisions depend on the size of the airport staff, availability of space in the terminal, and the cost/benefit of in-terminal vs. remote locations for a given airport management's operating philosophy.

Police Offices. Although the TSA is responsible for screening passengers and their baggage, TSA officers do not have authority to arrest. For this, a local law enforcement officer (LEO) is required. Typically, there is space for an LEO at the SSCP, but depending on the size of the LEO presence at an airport and any additional duties (such as traffic enforcement), additional office and support spaces may be required.

Medical Services. Some larger airports may have medical facilities in the terminal to respond to emergencies, or even for treating non-emergency passenger and employee problems. However, most airports have paramedics on site and/or Aircraft Rescue and Fire Fighting staff that will respond to medical emergencies as needed and do not require separate terminal facilities.

Public Relations and Information. All airports require some way of providing information to arriving passengers who may not be familiar with the airport or its region. Airports are using every marketing and public relations tool available to build a positive customer service image and make a favorable impression on travelers and visitors as they pass through their facilities. These tools can be simple information displays and counters with local brochures up to staffed counters or customer information centers. The range of services offered at the information center may include flight, airport, and city information; directions, lost and found; local phone calls; in-terminal paging services; valet and ground transportation coordination; and so forth. In either case the area required is relatively small, but location, typically on the arrivals pathway for passengers or in the baggage claim area, and visibility are crucial to the effectiveness of the service.

VI.3.14.5 Emergency Facilities

Depending on the geographic location of the airport, certain areas of the terminal building itself may require special facilities in order to respond to circumstances unique to the region. Such areas include isolation areas for the prevention of infectious disease at U.S. foreign ports of entry and safe rooms to provide shelter from tornado activity.

Isolation Areas. The Center for Disease Control (CDC) is a federal agency of the U.S. Department of Health and Human Services. A portion of the agency's responsibility is the prevention of the spread of human infectious disease brought into the United States from abroad. Staff are located at quarantine/border health offices at U.S. airport ports of entry. CDC personnel have the legal authority to quarantine and isolate any person(s) or animal(s) they believe to be carrying a communicable disease that poses a significant public health risk. Isolation areas separate the suspected person or animal from the rest of the traveling public and restrict their movement to prevent the threat from spreading. This prevention is accomplished by visually screening international arriving passengers into the United States via foreign ports of origin, as well as responding to reports of ill passengers by aircraft crew. Airports are required by regulation to provide quarantine/isolation space free of charge and, as a result, the CDC has no influential leverage as to where the airport authority places these areas (*44*). Early collaboration with the CDC can help to provide for efficient and flexible space in coordination with the CBP areas.

Tornado Shelters. U.S. airports that are located in areas of the country experiencing frequent tornado activity need to consider providing areas of the terminal that protect the traveling passenger from windborne debris. The Federal Emergency Management Agency has identified and mapped areas of the country that have higher levels of exposure to extreme wind hazard events such as tornadoes. Shelters or "safe rooms" are designed for the protection of wind forces and the impact of windborne debris. These rooms will provide a greater level of protection than those that comply with minimum building code requirements. Wind speed design criteria for tornado safe rooms range from 130 mph to as much as 250 mph depending on geographic location. Areas such as Gulf and Atlantic coastal areas have been documented as having the most occurrences of smaller tornadoes classified on the Enhanced Fujita (EF) Scale as EF0 to EF2, whereas the Great Plains region of the United States has been shown to have the highest occurrence rate of larger tornadoes classified as EF3 to EF5 (*45*). Restrooms are often used as safe rooms because of their multiple locations throughout the building, their structural surroundings, their lack of windows, and the added convenience of toilets/urinals and water supply. Other areas include stairwells, elevator cores, and mechanical rooms. The minimum recommended usable floor area for each seated, standing, and/or wheelchair-bound safe room occupant is 5 square feet, 6 square feet, and 10 square feet, respectively (*45*). Multi-use rooms with permanent fixtures such as restrooms will reduce the effective usable area and should be considered when planning new or multi-use safe rooms. Two hours is the typical maximum occupancy time for tornado safe rooms based on historical data. Signage is also critical in identifying areas designated as safe rooms, as well as directing passengers to these areas of the terminal.

VI.3.14.6 Structure and Non-net Areas

Non-net areas should be added to the recommended facility requirements to provide a better estimate of the total gross building area. Although the program areas are in terms of gross space, it is to be expected that there are always areas created in buildings that are unusable or occupied by special structures. Depending on how the individual program gross areas are determined, a factor of 2% to 5% should be added to the combined functional and support areas for non-net space.

VI.3.15 Gross Terminal Area Planning Factors

A terminal program should be a bottom-up process; that is, the total area should be the sum of the individual functional and support elements. When the process is completed, however, there is the inevitable desire to compare the program to other airports or to do a "sanity check" to see if the total area is within typical industry norms.

It is recommended that such comparisons should be done on the basis of area per NBEG and with airports that have similar characteristics. These comparisons should be done with care, as the terminal configuration can greatly affect the area per gate:

- The presence of extensive basements associated with baggage handling and APM systems can distort area comparisons.
- Multiple unit terminal airports generally have higher area per NBEG ratios than airports with a single terminal with similar gate capacity.
- Newer terminals designed to handle higher aircraft load factors tend to be larger per NBEG than older terminals.

Based on recent terminal programs, the typical ranges for new terminals are shown in Table VI-6. Mixed domestic/international terminals will typically be closer to the range of large domestic terminals.

Table VI-6. Typical sizes of new terminals.

Airport Terminal	Square Feet/NBEG
Smaller domestic	15,000–18,000
Larger domestic	18,000–24,000
International	28,000–40,000

VI.4 Other Facility Considerations

VI.4.1 Baggage Handling Systems

When planning a new passenger terminal, it is extremely important to plan a BHS that will appropriately meet the needs of the terminal and its passengers. The size (volume of passengers) and operation (hub or O&D) of the terminal are two of the most important factors to first consider when planning the BHS. These factors will strongly influence the choice of specific design components to make the BHS as effective as possible for the new terminal. As an example, other important factors to consider are the space limitations and requirements of the terminal, the budget of the airport owner, and the operational standards of the airline carriers. Together, all of these factors will help the airport planner and BHS planner/designer determine the best design for the individual terminal.

A BHS typically consists of different areas that serve different functions including baggage inputs, screening area, make-up area, and claim area. Additionally, support areas for the BHS are required, which include areas for motor control panels, control rooms, programmable logic controller vaults, and other non-conveyor BHS components. Once again, depending on the individual terminal, these areas can vary widely in many aspects including size, cost, design, and functionality. Inputs consist of ticket counter areas, curbside baggage check-in, and any other conveyor lines used to insert baggage into the BHS. Screening area refers to an automatic in-line baggage screening system, which is quickly becoming the norm for terminals to use. This system usually consists of one or more matrixes of EDS units combined with a way to sort the cleared bags from the suspect bags after they have been screened by the machines. The make-up area may or may not include sortation, which is the process of using the BHS to sort bags to assigned piers, run-outs, or make-up devices for loading onto the associated flights. A make-up area without sortation simply sends all bags to the same location where they can be manually sorted. The claim area consists of a flat plate or slope bed baggage delivery and various configurations of oversize baggage delivery.

In this section, detailed information related to BHS planning and design is discussed in regard to the environment (terminal size/operation) in which it is best utilized. This and other factors that affect the BHS planning and design are addressed in order to promote a deeper understanding of the relationship between the BHS and the terminal, and the functional requirements that affect both. Once this relationship and the requirements are clearly defined for the individual terminal, the typical areas of a BHS can be considered and analyzed to determine how each should be planned to best fulfill all requirements.

VI.4.1.1 Overview

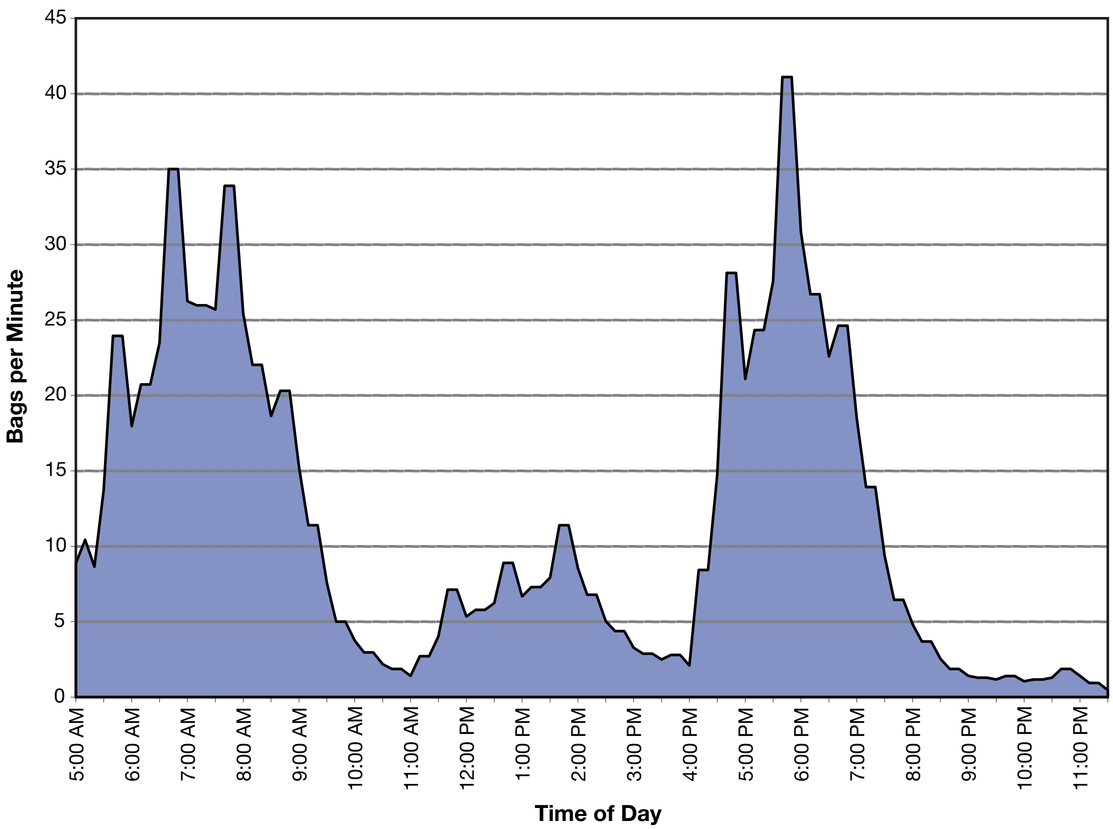
Passengers and baggage can be divided into six distinct passenger categories:

- International originating passengers
- Domestic originating passengers
- International destination passengers
- Domestic destination passengers
- International transfer passengers
- Domestic transfer passengers

The passenger volumes of each of these categories will help determine the type and size of BHS operation required during the planning stages. Unless actual data is accumulated or available as design criteria, it is suggested that 1.0 to 1.25 bags per domestic passenger and 1.25 to 2.0 bags per international passenger be used during the planning process. The originating passenger arrival profile combined with a flight schedule helps determine the outbound baggage volumes over the course of the day. This volume in turn can be used to size the input, and checked baggage screening and baggage make-up system requirements. Figure VI-45 depicts an example of data for outbound bag volume.

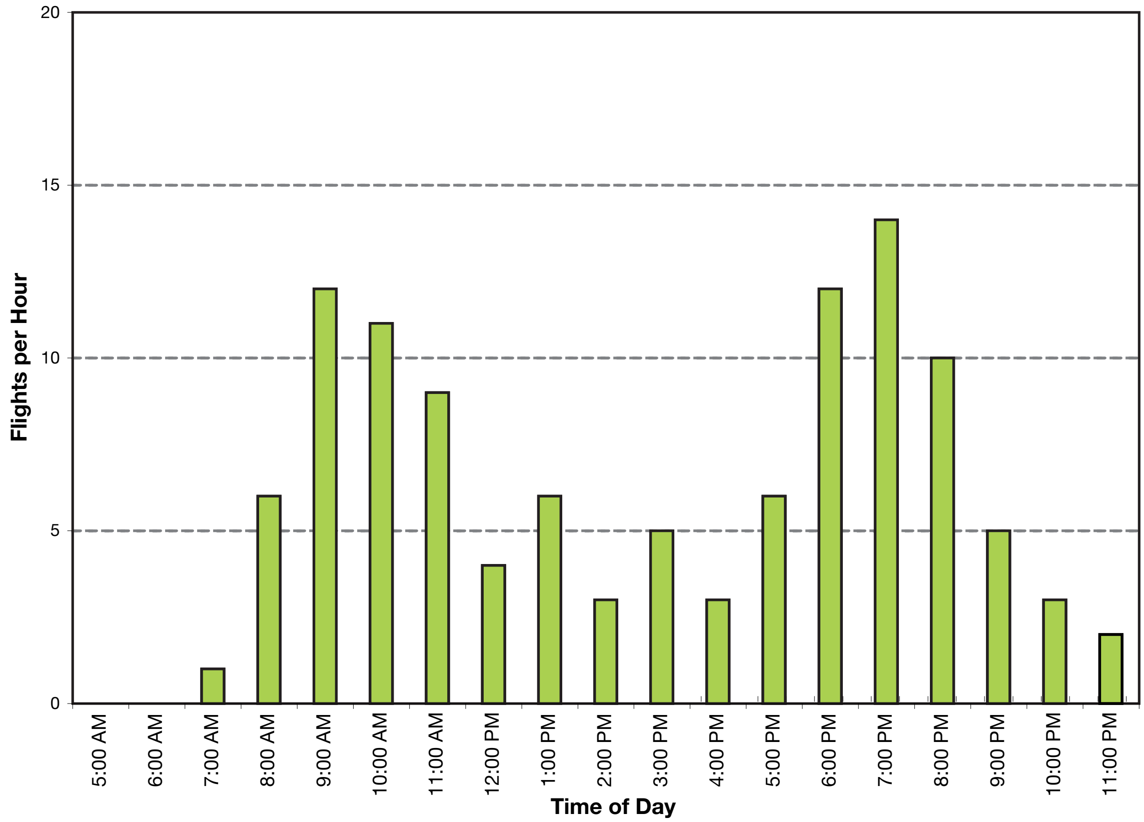
Similarly, the pattern of arriving flights combined with assumptions for aircraft unloading rates can help determine the requirements for inbound baggage handling and baggage claim as depicted in Figures VI-46 and VI-47. When assumptions for transfer passengers and baggage are added to the arriving flight pattern, transfer baggage volumes can be estimated as depicted in Figure VI-48.

Space Limitations and Requirements of the Terminal. Space limitations of the terminal structure can dictate the physical arrangement of departures, arrivals, and baggage make-up facilities. If the terminal design is a single-level facility, then the arrivals and departures facilities will be located on the same level but separated so that operations do not interfere with each other. If the terminal structure is designed as a multi-level building, the arrival and departure facilities can be located on different levels, directly above one another, to reduce the linear space requirements. Most large facilities arrange the departure level above the arrival level. Each facility, depending on its requirements, should plan on a minimum footprint to accomplish a desired LOS. For instance, some terminals have seasonal requirements for FIS facilities and can design retractable walls in the claim areas to double as both domestic and FIS facilities during certain times of the year. These retractable walls, when properly designed within a facility, can segregate the public side from the non-public side. Some code-share partners offer a higher



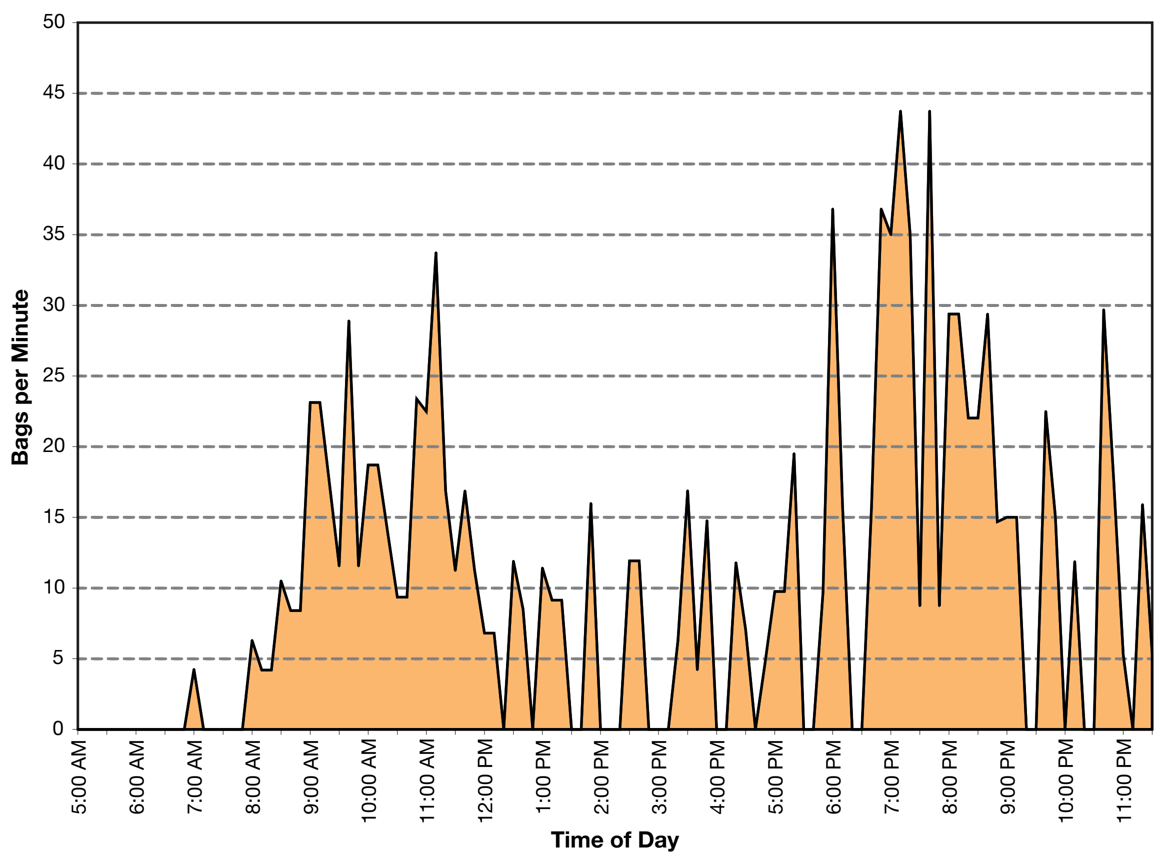
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-45. Outbound bag volume in bags per minute.



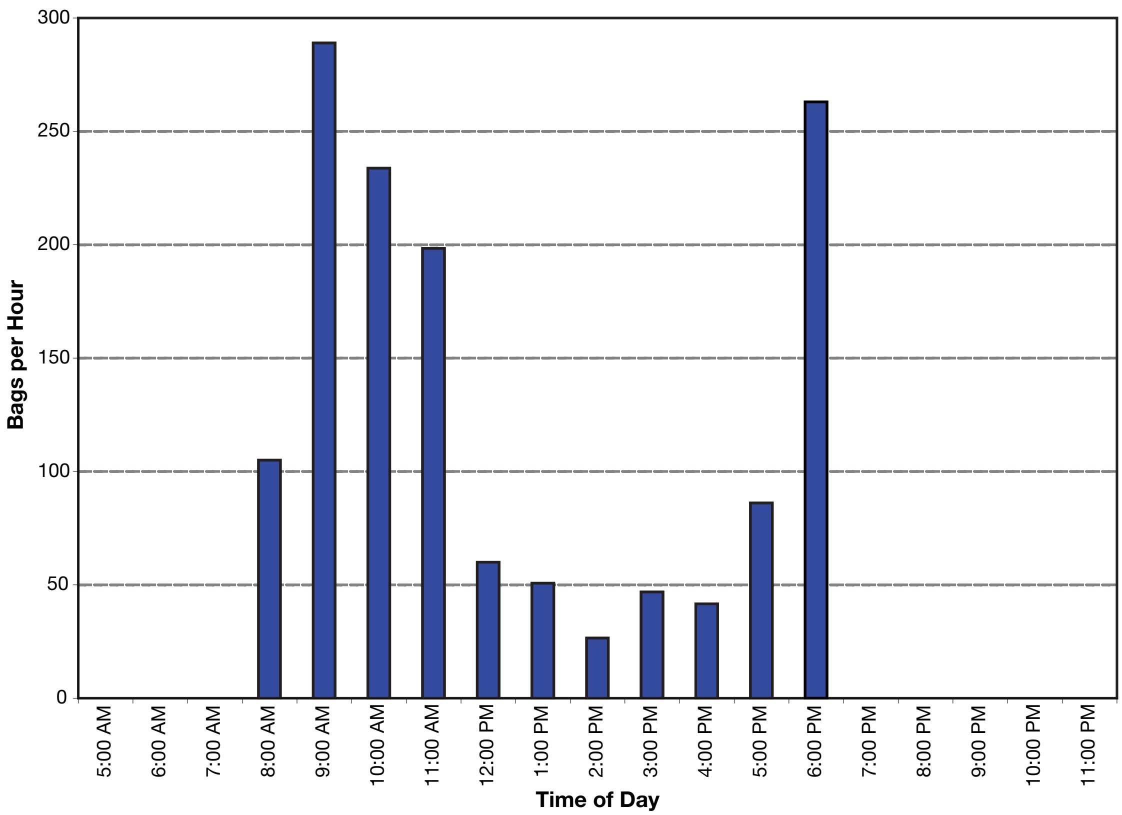
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-46. Inbound flights by hour.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-47. Destination bag volume in bags per minute.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-48. Transfer bags by hour.

LOS with dedicated check-in facilities for a preferred corporate account, or first class and business customers.

Budget of the Owner. The budget of the owner should take into consideration the BHS needs for the arrivals and departures facilities. Design issues that will affect the arrivals facility budget would be the type and length of claim devices used for the domestic and, if required, separate international claim devices. Flat plate devices can load baggage directly from the airport tug onto the flat plate, while slope bed devices require a conveyor to transport bags to feed the claim device. Real estate is typically a major concern when planning the claim facilities, and where the unload area is located for inbound baggage will determine which type of device should be designed. The following design issues will affect the departures facility budget:

- Are curbside facilities required and, if so, how many?
- What type of baggage screening system is required: an in-line or lobby-based solution?
- Do the airlines' ticket counter configurations require dedicated counters or common-use counters?
- Will the BHS be a centralized or decentralized baggage sortation make-up arrangement?

These design issues need to be evaluated before a comprehensive budget for the owner is established.

Operational Standards of Airline Carriers. The size of an airline's operation at a particular airport will determine what the operational standards may include. Many carriers are now subcontracting all the maintenance and baggage handling operations to third-party vendors.

This subcontracting could affect the decision of the preferred type of outbound BHS to be designed: either a manual or automated sortation system. When a third-party vendor is involved, comprehensive reporting capabilities for measuring the BHS performance usually becomes part of the standard operating procedures. A few standard issues to research are the following:

- How do the airlines handle transfer baggage?
- What are the times before flight departure that the BHS can accept either originating or transfer baggage?
- Where will the baggage be handled when the flight departure is several hours away?

VI.4.1.2 Outbound Baggage Systems

Outbound baggage systems can have up to five different types of inputs as discussed in Section VI.3.2.1:

- Staffed check-in counters
- Self-service check-in kiosks
- Bag drop counters
- Self-tagging stations
- Curbside check-in

There are nine types of baggage flow to consider.

Domestic Check-in. Domestic check-in usually consists of all levels of service provided within the same area: first class, business, and coach class check-in.

International Check-in. Depending on the amount of international traffic and the LOS the airline plans to provide, separate dedicated international check-in facilities could be required. Unless there is a dedicated conveyor feed to a make-up area, any conveyor input can be commonly used for both domestic and international, but only when there are no international flights scheduled for departure. Both international and domestic bags can utilize the same belt system, unless a dedicated wide belt system is required.

Remote Check-in. Many airports that typically have a high volume of business conference attendees or specific family vacation destinations have arranged for travelers to check-in and transfer their luggage to an airport-approved secured vendor prior to departing their hotels. After arriving at the airport, these bags must be delivered to the TSA for proper baggage screening prior to departure.

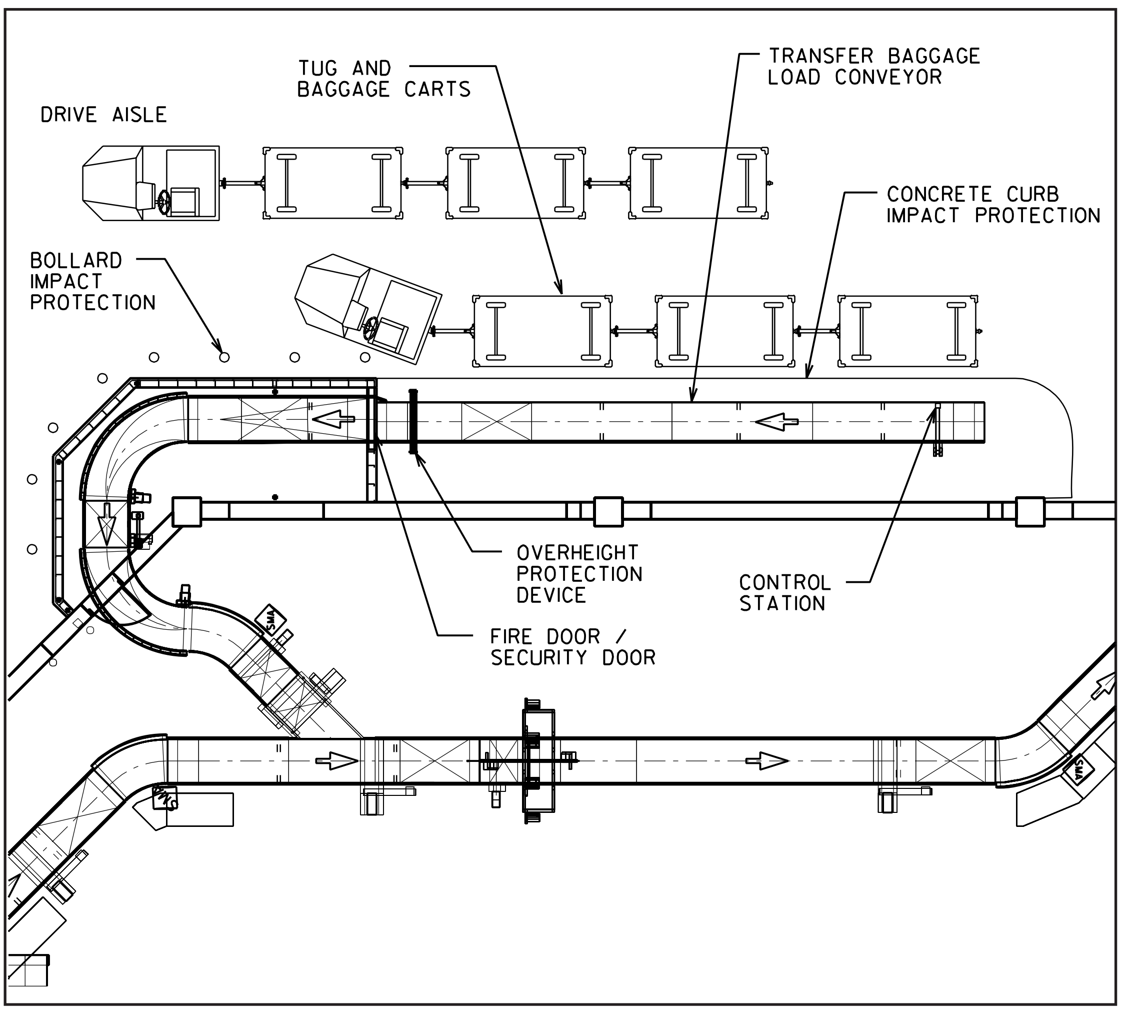
International Recheck (FIS). It is a requirement for arriving international passengers who are connecting on domestic outbound flights to claim all baggage, go through inspection by CBP as necessary, and recheck baggage prior to departure. In most FIS facilities, an additional conveyor belt is present that will take these bags to the outbound baggage system. Before these bags can be loaded or sent to the outbound make-up area, they must be rescreened if the TSA has not approved the upstream airport's screening system protocol.

Odd-Sized Check-in. Domestic and international odd-sized baggage is baggage that is too large to be handled by a normal conveyor system. It is typically manually handled at certain drop-off locations within the airport and delivered to the TSA for screening. In some instances the passenger will be directed to the bag drop-off point to deliver bags to the TSA for screening. After screening there is usually a dedicated odd-sized belt system designed to handle conveyable pieces of luggage (the conveyor is 45 inches to 65 inches in width) or a manual delivery for non-conveyable items like bikes, surfboards, etc., to the secured non-public side of the bagroom.

Group Check-in. Some airport facilities have separate group check-in counters for vacation destinations or bus drop-off points. These areas typically have a belt that feeds into either the main outbound baggage system or a dedicated make-up unit for the group check-in.

Transfer Baggage. Large volumes of transfer baggage usually do not occur unless the airport is operating with a hub carrier. Hub facilities require separate load belts distributed around the outbound baggage system that can feed directly to an automated sortation system and, if needed, a manual sortation device, like a flat plate for odd-sized transfers. However, from time to time, non-hub airlines require transfer belts that feed into the outbound baggage system because of code-share transfers between carriers. These transfer belts are typically located on the apron-level roadway and require additional protection from tugs and carts as depicted in Figure VI-49.

Early Bag Storage. Early Bag Storage Systems (EBSSs) are utilized in some facilities when a large volume of originating or transfer bags arrive so much earlier than flight departure



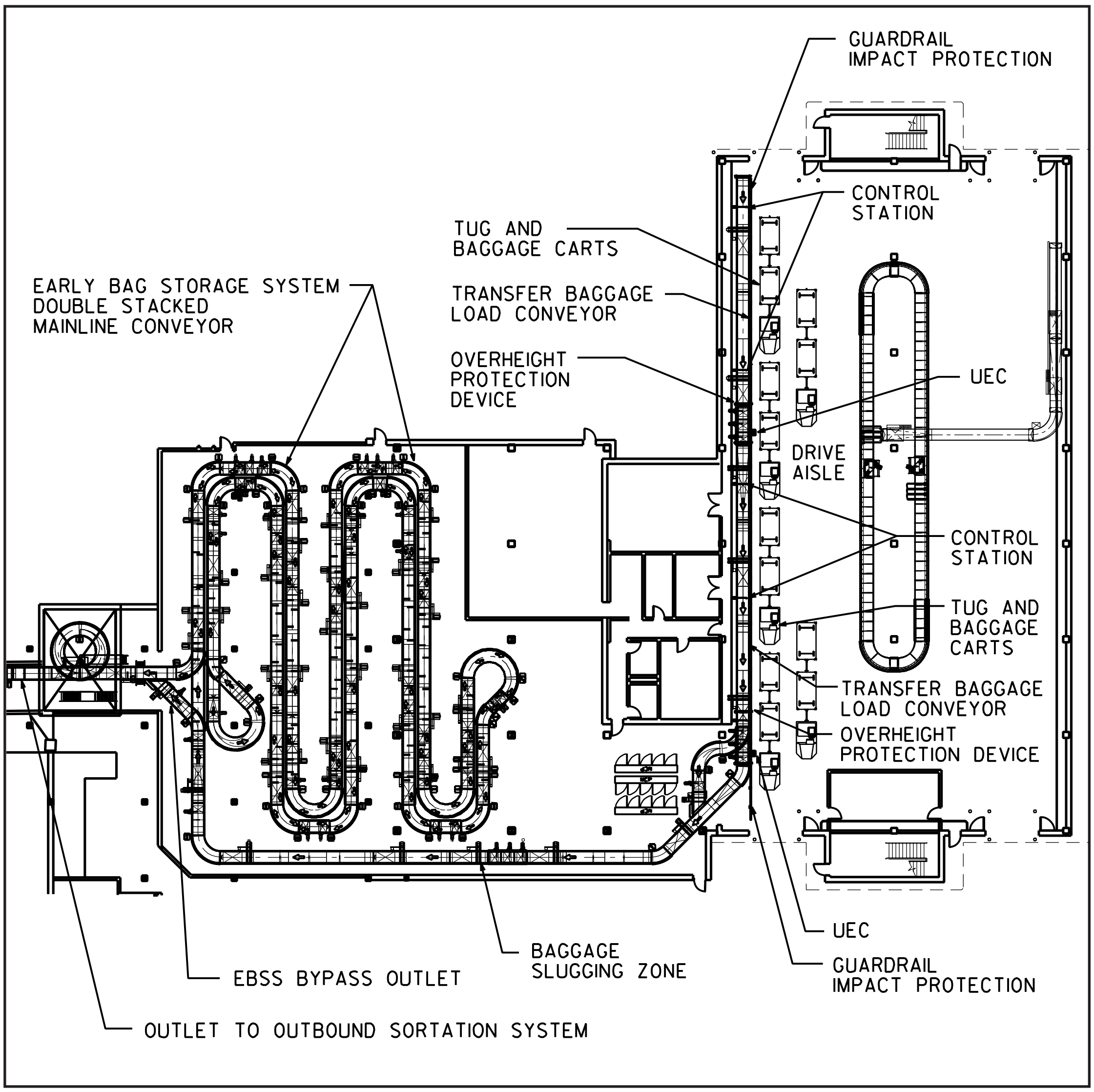
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-49. Typical transfer baggage load belt with concrete curb impact protection.

that the airlines do not have an economical method of handling or storing these bags within the outbound baggage system. The EBSS is typically located separate from the outbound baggage system and will feed bags back to the BHS for sortation and delivery as depicted in Figures VI-50 and VI-51. It can be loaded by either of two ways: (1) a dedicated transfer load belt for early transfer bags or (2) a diversion from the outbound sortation system for early originating bags. The bags stored in this facility usually have more than 120 minutes before departure.

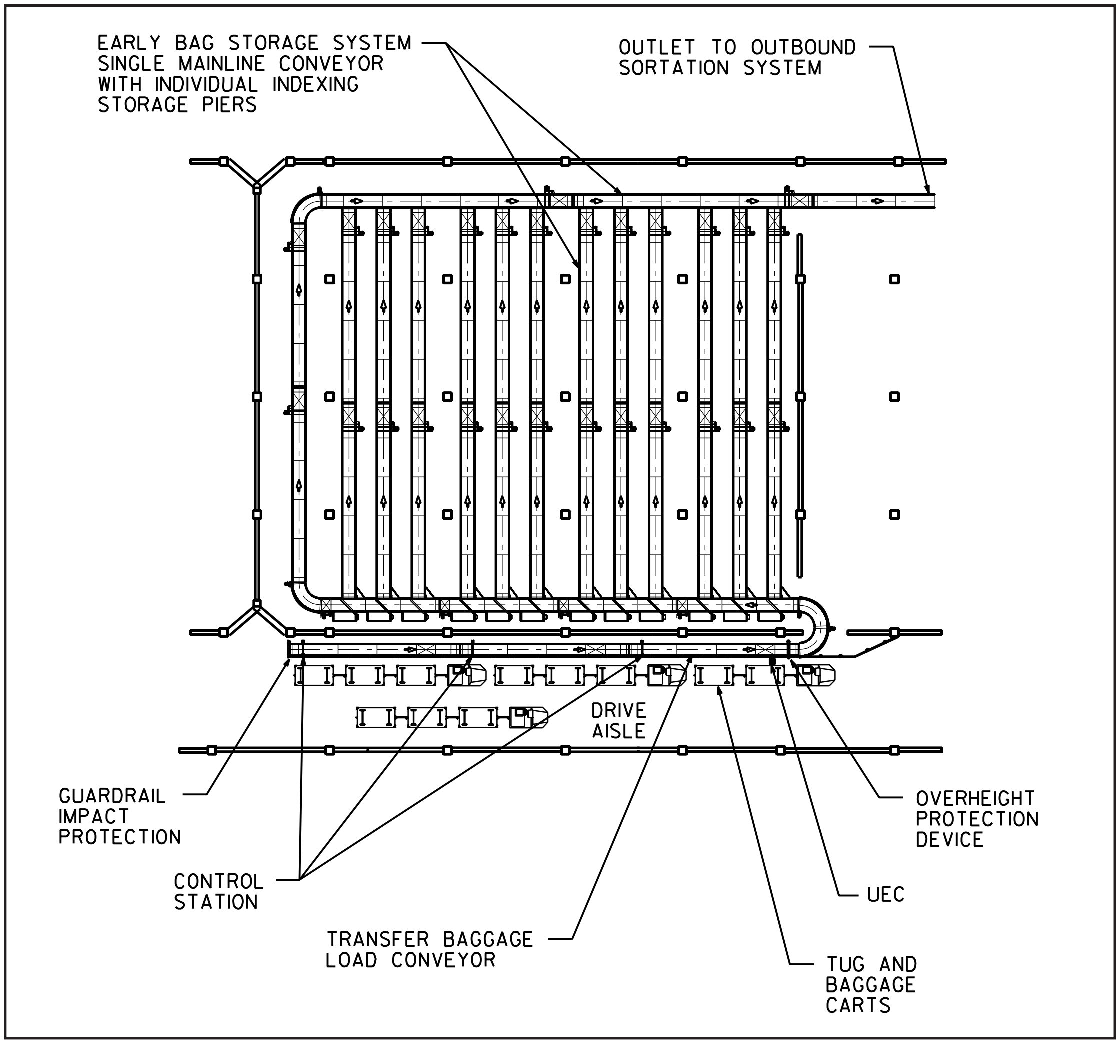
Special Handling Items. Some types of baggage require special handling:

- **Pets:** All checked-in pets are placed into an airline-approved container, but are never loaded onto a conveyor. Special attention is given to these containers; they are manually handled by airline-approved personnel. In some instances the customer will be directed to the pet drop-off point for delivery to the TSA for screening prior to airside delivery. Most airlines accumulate pets in a single area and usually handle pets in the same manner as non-conveyable luggage.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-50. Typical EBSS with double-stacked mainline conveyor and two load points.



Source: Star Systems, LLC—A subsidiary of Five Star Airport

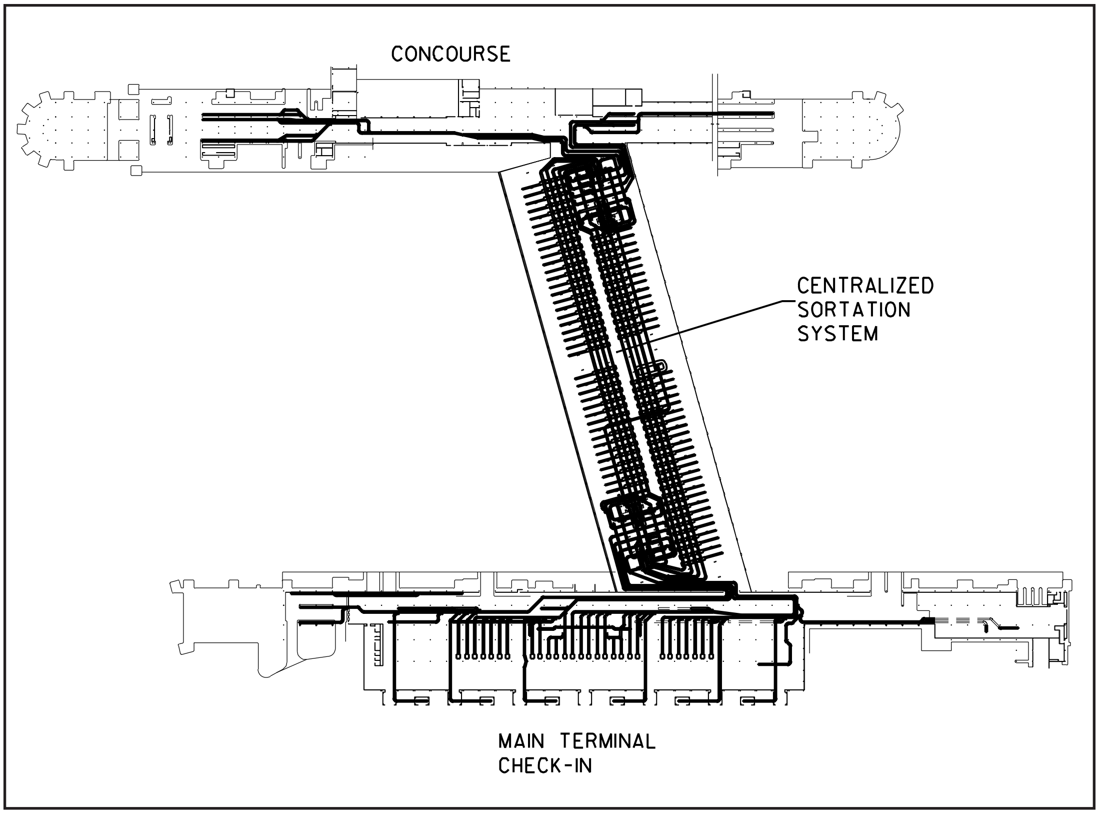
Figure VI-51. Typical EBSS with single mainline conveyor and one load point.

- **Firearms:** Firearms that have been identified by the passenger can be checked in either in its own protective case or within normal checked luggage, once the TSA has determined it is unloaded and safe. Many firearms are handled as odd-sized baggage by the airline for safe delivery to the plane.
- **Extra large items—sports gear (bikes, surfboards, SCUBA tanks), wheelchairs, medical equipment, etc.:** Extra large items that are non-conveyable in nature must have a process for their manual handling and delivery, usually to a single location, for TSA screening prior to airside delivery. Some facilities have a separate out-of-gauge drop-off location for the handling of these items that are typically delivered by the passenger after check-in.

VI.4.1.3 Baggage Sortation System Design Parameters

Types of Baggage Sortation Systems. There are four types of baggage sortation systems:

- **Centralized sortation (localized to terminal):** A centralized sortation BHS gathers all input bags, originating and transfer, into one location and then sorts the bags to the flight's sort designation as depicted in Figure VI-52. These systems usually employ automated tag readers (ATRs) for automated scanning and universal encoding consoles (UECs) for manual sortation if the automated scans fail.



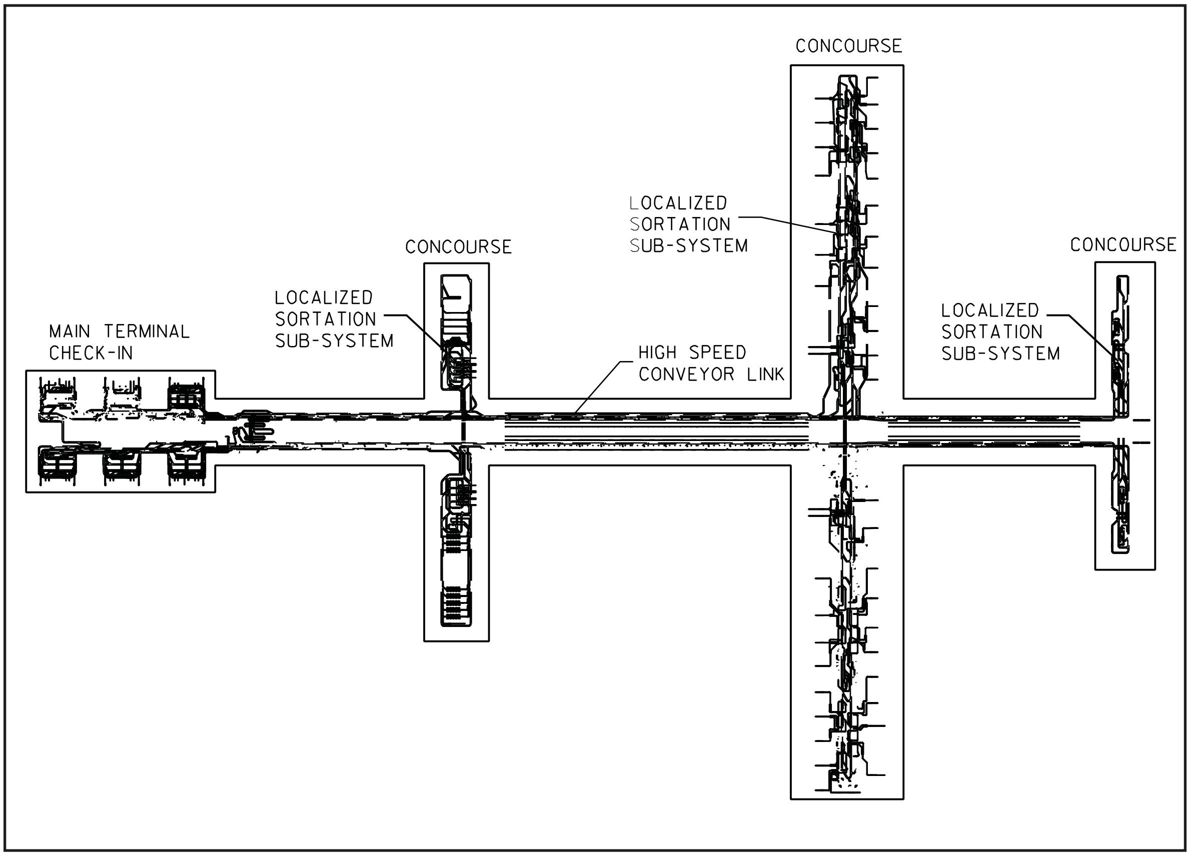
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-52. Centralized sortation baggage handling system.

- **Decentralized sortation (localized to gates):** A decentralized baggage sortation system sorts the bags at two or more locations, or the actual flight sortation is performed at or near the individual airplane gates as depicted in Figure VI-53. These systems usually employ ATRs for automated scanning and UECs for manual sortation if the automated scans fail.
- **Common-use sortation system:** A common-use sortation system incorporates all of the carriers' bags into one common sortation and delivery system to process and sort the bags by carrier destination. A major benefit of this system is that any future additions, removals, or modifications are simplified because all inputs feed into one single sortation and delivery system. Another major benefit is that if carriers are operating with sporadic departure times, all carriers' schedules can be combined to maximize the use of the sortation system.
- **Manual sortation:** A manual sortation system does not employ ATRs or UECs. The baggage sortation takes place in the baggage make-up area with airline personnel manually sorting each individual bag and placing it in the appropriate cart. In this arrangement, common make-up devices can be shared by multiple carriers if required.

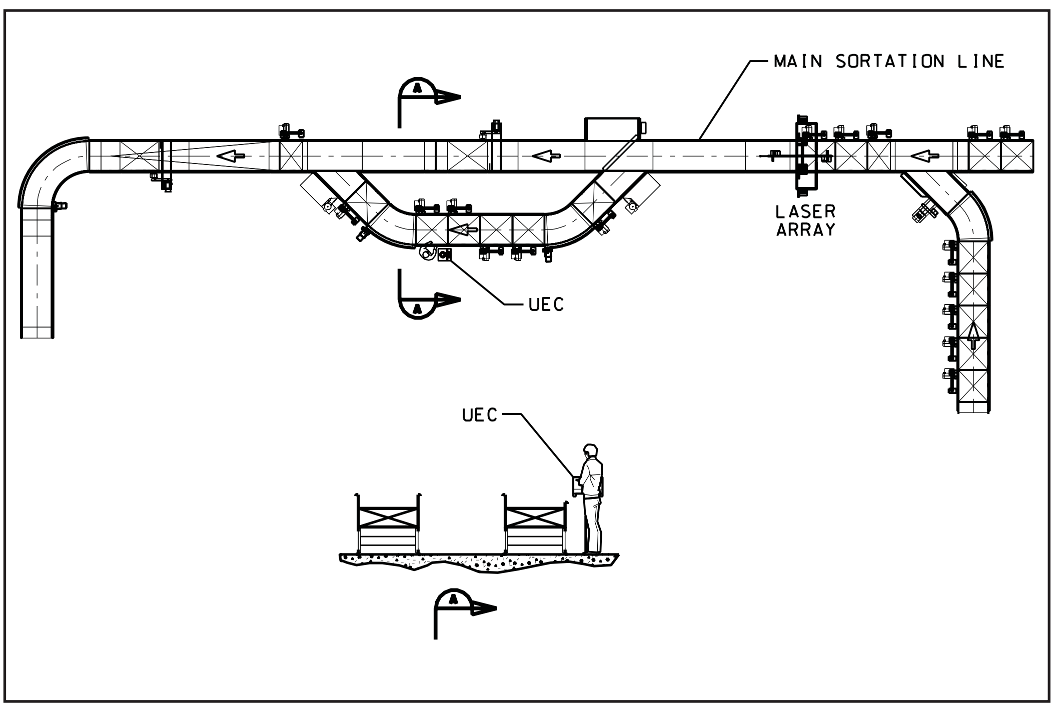
Baggage Sortation Components. Standard components of baggage sortation systems are ATRs and UECs:

- ATR locations: ATRs, or laser barcode reader arrays, are utilized to automatically scan baggage tags and sort baggage to the proper designated make-up destination.
- UEC workstation areas: UECs, or manual encode stations, are utilized to sort baggage manually to the proper designated make-up destination when the ATR fails to sort baggage automatically as depicted in Figure VI-54 and Figure VI-55.



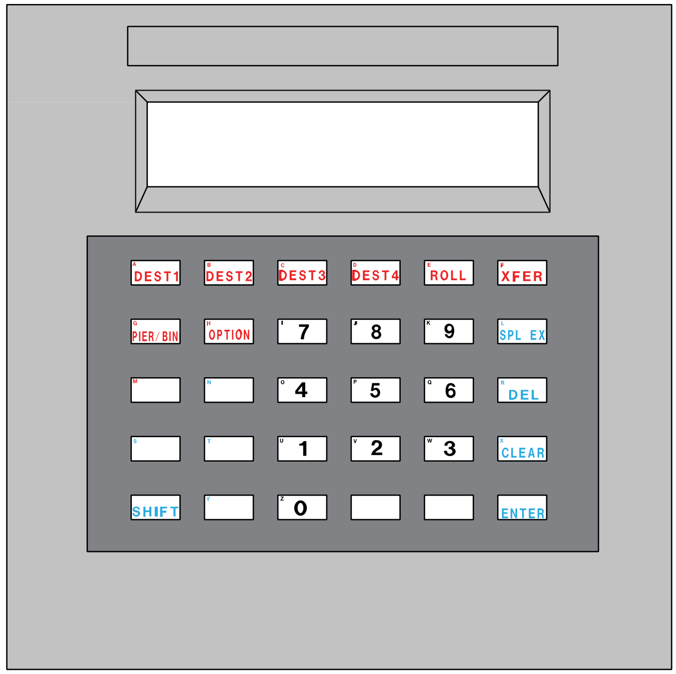
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-53. Decentralized sortation baggage handling system.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-54. Typical UEC workstation area.

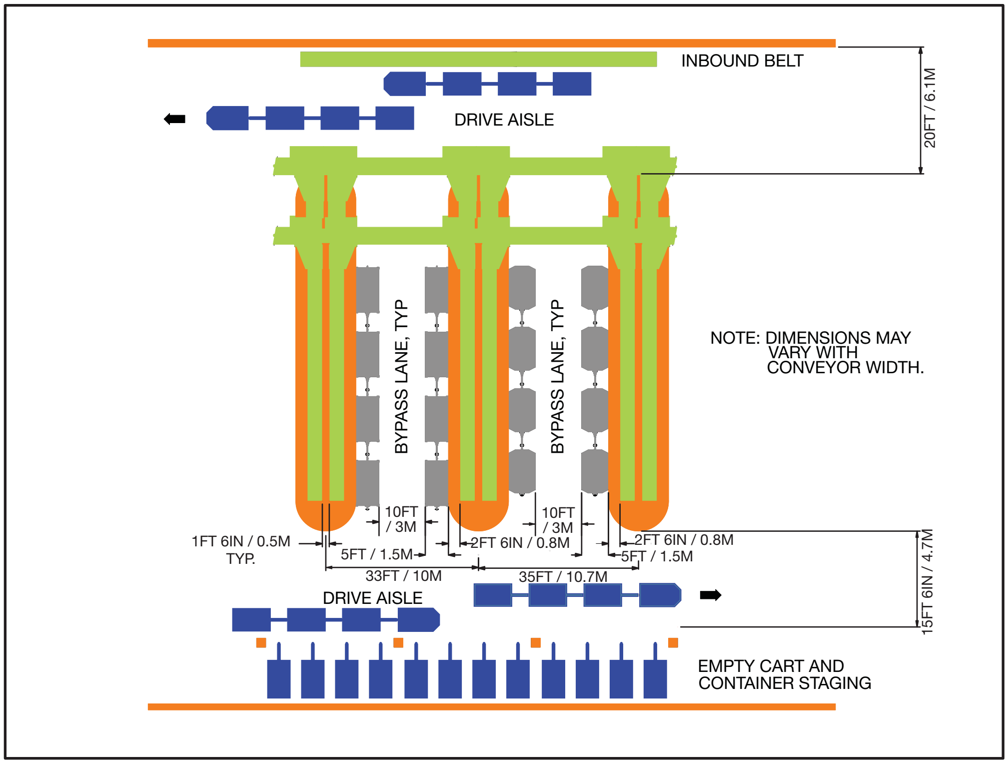


Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-55. Universal encoding console.

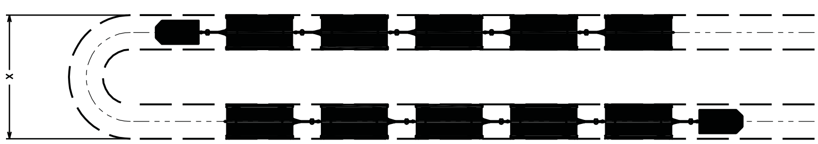
Baggage Sortation Operational Requirements. Proper operation of the baggage sortation system requires the following elements:

- **Drive aisle/drive-through rights-of-way and circulation:** Proper space allocation in the make-up area for tug and cart drive aisle/drive-through rights-of-way and circulation is crucial for optimizing the baggage handling operation as depicted in Figures VI-56 through VI-58. It is important to always maintain at least a minimum height clearance of 7 feet 6 inches above the finished floor for airline tug and cart clearance wherever the tugs drive or park as depicted in Figure VI-59. This minimum clearance only covers baggage carts and tugs, not specialty equipment that will access the same areas.
- **Baggage cart staging:** Adequate baggage cart staging is required in the make-up area to properly stage empty carts, as depicted in Figure VI-60.
- **Building column spacing:** Spacing between building columns should be carefully considered to allow optimal working space for baggage handling equipment, tug drive aisles, circulation, and storage.
- **Maintenance and bag jam clearing access:** Access lanes and doors in the make-up area will be required for baggage handling equipment, maintenance, and bag jam clearing. Minimum requirements for typical conveyor design are 1 foot from obstruction to the conveyor on the non-motor side, 3 feet from obstruction to the conveyor on the motor side, and 3 feet from top of the conveyor belt above to the obstruction. Other specialty conveyor equipment has further requirements and will be detailed in the BHS design package.
- **BHS control room:** The BHS control room contains the essential components to monitor and operate the BHS properly and optimally. Graphic monitors and video camera monitors are located in the BHS control room to assist the observation of the BHS. BHS control room applications need 400 square feet to accommodate the system.



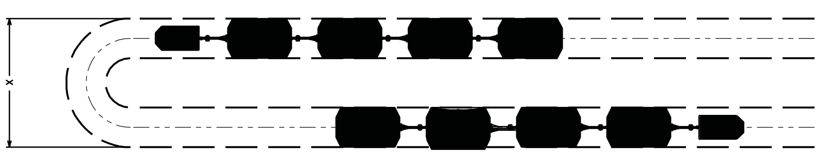
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-56. Space allocation for drive aisle/drive-through tug circulation.



5	18FT 1/2IN / 5.5M
4	18FT 1/2IN / 5.5M
3	16FT 6 7/8IN / 5.1M
2	16FT 6 7/8IN / 5.1M
1	15FT 1 1/8IN / 4.6M
No. of Carts	DIMENSION X

DIMENSIONS SHOWN ARE FOR A 12FT / 3.7M CART. DIMENSIONS MAY VARY WITH TYPE OF EQUIPMENT USED.

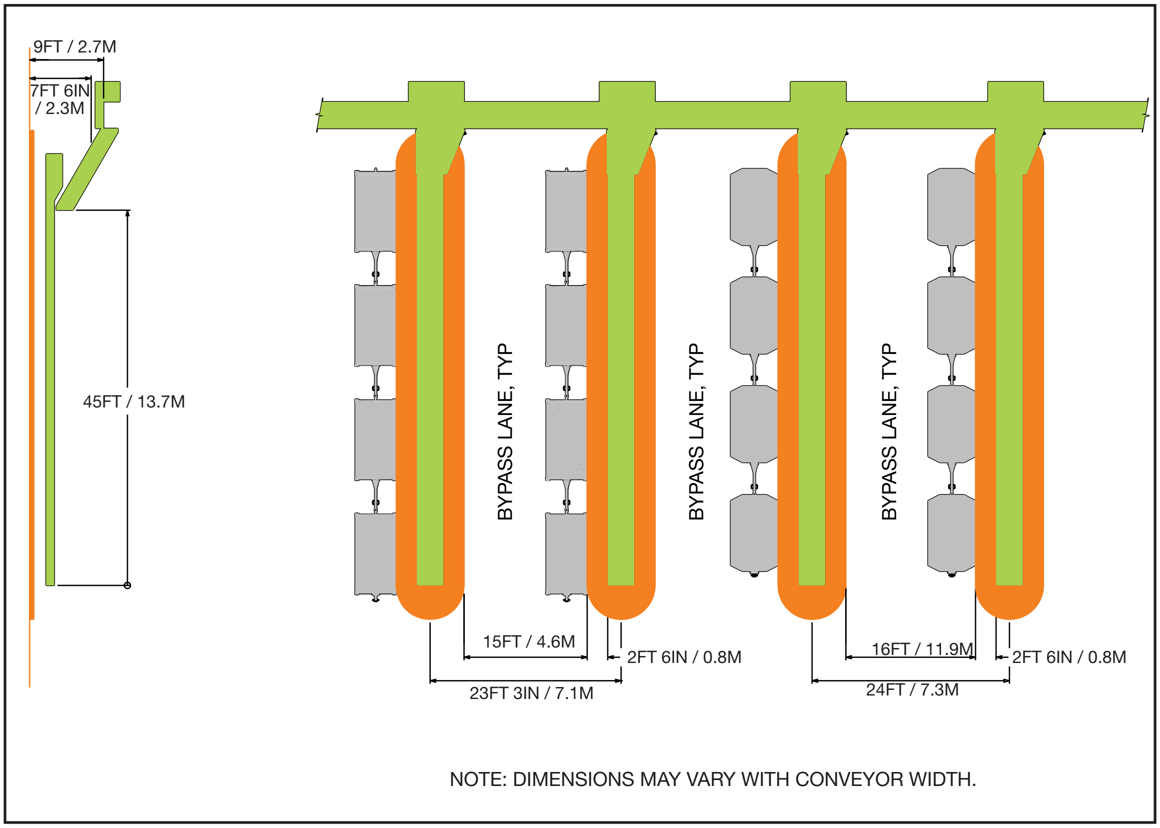


4	22FT 7 5/8IN / 6.9M
3	22FT 7 5/8IN / 6.9M
2	20FT 10IN / 6.3M
1	20FT 4 1/8IN / 6..2M
No. of Carts	DIMENSION X

DIMENSIONS SHOWN ARE FOR A SUEHIRO CONTAINER DOLLY. DIMENSIONS MAY VARY WITH TYPE OF EQUIPMENT USED.

Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

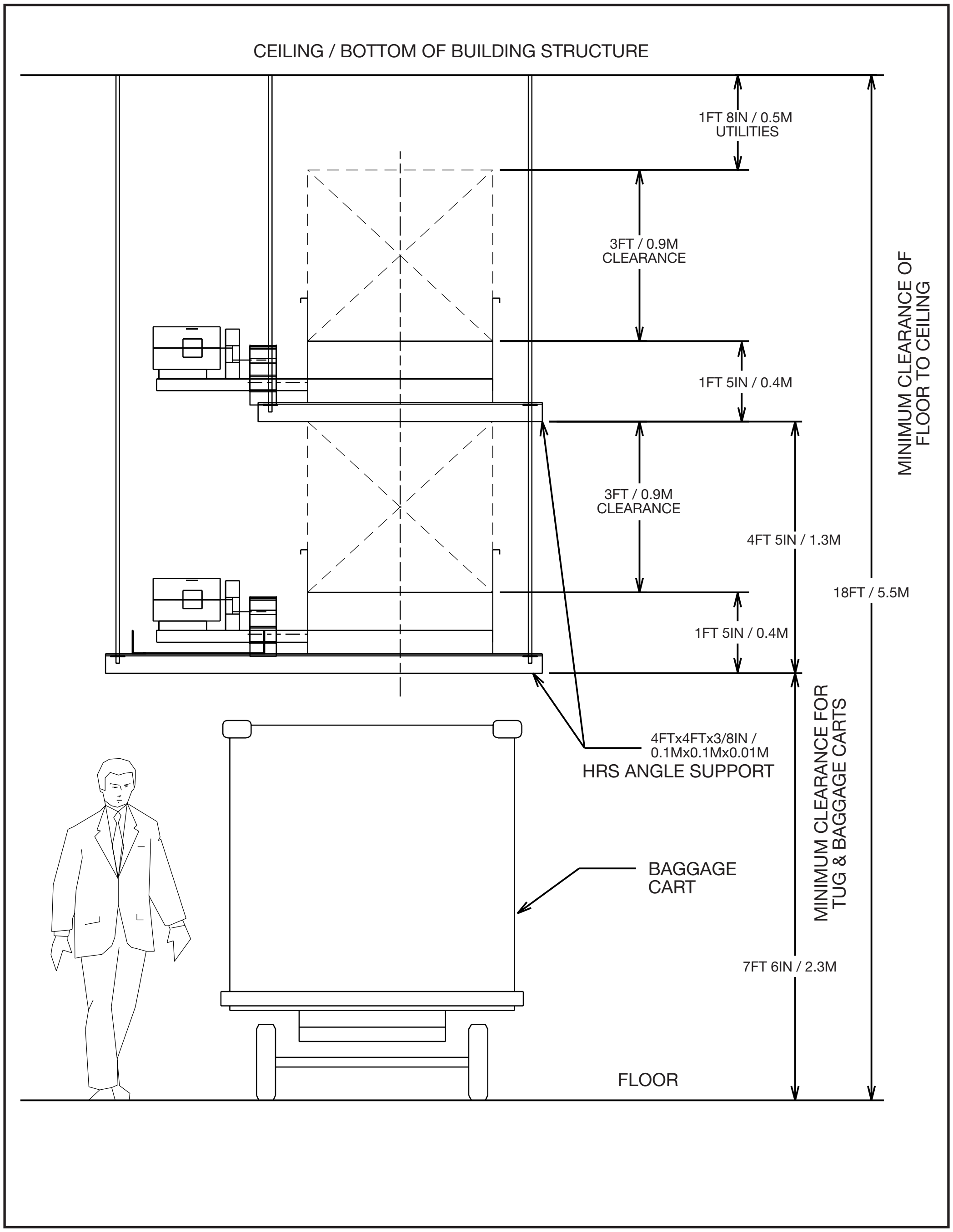
Figure VI-57. Turning radius for tug and cart.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

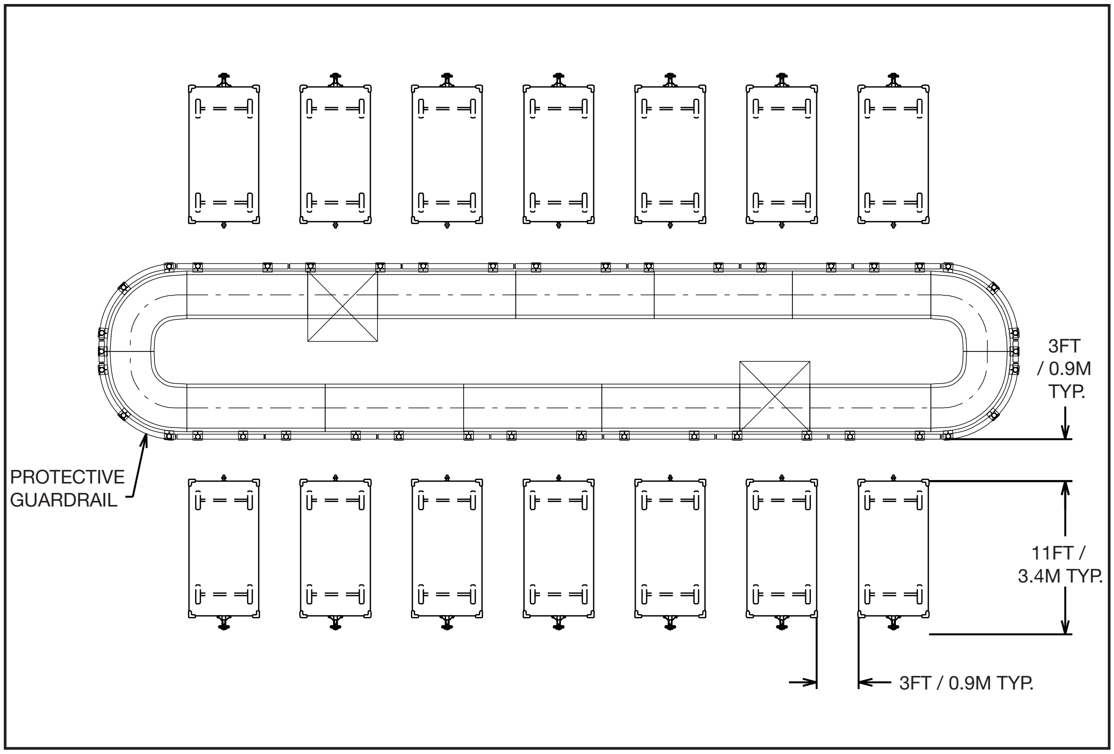
Figure VI-58. Sort pier spacing (single-sided piers with bypass lane, one mainline).

- **Human–machine interface graphics:** Human–machine interface graphics contain the current status of the operation of the BHS, such as bag jams, conveyor time-outs, and emergency-stopped conveyors. These graphics assist with the rapid resolution of an issue within the BHS.
- **Motor control panel locations:** Motor control panels (MCPs) can be placed in one general location/room or remotely throughout the BHS. MCPs require a minimum of 48 inches in front of the panel for Occupational Safety and Health Administration and access requirements. The quantity and size of the MCPs depend on the complexity and magnitude of the BHS. MCP sizes range from one to five bays and as a safe rule of thumb, MCPs can house up to 20 drives per bay as depicted in Figure VI-61.
- **Programmable logic controller vaults:** Programmable logic controller (PLC) vaults are valuable for housing all the PLCs in one location for easy access and maintenance. Also, a PLC vault can reduce the amount of time spent troubleshooting a problem during a BHS crisis. A room ranging in size from 200 to 300 square feet can accommodate most of the PLC vault applications.
- **BHS maintenance room:** A maintenance room/area is required to maintain, build, or repair conveyor parts to assist with the proper upkeep of the BHS. Special consideration of size and location of the maintenance room/area is required depending on the complexity and magnitude of the BHS. A room ranging in size from 300 to 800 square feet can accommodate most of the BHS maintenance room applications.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-59. Minimum clearances with double-stacked conveyor and tug drive aisle.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-60. Empty cart staging at flat plate claim device.

- **BHS spare parts room:** Conveyor equipment parts require replacement from time to time. Spare parts are kept on site to reduce the down time of the BHS. A spare parts room is required to house the required replacement spare parts. Special consideration of size and location of the parts room is required depending on the complexity and magnitude of the BHS. If possible, accommodate both the BHS spare parts and the BHS maintenance room in the same area.
- **BHS remote monitoring locations:** Establishment of remote BHS monitoring stations is necessary in the larger more complicated BHS systems to assist the daily operation and overall performance of the BHS. Certain areas, such as the EDS room, contain a dense amount of equipment in which a remote monitoring station can alleviate issues in a faster manner. Most of the BHS remote monitoring locations can be accommodated with 100 square feet.

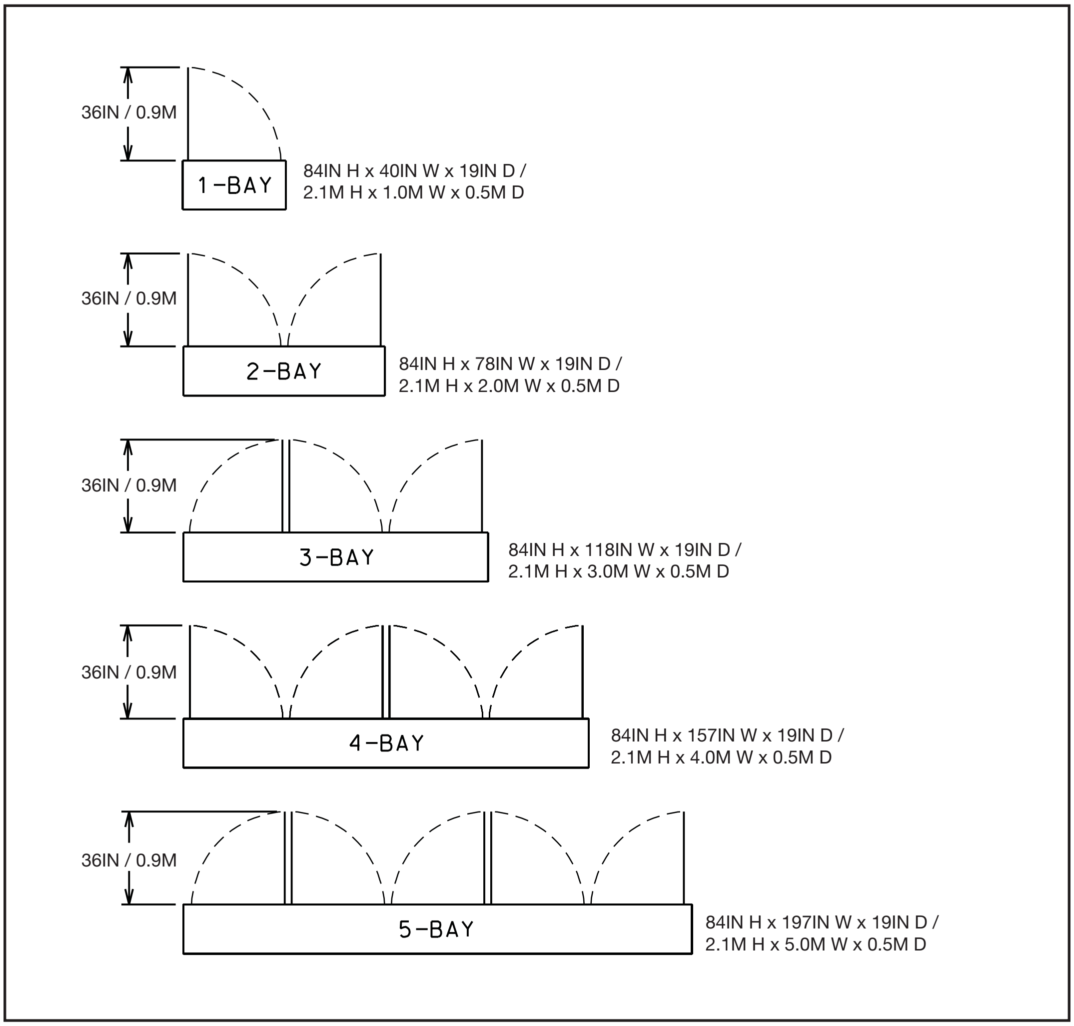
VI.4.1.4 Inbound Baggage Systems

As discussed in Section VI.3.7, there are two basic types of mechanical baggage claim units:

- Flat plate units are typically configured as “L,” “T,” or “U” configurations. Bags are loaded on the secured non-public side, then pass through the wall, and are claimed by passengers as depicted in Figures VI-62 and VI-63. This process occurs on the same terminal level with the unloading area adjacent to the claim unit.
- Sloped bed units can be located anywhere so long as the feed conveyors are able to reach the unit from either above or below as depicted in Figures VI-64 and VI-65.

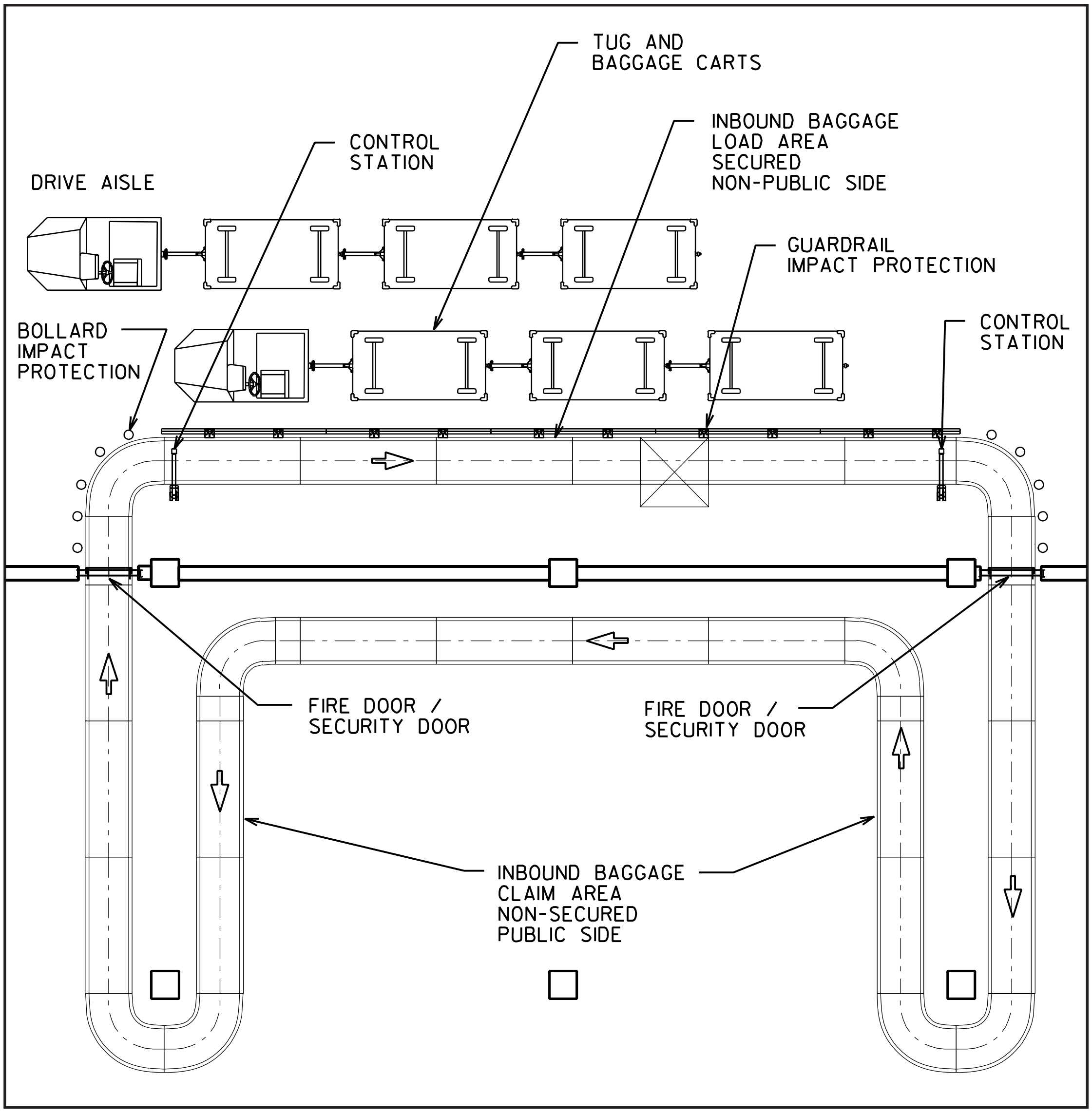
Odd-sized baggage is usually handled in one of three ways:

- Oversized belt: An extra wide conveyor system, anywhere from 45 inches to 65 inches in width, transports odd-sized bags from the apron level to the claim level generally between two claim units or against an exterior wall of the claim area. This conveyor system can be flat, incline, or



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-61. Typical MCP dimensions (20 drives/bay).



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

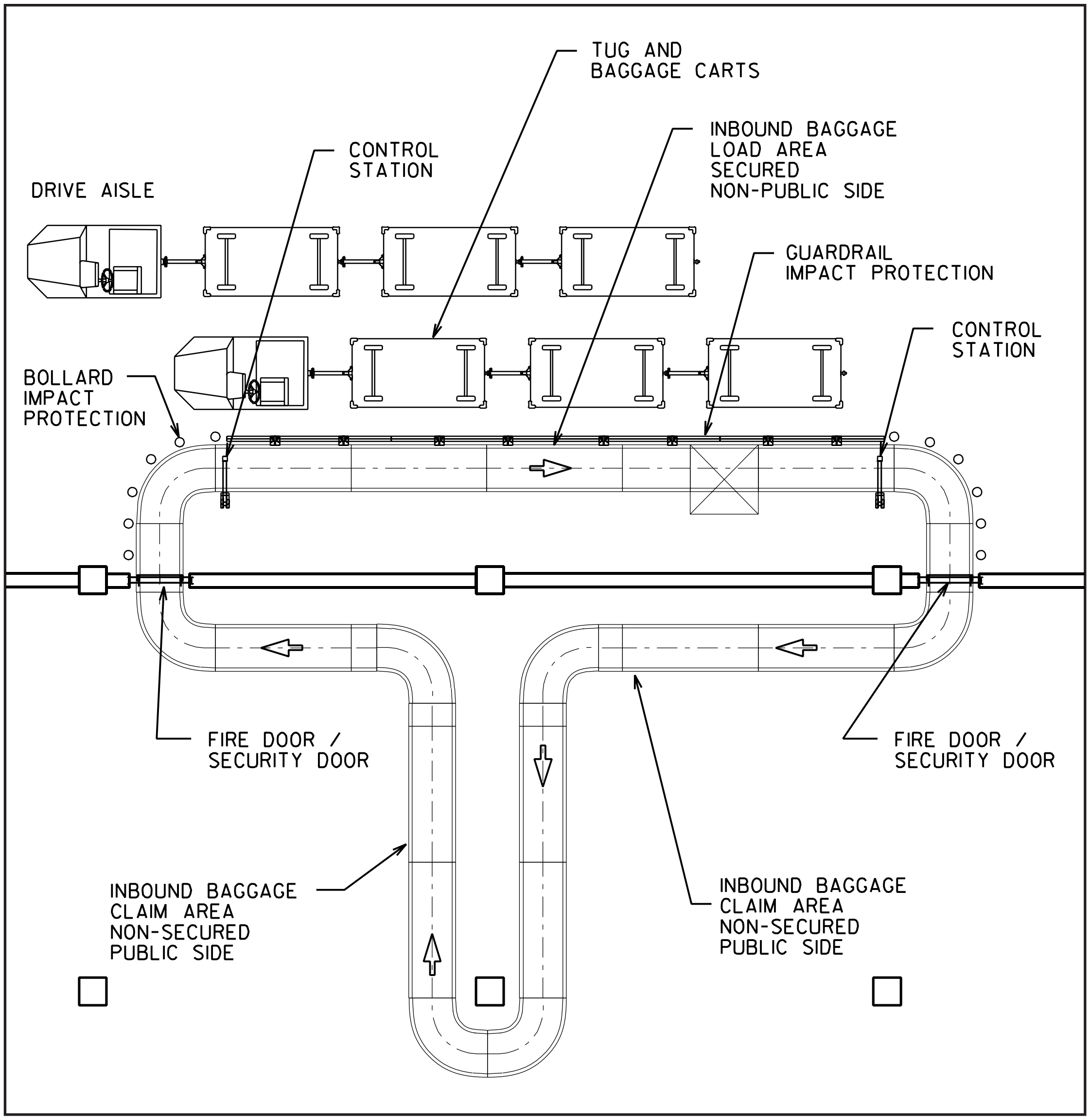
Figure VI-62. Typical flat plate claim unit for inbound baggage—"U" configuration.

decline before entering the claim area, but it is recommended that no turns be used in the odd-sized system.

- Oversized slide: Roll-up doors, around 6 feet to 10 feet wide and at least 5 feet high with a stainless steel slide, can be used to deliver oversized bags to the claim area. This system usually functions effectively only when the cart is unloaded at the same level as the claim area, like a flat plate claim arrangement as depicted in Figure VI-66.
- Manual laydown: When it is not practical to include either a slide or belt system, airline employees can take odd-sized luggage from the secured side to the non-secured side by using an airport access door, usually adjacent to the claim area, for passenger retrieval. This procedure also applies to special handling items.

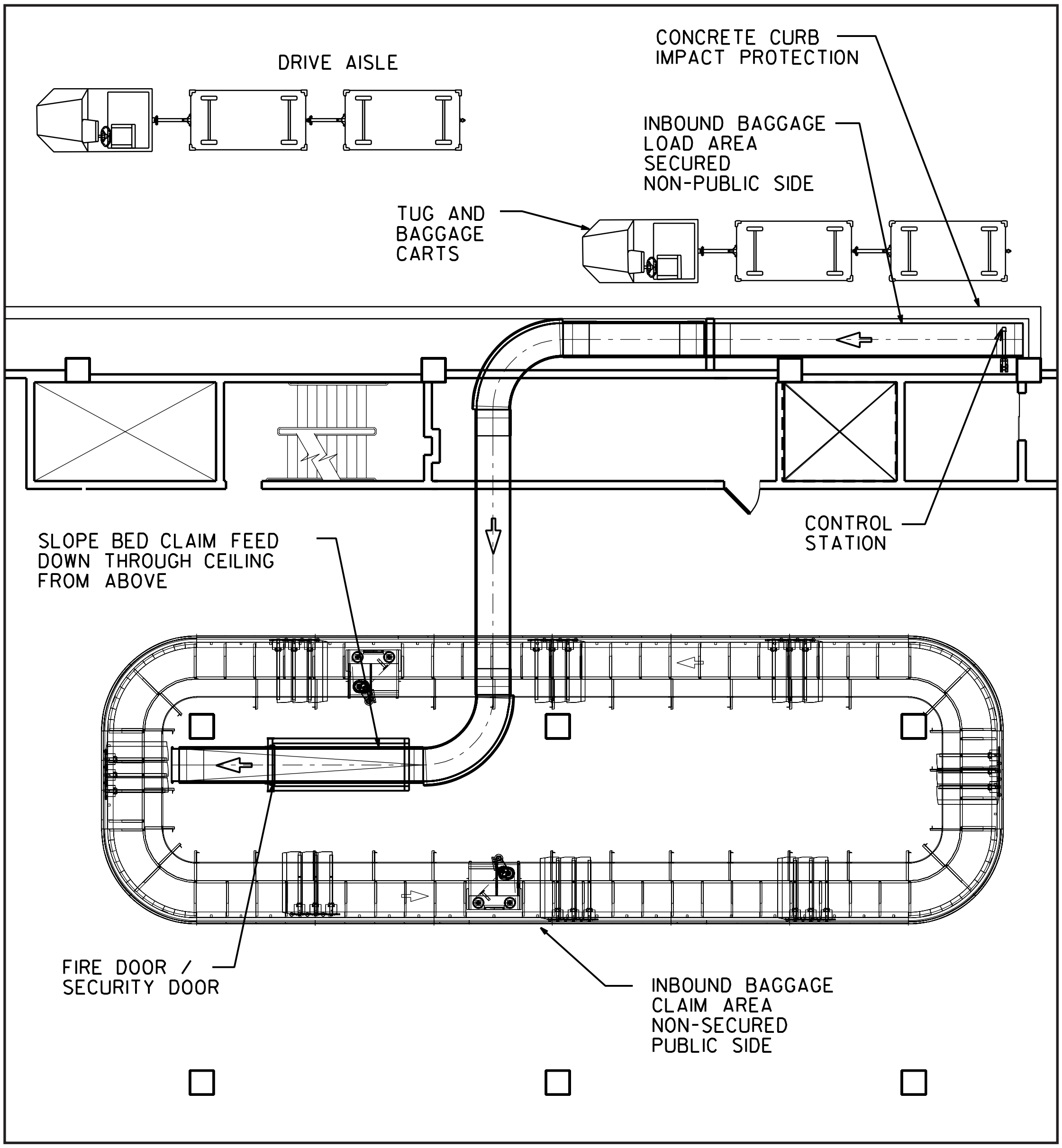
VI.4.2 Information Technology Systems

IT design in the terminal is no longer limited to point-to-point copper wire connections; the immense opportunities available in fiber optics and computerized local area network/wide



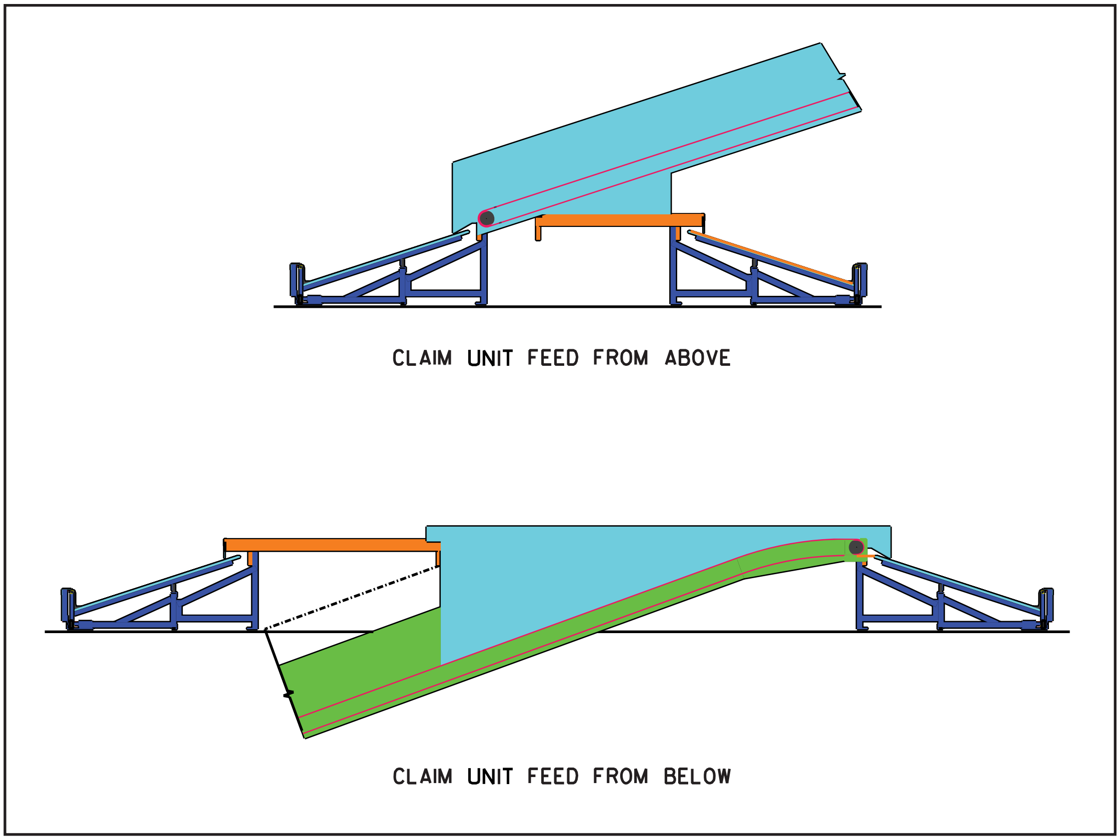
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-63. Typical flat plate claim unit for inbound baggage—"T" configuration.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-64. Typical transport conveyor to slope bed claim unit with conveyor feed from above.



Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-65. Side view of feeds for slope bed claim unit.

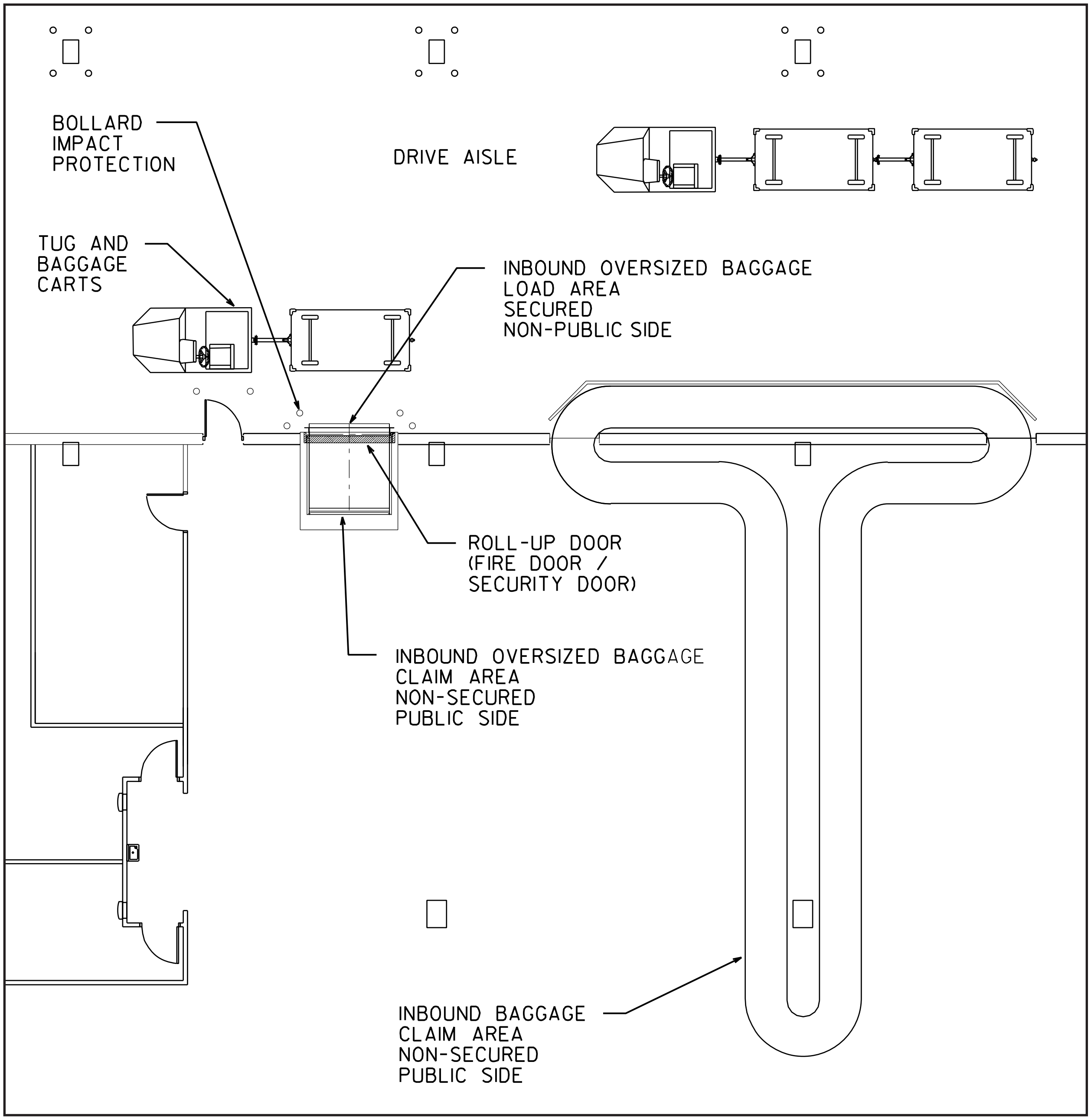
area network (LAN/WAN) implementation can now be optimized by the early inclusion of IT professionals in the planning and design process.

VI.4.2.1 Information Technology Issues

For most terminals, shared network applications will run on the airport's LAN. The most common LAN architecture is the star-configured Ethernet designed according to the Institute of Electrical and Electronics Engineers (IEEE) 802.3 series standards. The general configuration of such a LAN using a hierarchy of access, distributed, and core switches is shown in diagram format in Figure VI-67.

The airport LAN architecture impacts all terminal users. The range of user requirements and how user services are set up must be defined early in terminal design. Different terminal users will have different requirements for access and security permissions, network bandwidth, system availability, storage, and other functions. Servers might be centralized or located at the LAN edge depending on their functional and service requirements.

Except for greenfield airports, most terminal design projects will require integration with existing facilities including an airport LAN, which might be outdated or under-designed. This integration, in turn, will require that a detailed understanding of both wired and wireless capabilities, connectivity, backup policies, and other aspects of the LAN be developed during terminal design so that specifications for terminal user services and connectivity can be coordinated with the airport IT and/or telecommunications departments that will be responsible for provisioning and maintaining them.



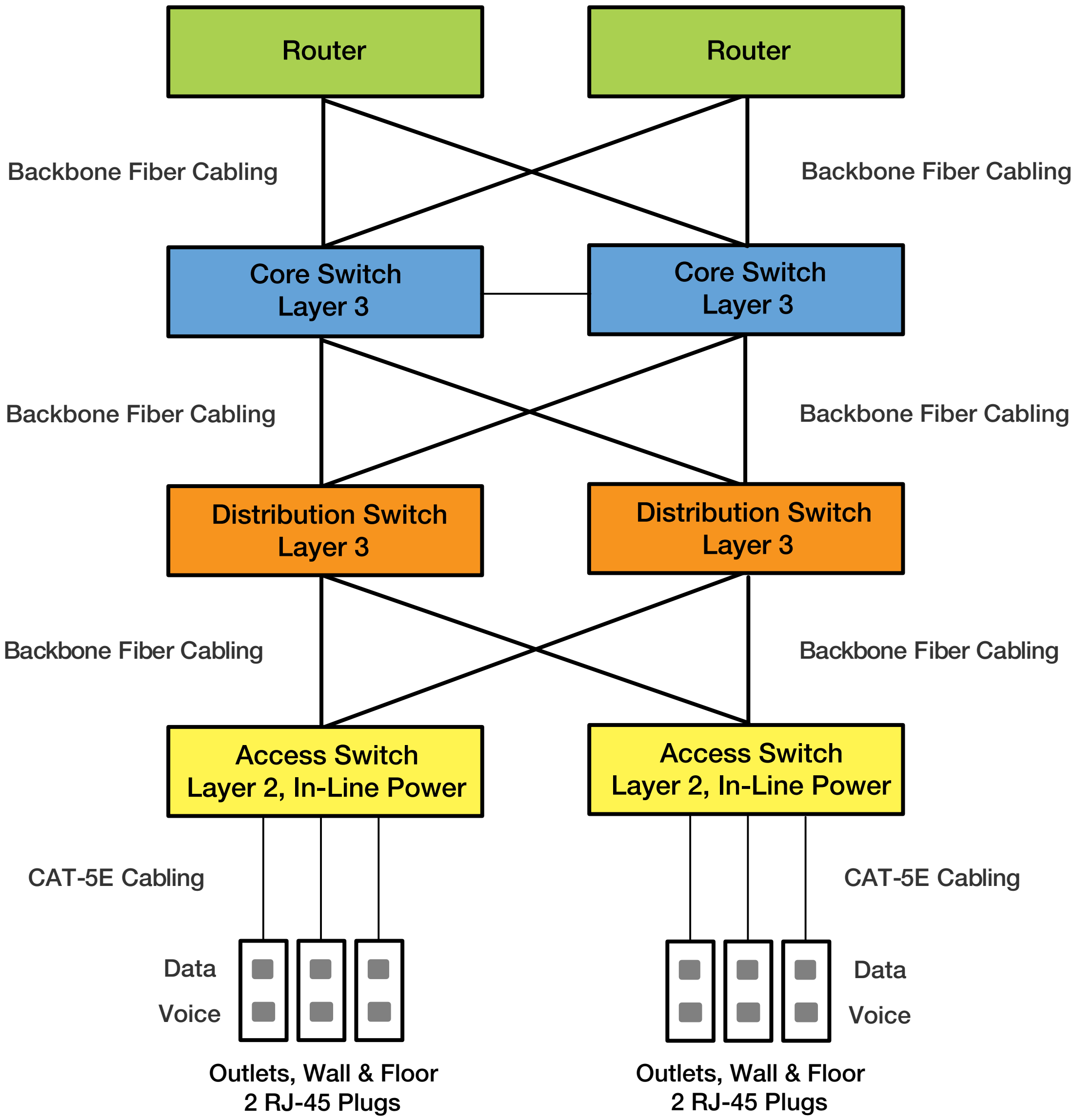
Source: Star Systems, LLC—A subsidiary of Five Star Airport Alliance

Figure VI-66. Inbound oversized baggage slide claim unit in a single-level terminal.

VI.4.2.2 Information Technology System Performance

In addition to security, specifications for networked terminal facilities should address requirements for bandwidth (wired and wireless), availability, uninterruptible power supply (UPS), and emergency power backup.

Bandwidth is a particularly major issue if security surveillance video is to be carried over a shared IT network. Even with the best compression [which is currently represented by MPEG-4 AVC and is designated H.264 by the International Telecommunication Union (ITU)], video streams will still range from 1 to 5 megabytes per second (Mbps) or more depending on scene content, camera resolution, video frame rate, whether all video signals are to be transmitted or only selected



Source: TranSecure

Figure VI-67. Distributed network model.

event video frames, the application of video analytics, and other variable factors. Bandwidth requirements also depend on network architecture, e.g., performing compression and video analytics at the edge of the network will conserve network bandwidth but will affect network management and device maintenance.

Network availability is the airport's responsibility, but air carrier demands for availability (up time) may dictate how availability is achieved. In the case of common-use gate podiums, for example, service availability specifications may dictate that service be provisioned from separate telecommunication rooms in the terminal in order to minimize the possibility that all service will be lost if one segment fails.

Similarly, electrical power for the network is the airport's responsibility, but airport backup and cutover policies may not be acceptable to its tenants (and may conflict with the airport's own security needs). A general airport policy of 3-hour UPS backup, followed by the cutover to emergency engine-generators, may be an adequate safeguard for most network services, but not for mission-critical functions including security systems, which must, by definition, remain fully available when an incident occurs.

Space requirements for UPS are important design issues, but more critical are such details as the amount of power supplied (KVA ratings); whether the UPS should be included per rack or have a single, large UPS to power everything in a telecom room; disciplined periodic battery replacement in UPS units; cutover time for backup; and sufficient air conditioning if large UPS units are used.

VI.4.2.3 Information Technology System Security

Securing user services over a shared network requires attention to both physical access to facilities and logical access to various computer systems. Physical security, i.e., card and key access control to telecommunication and server rooms, is the responsibility of airport security (which is often a duty of the operations department), but logical access to network services will be determined by IT department equipment, policies, and procedures. Logical access, for example, might be controlled using virtual local area networks (VLANs) created on switches, but VLANs may not be acceptable to some users who may require LAN segments isolated by routers or may even require their own dedicated networks.

VI.4.2.4 Common-Use Facilities

Airport managers and airline tenants constantly search for ways to improve the efficiency of their operations and the services they deliver to customers. Airport operators focus on adding flights (and airlines) and maximizing the use of their facilities. For terminal facilities, the metrics are passengers per gate per day, i.e., utilization, and revenue per gate per day. The concept of the common-use facilities that has evolved to satisfy these metrics is described in detail in *ACRP Synthesis 8: Common Use Facilities and Equipment at Airports* (*39*).

Common-use terminal models can be set up for exclusive use, in which airline-specific spaces (e.g., ticket counters, ramps, gates, and holdrooms) are designated for exclusive use by an airline or for common use, in which case all terminal spaces are available to all airlines willing to pay the associated rates and charges for the period of use. An airport may employ software for modeling space usage to maximize its metrics, and additional programs to monitor actual usage and provide status reporting to check tenant usage reports.

Technology, especially information technology and systems, is essential for managing common-use facilities. The supporting technology often includes platforms and application programs such as the following:

- LAN and WAN, both wired and wireless
- Passenger paging systems, both audible and visual
- Telephone systems, not only for voice services including Internet Protocol (IP) voice, or VoIP, but also for short-haul modems that connect airline ticket counters and gate computers to airline reservation systems
- Multi-User Flight Information Display Systems (MUFIDS)
- Multi-User Baggage Information Display Systems (MUBIDS)
- Gate management systems, including CUTE
- Ticket counters, including CUSS kiosks
- Local departure control systems
- Air operations database systems
- Common-use baggage sorting systems
- Baggage reconciliation systems, including the use of RFID devices
- Wired and wireless Internet access
- Cable television delivery to holdrooms and other public areas

Although this list is not exhaustive, it does demonstrate the impact that technology has on implementing a wide range of functions, including airport common-use policies and programs, communications, administrative functions, security, and more. For additional information on common-use facilities, please refer to *ACRP Synthesis 8* (*39*).

The common-use platform of choice is the LAN. The LAN interconnects user computer terminals over a cable plant backbone, which may have both fiber and copper elements as well as wireless extensions, known collectively as the premises distribution system (PDS). The PDS is usually integral to the airport's LAN infrastructure and itself is an example of a common-use design. Elements of the airport LAN may be segmented physically using cabling dedicated to certain common-use nodes or logically using VLANs to safeguard against tenant transmissions being intercepted and/or routed to unauthorized parties.

Securing data transmitted over the LAN is a critical aspect of the design process and another is reliability. Tenant airlines will be unwilling to depend on the LAN for common-use services unless it is able to demonstrate availability comparable to the best telecommunication systems, e.g., 99.99% or better, over long periods of time. Reliability is equally critical for airport managers, because ticket counters and gates that are not operating are not producing revenue.

VI.4.2.5 Planning Considerations for Passenger Check-in Facilities

IATA and the airlines are pursuing several initiatives to improve passenger processing and to cut costs including the following:

- e-Ticketing
- CUSS
- Barcoded boarding pass
- RFID
- e-Freight

These initiatives depend on the availability of IT network resources, including the provisioning of connectivity to support changing requirements. This connectivity may be provisioned by means of wired or wireless technology, or a combination of the two in terminals and at remote sites:

- e-Ticketing can be done on or off premises.
- CUSS, which enables multiple airlines to provide a check-in application for use by passengers on a single device, can be done on or off premises.
- Barcode reading of boarding passes, a well-developed technology, can be done with wired or wireless devices.
- RFID, which can also include security functions such as tracking vehicles on airside, is by definition a wireless service.
- e-Freight can be done on or off premises where the TSA has pre-approved the shipper.

McCarran International Airport in Las Vegas (LAS) has been a leading user of network resources to improve check-in operations off site. LAS has installed CUSS kiosks in locations such as hotels, convention centers, and other destinations where travelers may be concentrated, effectively extending the stay of vacationing passengers by allowing them to perform most of their check-in processes (e.g., check bags and obtain boarding passes) before coming to the airport.

Wireless technology now enables most, if not all, check-in functions to be performed away from terminals. It could also reduce the size and cost of terminal lobby areas by reducing the volume of in-terminal check-in and by expediting passengers through checkpoints.

VI.4.2.6 Public Address Functions

Public areas of a terminal and passenger airside facilities, including airline holdrooms, should be provisioned with means for paging and mass notification. These systems need to be modular so they can be adapted to new or changing uses in different parts of the airport (passenger halls, retail areas, etc.) and controllable by zone according to the messaging function being performed.

Public address (PA) systems should provide a range of services including local and area-wide paging and public notification. Audio speakers should be placed and audio output should be dynamically adapted to ambient noise levels so that announcements can be clearly heard throughout the local areas even at peak traffic levels. Performance specifications should be based on acoustic testing or, where this is not possible, on acoustic modeling of the local environment. The PA system should enable individual zones to be paged by a PC-based administration interface that provides controls for audio inputs, outputs, and control signals.

Permanent program storage should be accomplished in non-volatile memory. If there is a power interruption, the software and system configuration should be retained and updated automatically on resumption of normal power. In case of power failure or data-link loss, there should be no loss of operating configuration information and operator intervention should not be required.

When used for emergency notification, PA systems should provide supplemental reach to overhead paging, parking, inter-building, and even individual area notification including compliance with *Federal Emergency Decision and Notification Protocol* and other inter-agency requirements.

VI.4.2.7 Flight Information Technology—Flight Information Display System/ Multi-User Flight Information Display System

A MUFIDS is an airport-provided application located in public areas and common-use areas of a terminal that provide passengers with essential flight information including code-shared flight designations, arrival and departure gates, arrival and departure times, baggage carousel designations, and emergency alert notifications. MUFIDS also enables the airport operator to effectively manage the assignment of gates and communicate essential airfield operational and passenger processing information to airlines and ground handlers.

MUFIDS hardware and software should be engineered around a core of industry-standard workstation, PC, and LAN hardware and software and should be capable of displaying flight information to groups of users with diverse requirements. The system should be scalable to accommodate future growth at the airport and to support data distribution throughout the airport.

A MUFIDS should allow individual displays and display banks to be configured to provide airline-specific information, location-specific information (e.g., flights associated with a given concourse), airport-wide information, or combinations thereof. The flight-related displays or display banks provided/supported should include the following:

- Departures banks
- Arrivals banks
- Gate podium displays
- Passenger loading bridge displays
- Baggage Information Display Systems (BIDS) including at entrances to baggage claim areas and above baggage carousels

MUFIDS displays will run as a service on the airport's IT network backbone, often as VLANs to be able to isolate the flight information from other services and to enable its quality of service to be set for the required bandwidth during information updating. The airport, through its IT department, will normally provide these services in accordance with requirements developed in coordination with the airlines during the terminal design process.

Airlines will typically provide automated interfaces to support the downloading of schedules, schedule changes, and near real-time updates of estimated arrival/departure information. Many of these interfaces will use short-haul modems connected over telephone lines to airline host reservation servers. It should be possible for airlines to automate downloads/updates of flight data without affecting master schedules; to distribute and process data to designated displays; to record and store logs of system activities including audit trails; and to access MUFIDS data across the airport IT network, including access from remote sites over the Internet via the airport's website.

MUFIDS installation should include means for the airport's maintenance organization to locally monitor the status and performance of application programs residing on the primary MUFIDS servers. Database applications should be monitored for errors and application alerts that affect the ability to drive the MUFIDS displays, or that could lead to a system failure. Ideally, maintenance technicians should be able to diagnose problems as they are discovered by attaching a laptop computer, a tablet, or a PDA, equipped with suitable diagnostic software, to a nearby MUFIDS network element.

VI.4.2.8 Community Antenna Television

CATV (originally "community antenna television," now often "community access television") is more commonly known as "cable TV." For terminals, CATV is often a means of generating revenue for the airport by displaying advertiser-sponsored programming integrated with broadcast programming.

The requirements of the commercial sponsor include display location, size, channels to be displayed, and other aspects of the system; they will need to be determined early in the terminal and network design process and coordinated with the airport engineering, IT, and maintenance departments.

VI.4.2.9 Information Technology Network Equipment

A well-designed network will offer predictably consistent performance, resilience, and scalability. Performance requirements are determined during system design and will require consistently high performance in application response time, variations in system response time, and other performance parameters.

For the network to provide a resilient platform for the applications it supports, an airport IT network should be specified as available at least 99.99% of the time, allowing for scheduled maintenance, and structured so that a failure of a single device or network connection does not cause failure elsewhere on the system. The system should allow "hot" replacement of faulty parts without shutting down the affected network components or interrupting user services.

To be scalable, the network should support growth to a projected set of functions and/or capacity over a stipulated time period as determined during terminal design, without having to be radically redesigned and with minimum obsolescence of core equipment. The network should be able to handle both the addition of users, network nodes or sites, as well as the addition of new applications with increased bandwidth needs. Certain operational upgrades, such as increased memory and processing power on the network routers and switches, may also be required during the network lifetime, but none of this should require a radical overhaul of the network infrastructure to support projected growth during the network's lifetime.

These design objectives should be defined at the outset of the terminal design process by identifying performance parameters and setting target values, which will ultimately be dictated by the application requirements. Values should be set for network availability or downtime, including how such targets are to be validated and tested. In a shared IT environment, where security is one of several applications on the network, IT policies for availability and downtime should be reviewed against security requirements, including zero downtime for critical functions.

The following steps provide guidelines for approaching the fundamental tasks of the design process:

- Specify performance parameters so that user applications can normally be accessed fully and quickly, without data loss or slow response times. Determine the performance parameters that best specify each of the design goals, for example, application response time, percentage of data that is lost in transmission (packet loss), delays in transmission that arise from passing through multiple switches or other devices (latency), and user access to operating services and programs (application availability).
- Identify the scope of design constraints such as budget, implementation timescale, support of legacy equipment, incorporation of specialized departments that require unique network specification, and policies resulting from a shared IT environment.
- Set target values for the relevant network performance parameters in the context of the identified design constraints.
- Start with high-level design to resolve major issues such as the selection of wireless LAN technology, equipment, and user permissions; the IP addressing plan; the degree to which routing is used instead of switching; backup and recovery provisions and procedures; etc.
- Formulate a network architecture with distributed components whose main functionalities remain at the outer edge of the systems and whose functions would require high bandwidth if they were to continually transmit data to the central processing unit (CPU). At the edge, they can perform more effectively and reduce traffic over the network because only the results of the operation have to be transmitted, not the complete data input stream, as would be the case with centralized systems where most of the data processing occurs primarily at the main CPU for later redistribution. Edge devices are especially useful for high-bandwidth functions such as video surveillance, because they enable signal compression and encryption to be done before the signals are transmitted over the network fabric.
- Formulate a specific network design plan that addresses the operational and technical details and design alternatives. The network may be a new installation, but more likely it will build on an existing communications infrastructure of cabling, network topology and equipment, and software and operating policies. The service needs of all stakeholders should be identified, described, and quantified, with particular attention to the need for securing voice, video, and data streams and storing video archives.

VI.4.2.10 Information Technology Cable Plant

A terminal cable plant can include some or all of the following elements:

- Network copper cables such as CAT-5 or CAT-6
- Metallic hardwire and cables that are suitable for transmitting analog and digital signals, including voice, data, and video such as RS-485 cabling
- Fiber optic cables, particularly for the IT backbone, but also including point-to-point cabling for video cameras and other high-bandwidth devices
- Analog or digital data circuits directly owned or leased from commercial carriers
- Wireless communication media, including radio frequencies, microwave frequencies, cellular frequencies, and infrared frequencies, equipped with encryption or other means of securing the signals appropriate to their application.

For terminal LANs, a cable plant will comprise fiber optic backbone cabling, copper premises cabling, the associated cable pathways, user outlets, and telecommunication rooms with their associated termination equipment, enclosures, backup power equipment, and cable plant management software. Together, these elements enable voice, data, and video communication transmission for airport-owned and tenant services in the terminal to other facilities on the airport and to facilities external to the airport.

The design of the terminal cable plant and its cable pathways will be dictated by the LAN topology, by current and future service requirements, and by local site conditions including physical access and cable pathways routings. Cable spaces and pathways should comply with the latest edition of the American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Energy Information Administration (EIA) standard EIA-569-B, *Commercial Building Standard for Telecommunications Pathways and Spaces.* Candidate pathway types include the following:

- Ceiling—Open environment above accessible ceiling tiles and framework
- Access floor—raised modular floor tile supported by pedestals, with or without lateral bracing or stringers
- Tray & runway—prefabricated rigid structures for pulling or placing cable
- Conduit—metallic and non-metallic tubing of rigid or flexible construction permitted by applicable electrical code
- Vertical pathways—sleeve or conduit and slot penetrations for access to other floors
- Partition cabling—where demountable partitions are used to conceal cables

Cable sizes and quantities will determine the conduit and space needed in raceways. Maximum capacity of conduit and raceways (cable trays) should not exceed a calculated fill ratio of 50% to a maximum of 150 millimeters (6 inches) inside depth. To allow room for future expansion, and to facilitate additions and the removal of cables, a lesser fill ratio should be considered.

Innerduct should be used to protect fiber backbone cable that runs in shared pathways. Conduit should be used for all wall penetrations to maintain the overall fire rating of the walls.

Cable pathways, which carry signals for security equipment, should be routed in secured areas of the terminal. Where these cables are routing in public areas, they should be enclosed in metal conduit or electro-mechanical tubing. This guidance should also be applied to LAN cabling because the LAN is critical to terminal operations and, with the advent of IP cameras and IP-based access control systems, will be carrying critical security information.

When using physical communications media, the terminal design should ensure that the cables selected are in compliance with established EIA/TIA and IEEE industry standards and that replacement materials are commercially available for the predicted lifetime of the system.

VI.4.2.11 Telecommunications Rooms

Due to the distance limitations of copper Ethernet cabling, telecommunications rooms should be distributed throughout the terminal to provide adequate capacity coverage and reach for both planned and future applications. Working space around equipment racks for maintenance personnel should be provided, and there should be enough room to accommodate reasonably foreseeable future expansion requirements. Telecommunications room design should address panel space for cable terminations, switches and relays, remote field panels, remote diagnostic and management computer stations, and power service with redundancy and/or emergency backup capability, as appropriate. Special consideration should be given to providing adequate physical clearance to access the equipment including HVAC service based on thermal analyses of installed equipment and local UPS to power equipment in the event of a power failure.

Telecommunications rooms should have controlled physical access, preferably using the most secure means provided by the airport's security access control system.

It may be appropriate to consider HVAC system backup. Most terminals are fed from a central electrical plant, either remotely or on site. Although electrical HVAC equipment may be powered by an emergency generator, the chilled water system may not, which negates the effectiveness of the electrical components in the cooling system. Sensitive electronic equipment in a non-air-conditioned room may become damaged or will shutdown in a short time due to overheating.

If telecommunications rooms require tenant access, they should have a clearly defined tenant area, physically separated from the airport facilities, such as by chain link fencing, or appropriate separate rack arrangement.

Raised floors for either intermediate distribution frame or main distribution frame locations allow for below-floor cable management systems and under-floor air distribution to maximize cooling of the rack-mounted equipment. A carefully designed and electrically grounded system is critically important to successful operation of digital data equipment because poor grounding is one of the most common sources of electrical signal interference, especially in older systems.

VI.4.2.12 Network Management

Network management is the airport's responsibility. Service level agreements should be established for tenant services, and actual performance should be continuously monitored, with the results documented and available to affected parties.

Bandwidth utilization and quality of service should receive special attention because of their impact on the performance of critical functions. Bandwidth utilization and quality of service will be especially critical for video and voice transmissions, which can tolerate only minimal network transmission delays (latency) and dropped elements (packets), and for the co-existence of video transmissions sharing bandwidth with other applications on the LAN.

VI.5 Additional Considerations

VI.5.1 Building Systems

Building systems, although often overlooked during the planning phase, are some of the most expensive components of a terminal complex. The number and complexity of systems poses a spatial challenge for the terminal designer and a scheduling challenge for the program manager. Potential connection back to existing systems at the airport without interruption to service should be planned for accordingly as well as evaluation of potential space constraints and aesthetic details.

VI.5.1.1 Structural

Efforts should be taken to allow for future expansion of the terminal and concourse facilities by designing the structural support systems to handle potential additional loads and incremental curtain wall or structural wall expansions. Depending on the design intent of the architect, structural components can be left exposed as part of the aesthetic quality of the architecture. Additional efforts should also be made to allow for maximum internal flexibility of the plan and ease of passenger movement throughout the facility.

VI.5.1.2 Mechanical/Electrical/Plumbing

This area of the plan includes all the utility support areas for the terminal and concourses. Recent trends in computer systems, telecommunications, and other building-related systems have increased the demand for these areas within the terminal building. Some of these areas can be accommodated in the airline operations area whereas common-use systems need to be located in the airport-controlled areas. Plumbing is also a difficult system to remove and or relocate within a terminal facility. Thus, areas such as restrooms should be located in areas that are less likely to require future relocation if possible.

VI.5.1.3 Electrical Power

The terminal design process should address the potential impact of electrical power outages on the availability and integrity of security, communications, operations, and emergency egress systems.

In addition to maintaining operational stability, the goal of power system design is to assure protection of critical terminal systems and the IT network from damage resulting from loss of power or power-on spikes. Electrical system architecture should be designed to provide the greatest uptime and availability through the use of main-tie-main breaker arrangements, UPS, and battery backup systems.

Assessment should consider the need for low-voltage devices and control systems, battery-driven remote and stand-alone devices, standard 110/220 voltage for operating equipment such as lighting and CCTV monitors, and high-amperage/high-voltage systems for such things as EDSs and other screening and security equipment.

If possible, power feeds for the terminal should be arranged from two separate sources, such as an emergency diesel generator system connected to the emergency (buss) distribution system. Use of automatic transfer switches should be provided to achieve automatic shift to the emergency power source.

Redundant or backup system issues include the location and capacity of stand-by generators; the installation of redundant power lines to existing locations as well as to alternative locations where emergency conditions might cause shifts in operational sites; the installation of power lines, or at least sufficient additional conduit capacity and pre-installed pull-strings, for later installation of additional cables without re-trenching; installation of conduit to known future construction locations such as expanded terminal concourses; and the use of multiple feeds (from separate circuits and separate substations when possible) and geographical separation where multiple feeds exist. A minimum of two power distributions (busses) should be provisioned for terminal facilities, one for mission-critical systems and one for non-critical usage.

VI.5.1.4 Security Lighting

Security lighting design should address both interior and exterior visibility, including visibility around terminal perimeters and roadways. Lighting specifications should assure sufficient illumination to minimize undesirable shadowing as well as the potential of blinding surveillance cameras. Illuminated levels should conform to federal and industry standards, such as the Illuminating Engineering Society of North America (IESNA) or other recognized industry bodies.

In general, these terminal lighting guidelines should be followed:

- Comply with FAA requirements for exterior lighting, including FAA restrictions on the placement, height, and intensity of lighting that may impact aircraft operations.
- Locate perimeter lighting a sufficient distance within the protected area and above the fence so that the light pattern on the ground will include an area both inside and outside the fence.
- Locate perimeter lighting continuously and on both sides of the perimeter fence and sufficient to support CCTV and other surveillance equipment. The lighting should be arranged so as to create minimal shadows and minimal glare in the eyes of security guards and camera lenses.
- Illuminate all vehicle and pedestrian entrances to the facility; this should not cause blinding of the drivers or cameras.
- Illuminate manned entrances at a level sufficient to identify persons, examine credentials, inspect vehicles entering or departing the facility premises through designated control points (so that vehicle interiors can be clearly lighted), and observe persons slipping into or out of the premises.
- Illuminate gate houses at entrance points at a reduced level of interior illumination to enable security guards to increase their night vision adaptability, and avoid illuminating them as targets.
- Provide portable floodlights to supplement the primary system, especially during security incidents and emergencies.
- Secure wiring for security lighting against tampering.

VI.5.1.5 Public Telephone and Internet Access

Demand for large banks of public telephones has lessened considerably due to the rapid expansion of cell phone networks and near-universal availability, but public communications must nonetheless be accommodated, particularly telecommunications devices for the deaf per ADA requirements in the United States and full services at airports where foreign travelers' devices may not have internationally compatible access. Further, both wired kiosks and wireless Internet capability are now considered to be a minimum service standard.

VI.5.2 Airport Terminals and the Arts

The successful integration of art and architecture, during an airport terminal design project, plays an important role in the public's perception of the facility. Just over half of the states in the United States have legislated art ordinances that encumber a percentage of the Capital Improvement Program (CIP) for art in, on, or adjacent to any publically funded project, including airport terminals. Typically, the funds set aside for the commissioning, purchase, and installation of public art ranges from approximately half of 1% to as high as 2% of the CIP budget. Often the art project for an airport terminal focuses on establishing a "sense of place" reflective of the local and regional community the airport serves. Most airports serve as a front door to passengers arriving into the city, thereby often serving as the first and last impression of the city for the traveling public. The integration of art and architecture, often one of the goals of the public arts programs, is an important element in successfully planning and designing an airport terminal.

CHAPTER VII

Terminal Landside Facilities

Activity on the terminal landside is driven primarily by the operations of the passenger terminal and secondarily by cargo activity, if present at the airport. The flow of vehicles on the landside is directly related to the number of passenger arrivals and departures at aircraft gates and to the trucking of freight to and from cargo handling and freight forwarding facilities. Other factors that influence the volume of landside movements include trips to and from the airport by employees, meeters/greeters, and other visitors to the airport terminal, as well as traffic that travels through, but is not destined for the airport (cut through).

Traffic on the airport landside is subject to very high peaking characteristics, often with multiple peaks throughout the day. This peaking is tied to the terminal activity and is often offset from the peaking occurring in the surrounding roadway and highway system. In addition to these peaking characteristics, many other characteristics define airport landside traffic activity:

- **Slow speeds:** Vehicular speeds on airport roadways tend to be much slower than surrounding roadways. This slower speed is caused by the complex roadway layouts, multiple decision points, and the constant stopping and starting of vehicles. Because of the slow speeds, many of the standard roadway analysis techniques are often not effective in landside planning. These analyses need to be adapted for the airport environment.
- **Many different types of vehicles:** Different types of vehicles traverse roadways on the airport. Private automobiles often make up the largest share, but there are many buses, taxis, limousines, service vehicles, and trucks on the roadways. Each of these vehicle types has different operating characteristics. This situation calls for analysis techniques that can address these differences.
- **Complex routing:** There is a need at most airports for vehicles to have multiple ways of navigating the roadway system. Even though most vehicles operate in a closed system, there are typically many potential routes. For instance, a private automobile may enter the airport, go to the departures curbside to drop off passengers, and then proceed to short- or long-term parking (on or off airport). Other automobiles may go directly to parking or may recirculate. Shuttle buses and commercial vehicles often have complex routes, stopping at many points in the airport.
- **Variability of access system layout:** There are many variations in airport roadway layout, even among airports of the same size and function. Roadway layout is driven by the regional access system and the placement of the terminals and parking.
- **Complex decision making:** The combination of multiple routes with variability of system layouts in a limited area of land often results in complex decision making by those using the airport roadway system. There are usually a large number of merge/diverge points with drivers often having to make decisions in very short distances.
- **Infrequent users:** Many of the drivers on the airport make only occasional visits to the facility, perhaps only once or a few times per year. This lack of constant use often contributes to the lower speeds and slower reaction times for decision making.

All of these factors make for an interesting and challenging planning process on the landside. This complexity calls for the use of a lot of creativity in adapting traditional transportation planning techniques and the adoption of specialized techniques to be used at airports. With this complexity it is also important to consider wayfinding and signage early in the planning process of new or reconfigured airport terminal ground access systems.

For additional information, consult *ACRP Report 10* (*34*), which aims to develop new concepts that will stimulate design innovation for terminal landside facilities.

VII.1 Transportation/Traffic Planning

Airport ground access networks are complex systems of interrelated facilities serving a variety of users. Therefore, planning for these systems requires a large and complex set of data, covering all of the components of the ground access system. This section presents the outline for data collection, the analysis and evaluation of the existing facilities, and the planning for new or upgraded facilities.

VII.1.1 Data Collection

The objective of a data collection program for ground access facilities is to gather the information necessary to determine existing and future adequacy of the ground transportation systems. Data that may be needed for this analysis and evaluation process includes the following:

- Inventory of physical characteristics—roads, parking, curbfronts, transit, and so forth.
- Existing O&D airport passenger activity
- Employee shift data
- Mode split data (private automobile, bus, train, taxi, etc.)
- Vehicular traffic counts
- Curbfront data—vehicle dwell times, occupancy, vehicle classification
- Parking information—passenger parking, employee lots, rental car, and so forth
- Commercial vehicle activity—taxis, limousines, courtesy vehicles, and so forth
- Rental car activity
- Public transportation information—buses, trains

A data collection program may include all of the data listed above or a subset of these, depending on the planning needs and what information is already available. As much as possible, all data, particularly count data, should be collected on the same day(s) and at the same time(s), so that it is as consistent as possible. Ideally, data should be collected during an average day in the peak month (PMAD).

If it is not possible to collect data during the peak month, it should be collected for an average day during another month, avoiding holidays, peak travel times (like Spring Break), and special events. Data can then be adjusted to reflect the PMAD, according to the airport's flight schedules and passenger activity. Some information, such as parking activity and rental car activity, may be available from the operators of these facilities. Modern parking revenue control systems can provide a lot of data by hour on movements in and out of the passenger parking lots. Other data can be collected through interviews and observations, as described below.

VII.1.1.1 Passenger Survey

Airport passenger surveys are typically conducted at the beginning of an Airport Master Plan or at the beginning of a major airport development program. These surveys, which are described in Section IV.2.5, cover all aspects of air passengers' trips. Included in this survey are a set of questions oriented toward the landside portion of the O&D passenger's trip. However, this data may not be available or may be out of date when a ground access study is being conducted. A survey of O&D passengers can be done to gather the few key items needed for the study. This type of survey can be conducted by interviews with departing passengers who are waiting at the gates. The information that needs to be gathered for ground access generally includes data about access modes and routes to the airport, such as the following:

- Mode of arrival at the airport (automobile, taxi, bus, etc.)
- Parking location (short term, long term, off airport, etc.)
- If automobile, number of people in vehicle
- Route used to access airport
- If automobile, route taken within the airport (to parking first, to terminal then to parking, etc.)
- Time of arrival before flight time

For additional information, consult *ACRP Synthesis 5* (*46*), which addresses ground access mode choice models and their role in airport planning and management.

VII.1.1.2 Traffic Counts

There are two primary types of traffic counts: automatic traffic counts and intersection turning-movement counts. Automatic traffic counts are typically conducted by a machine over a period of 24 hours or more and provide a count of total traffic passing through the count station in 15-minute increments. They are useful for determining total traffic throughout the day, as well as determining peaking characteristics for roadways. Ideally, for a comprehensive data collection program, counts would be conducted for all entrance/exit roadways and ramps, terminal approach roads, terminal curbfront roads, recirculation roads, parking lot and rental car area entrances/exits, and service roads on the airport property, as well as off-airport facilities providing airport access. Manual traffic counts may also be needed for areas that cannot be captured by automatic counters. These areas may include weaving and merging maneuvers.

Intersection turning-movement counts are conducted manually, typically for a 2- to 4-hour period covering the peak hour of airport and/or off-airport traffic (or for multiple peak periods, if more than one peak needs to be analyzed). Turning-movement counts should be conducted for on-airport signalized and major unsignalized intersections, and off-airport intersections that provide airport access.

VII.1.1.3 Parking Lots

For public parking lots, it is important to examine the number of spaces available in different parking lots (i.e., short term, long term, economy, valet) at different times of day. Typically, the capacity (total number of parking spaces) of the lot will be determined through a physical count, as-built construction drawings, or possibly through examination of aerial photography for surface lots. Then, the number of occupied spaces will be counted, preferably at several times of day (i.e., morning, mid-day, afternoon). It may also be useful to gather information such as the average parking stay for various lots, if such data is available from the parking operator.

Similar counts can be conducted for off-airport parking lots and employee parking lots. For employee lots, the counts are ideally conducted near a shift change time, when the number of vehicles in the lot is likely to be at a maximum.

VII.1.1.4 Curbfronts

Data collected for curbfronts typically includes vehicle volumes, vehicle classification, and dwell times. Curbfront observations should be conducted during peak times. Separate observations should be made for arrival and departure curbfronts, because the characteristics of the vehicles will differ. Total vehicle volumes can be determined through automatic traffic counts as described previously. However, depending on the curbfront configuration, not all vehicles passing by the curbfront will necessarily stop. Vehicle classifications at curbfronts will include automobile, taxi, limousine, bus, hotel/motel shuttle, rental car shuttle, off-airport parking shuttle, and any other vehicle types that stop at the curbfront.

Dwell times are collected by surveyors with stopwatches, who measure the time from when the vehicle stops at the curb until the vehicle is ready to depart the curb. Dwell times are calculated separately for different vehicle classifications.

VII.1.2 Analysis and Evaluation

Analysis and evaluation of existing and future ground access conditions for airports require a variety of methodologies, each tailored to specific facilities.

Airports vary greatly in their size and layout, making it difficult to arrive at guidelines for the development of airport roadways. There are many standard traffic and roadway resources that can be used. The most widely used of these are the following:

- *Highway Capacity Manual 2000,* Transportation Research Board (TRB). This is the standard manual used by traffic engineers. It quantifies congestion and highway operations in such a way that rational solutions can be determined.
- *Manual on Uniform Traffic Control Devices* (MUTCD), 2003 Edition; United States Department of Transportation, Federal Highway Administration. The MUTCD defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets and highways.
- *A Policy on Geometric Design of Highways and Streets,* 5th Edition; American Association of State and Highway Transportation Officials. This fifth edition of AASHTO's "Green Book" contains the latest design practices in universal use as the standard for highway geometric design.

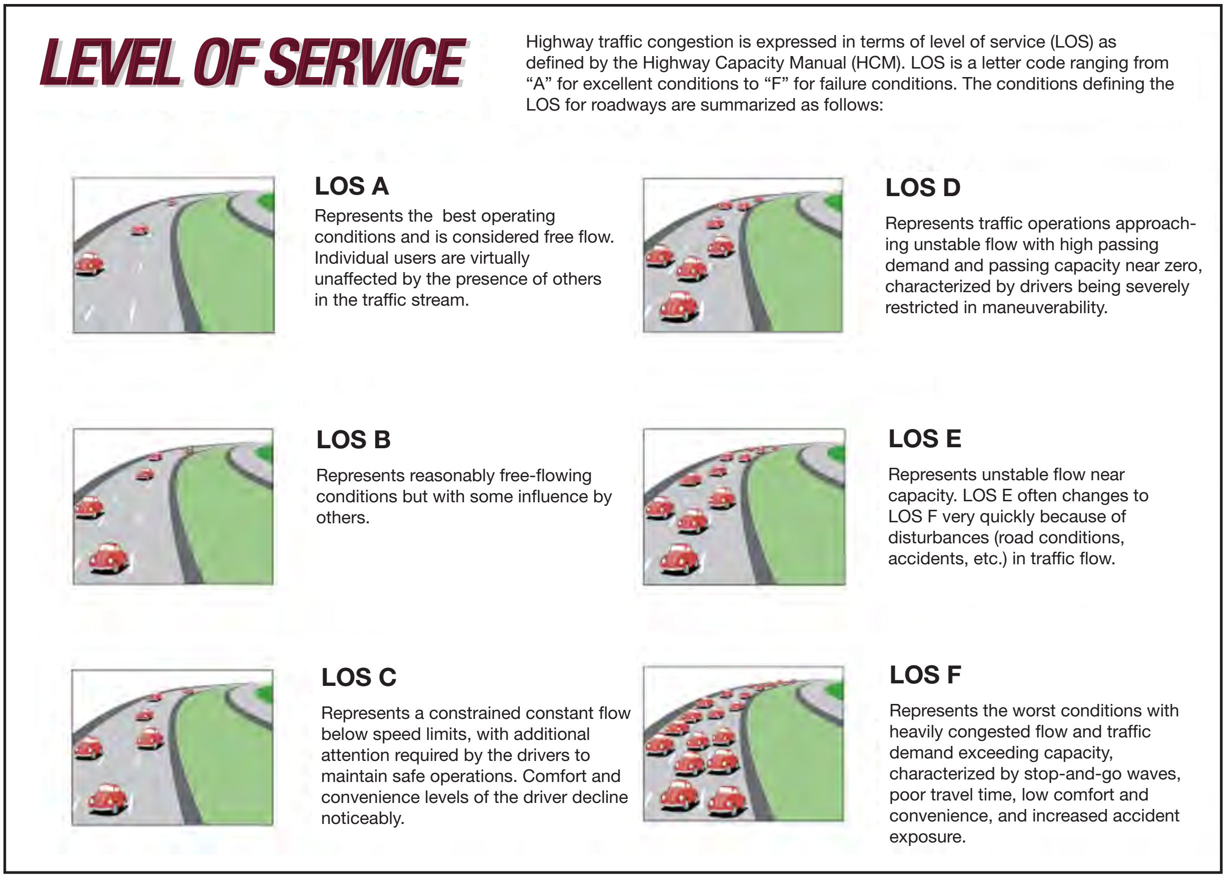
The quality of a driver's experience when traveling on a roadway facility is often described using LOS, expressed as a letter between A (best) and F (worst). According to the *Highway Capacity Manual* (HCM), LOS "is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience" (*47*). Figure VII-1 shows LOS for roadways in graphical form, with descriptions of each level.

VII.1.2.1 Intersections

On-airport intersections are usually similar in geometry and operating characteristics to off-airport intersections and can typically be evaluated using the same techniques. The HCM is a manual produced by TRB that details methodologies for analyzing roadways and intersections and is the standard for roadway analysis, both in the United States and in many other nations. Analysis according to HCM procedures can be completed by hand but is more typically done using a commercially available software program such as Highway Capacity Software or Synchro. HCM methodologies use information including traffic volumes and roadway characteristics to rate the LOS of the intersection.

VII.1.2.2 Roadways

On-airport roadways typically differ in geometry and operating characteristics from off-airport roadways. On-airport roadways typically have slower operating speeds, more frequent signage and decision points, and a different vehicle mix from off-airport roadways. These characteristics mean that standard HCM techniques may not be sufficient for evaluating on-airport roadways, although it may be possible for HCM methodologies to be used for some situations at the discretion of the planner. Simulation programs are often generally a better choice to model the intricacies of airport roadway systems.



Courtesy of: McCormick Taylor

Figure VII-1. LOS for roadways.

VII.1.2.3 Curbfronts

Curbfronts are generally evaluated using a curbfront demand model, which uses vehicle length, curbfront dwell times, and the volume of vehicles to determine the approximate length of curbfront needed to serve the vehicular demand.

VII.1.3 Ground Access Plan Development

The data collection and evaluation phases lead into the development of a ground access plan. The flowchart in Figure VII-2 depicts the process of developing a ground access plan. The existing ground access conditions, together with the Airport Master Plan, form the basis for developing a ground access plan. As described previously, the data collected on ground access facilities can be analyzed to determine existing deficiencies in the ground access system. Based on the Airport Master Plan, alternatives for improvements to the ground access system can be developed.

Future air passenger demand for the target analysis year can be used to "grow" existing traffic volumes to future levels. Based on the future traffic volumes, the alternatives that have been developed can be evaluated to determine if they will meet the needs of airport users or if additional deficiencies exist. The alternatives can then be refined, and a preferred alternative selected that will have the capacity to handle expected future traffic volumes, while fitting in with the future plans for the airport.

For additional information, consult *ACRP Report 4* (*48*), which documents recent trends in airport ground access.

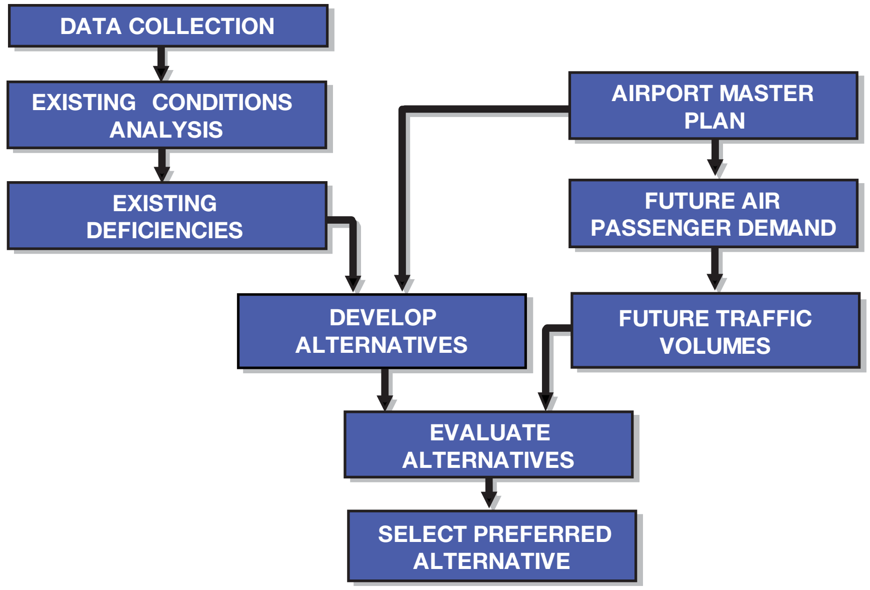


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Figure VII-2. Flowchart to develop ground access plan.

VII.2 Intermodal Connections

There are two types of intermodal connections to be considered in planning for an airport terminal. The first type is a connection with a regional rail or bus system on or near the airport. A rail or bus system connection can be a very important enhancement to the airport's ground access system. Connection to a regional system provides more flexibility for air travelers. It also provides an alternative means of access for airport, airline, and concession employees.

The second type of connection is for on-airport rail and bus transit systems. Transit stations and staging areas for these can be free standing, such as a ground transportation center (GTC), or consist of a series of stations at terminals and other facilities, such as on a people mover system.

VII.2.1 Rail/Transit

The connection of the airport to a regional rail system can provide many benefits for the airport. Stations on or very near to the airport can spread out the access demand, provide a low-cost method for travelers and employees to access the airport, reduce vehicular traffic on the airport, and reduce congestion at the terminals. Two important considerations in planning for an on-airport system are the station and track locations, and the station layout.

Typically only one station of the regional system is at the airport. Many airports have such a connection such as San Francisco, Hartsfield–Jackson Atlanta, Chicago O'Hare and Midway, Reagan Washington, and Minneapolis–St. Paul. Most of these systems are heavy-rail, subway-type systems. The connection in Minneapolis–St. Paul is a light rail system that operates on exclusive rights-of-way or in mixed street traffic. While these systems provide a great alternative to travelers, the most usage of the airport stations tends to be from those who work on the airport property.

Typically a regional system connects to only one station on the airport. This station should be located in the areas of highest passenger demand, such as a terminal. Given the space considerations, this might not be possible, so the regional station may need to be connected to a station away from the terminal, such as at a GTC. From here the passengers and employees can walk to the terminals or connect to an on-airport bus or rail system.

New station and track locations should be placed so as not to restrict future growth and flexibility of airport facilities. Station boarding platforms should be wide enough to handle peak period loads. Considerations regarding the location of the station should include the average and maximum walking distance of a user to reach the terminal, ease of access to/from the terminal building, and whether changes in the demand level for the facility varies greatly by time of day.

Station platform configurations can be either center-island or side platforms. Center-island platforms place the passenger boarding/waiting areas between the track alignments, resulting in passengers traveling in each direction on the same platform. Side platforms place the passenger boarding/waiting areas on opposite sides of the track, resulting in passengers traveling in each direction on separate platforms. Side platforms can provide direct access to adjoining areas without level changes while center-island platforms require passengers to make a level change to leave the track area.

VII.2.2 Commercial Vehicles/Transit Staging Areas

There are two main types of on-airport intermodal facilities that have special characteristics. One is for commercial vehicle staging areas for vehicles before being dispatched to the terminal curbfronts. The second type of facility is a GTC, which provides a centralized area for all types of commercial vehicles to pick up and drop off passengers.

VII.2.2.1 Commercial Vehicle Staging Facilities

Vehicle staging facilities are typically used for taxis and limousines that are picking up passengers at the airport. These vehicles proceed to the staging facility to be dispatched to the terminal curbfronts instead of going directly to the terminal. The amount of curbfront utilized by the commercial vehicles can be minimized by regulating the number of commercial vehicles on the terminal curbfront at any given time through centralized dispatching at the staging facility. The extra space gained at the terminal curbfront can be reallocated for other uses. In addition, the amount of commercial vehicle recirculation around the terminal curbfronts while waiting for passengers can be reduced to negligible levels.

Access to a staging facility should be kept to a minimum (one or two access points of off-airport roadways) and can be gated to restrict access to only the commercial vehicles authorized to operate on the airport. Similarly, exits from the staging area should also be minimized. Exit points from the staging area are also typically gated.

Internal layouts to the staging facility vary by the types of vehicles utilizing the lot. Lots can be arranged similar to standard parking lots with individual spaces (either at 90 degrees or angled). Another option, such as the commercial vehicle hold area at Chicago O'Hare, is to have vehicles queue one behind another forming a dispatch line of vehicles. In this configuration, an additional planning consideration would include adding an empty row for bypass and emergency purposes every five to six lanes. Taxi and limousine staging areas are typically separated for operational purposes. Amenities for waiting commercial vehicle operators should also be considered within the facility area. Typical amenities can include restrooms, vending areas, and sitting areas.

Installation of automatic vehicle identification systems also helps manage the commercial vehicle areas using microwave technology and car identification tags. These systems identify, monitor, and control the drivers in the holding area.

VII.2.2.2 Ground Transportation Centers

GTCs provide a centralized location for commercial vehicles to pick up and drop off passengers. A GTC can be located directly at the terminal building with operations separate from the private vehicle pick-up/drop-off locations, such as at Hartsfield–Jackson Atlanta, or at a separate location away from the terminal building. GTC operations separated from the terminal require the additional capability of transferring passengers to and from the terminal by on-airport transit, but can allow for greater flexibility for expansion of the GTC, if needed.

Access to and from a GTC would have similar requirements to a staging facility. The internal layout of vehicular operations at a GTC would mirror those of a typical curbfront with commercial vehicle operations.

VII.3 Airport Roadway Systems

The airport roadway system comprises a variety of roadways. The roadway system at larger airports can be especially complex. The major types of roadways on an airport are shown in the flowchart in Figure VII-3 and are described in the following subsections.

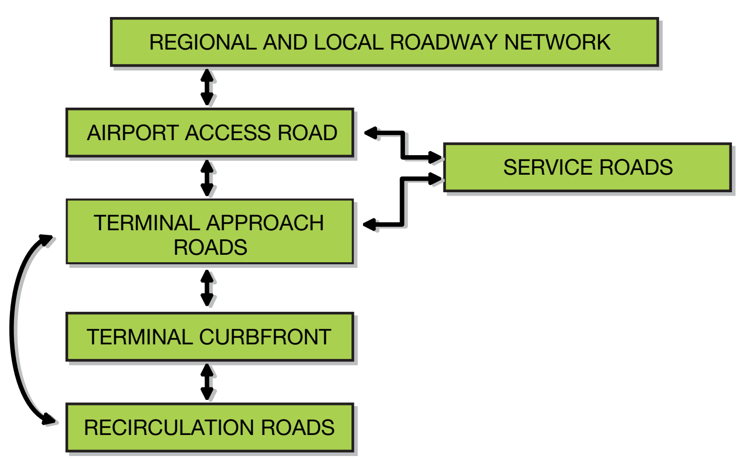
VII.3.1 Entrance/Exit Roadways (Airport Access Road)

The airport entrance/exit roadway, also known as the airport access road, connects the interior airport roads to the local and regional roadway system. These roadways will need to have the capacity to handle the volume of traffic for now and the future. These access roads can vary from arterial roadways with traffic signal control to limited access/freeway-type facilities at larger airports.

Many large airports have a closed loop access road system. These systems are typically free-flow facilities that provide access to and from the terminal. They have the advantage of providing a smooth transition from the regional/local roads to the terminals. These transition roads allow space to provide signage for terminals and other facilities, and the distance to allow drivers to make decisions. A key feature of closed loop systems is the distance away from the regional/local road connection to the airport. There needs to be adequate distance to provide this type of facility. The following airports have examples of these closed loop systems:

- O'Hare International Airport (Chicago)
- Minneapolis-St. Paul International Airport, Lindbergh Terminal
- Charlotte Douglas International Airport
- Cincinnati/Northern Kentucky International Airport

Some airports are located adjacent to the regional/local roadway system and have no room for a loop road. More airport signage needs to be provided on the regional/local roads. Often the



Source: Kimley-Horn and Associates, Inc., All rights reserved.

Figure VII-3. Components of the airport roadway system.

entrances to the airport are under traffic signal control. In this scheme there is also little likelihood of cut-through traffic. The following airports have examples of these systems:

- Midway International Airport (Chicago)
- John Wayne Airport (Orange County)

Some of the considerations in the design and function of the airport access road are the following:

- Provide a transition from regional/local roads
- Provide adequate area for signage—terminals, airlines, rental car parking
- Provide adequate area for decision making
- Efficiently distribute traffic to the facilities on the airport

The airport access road should be designed to function as the gateway for the airport. Its main purpose should be to serve airport traffic. The design should restrict the use of non-airport traffic as much as possible.

VII.3.2 Terminal Approach Roads

The terminal approach roadways are located between the entrance/exit roadways and the terminal curbfront roadways and are part of the airport circulation roadway system. These roads typically have lower operating speeds than the entrance/exit roadway, more ramps and intersections, and more decision points. These roadways distribute traffic not only to the terminals, but also to passenger parking and rental car parking areas as depicted in Figure VII-4.

Some of the operational and design considerations for these roadways are the following:

- Provide a transition to the terminal curbfront roadways
- Provide adequate distance for decision making
- Provide smooth channeling of traffic to the terminal curbfronts and parking
- Provide adequate separation of decision points

VII.3.3 Terminal Curbfront

The terminal curbfront roadways are located adjacent to the terminal curbfronts. These are typically one-way roadways, operating in a counter-clockwise direction. These roadways can have

Figure VII-4. Roadway system at Lindbergh Terminal of Minneapolis-St. Paul International Airport.

a wide variety of configurations, depending on the layout of the terminal. The major variations are based on the number of levels in the terminal. The most typical layouts are the single-level and two-level or double-level terminals. The single-level terminal can have arrivals and departures on one side or on both sides of the terminal. A double-level terminal typically has arrivals (baggage claim) on the lower level and departures (ticketing) on the upper level. Multiple-level terminal configurations also need to take adequate ventilation considerations into account for the lower level curbfront areas.

Terminal curbfronts at mid-sized and larger airports often have outside curb areas to provide more length of curb, especially for the arrivals level. Many airports—such as Denver, Phoenix, Chicago O'Hare, Atlanta, and Charlotte—use this model. One of the advantages of this system is that private and commercial vehicles can each be given their own curbfront.

Pedestrian crossings are an important component of terminal curbfront roadways. The emphasis on the design and operation of these facilities should be on safety. Optimally, vehicular traffic and pedestrian traffic should be physically separated. However, this separation is often difficult to provide with airport terminals. Most airports have at-grade pedestrian crossings on the curb.

Some of the key points to be considered on the design and operation of curbfronts are the following:

- Lighting
- Speed tables/humps at pedestrian crossings
- Crossing guards
- Adequate transition areas
- Sidewalk/curb width—at least 12 feet; 15 to 20 feet is desirable
- Signage—large type, lighted
- Pavement marking—reflective, raised (where possible), rumble strips
- Ventilation—on lower levels if applicable

VII.3.4 Recirculation Roads

Recirculation roads are typically located at the end of each terminal. They are characterized by tight turning radii and low vehicle speeds. They are typically one-lane roadways. Recirculation roadways are important for the smooth flow of traffic in the terminal area. They should be provided immediately after the terminal. For two-level terminals, recirculation should be provided from each level to each level, if possible. This can be done in a number of ways.

One of the key features of recirculation roadways should be to provide as much flexibility as possible. The following are many of the desirable movements to be provided by recirculation roads:

- Return to same terminal curb
- Go to same terminal, different level
- Go to parking
- Go to next terminal
- Go to previous terminal
- Go to the airport exit

Because many recirculation roads are only one lane, a shoulder should be provided to allow a stalled vehicle to be passed.

VII.3.5 Service Roads

Airport service roads provide access to those areas on the airport that are oriented toward non-passenger–related activities, such as freight loading/unloading areas, employee parking, links to airfield access, airport maintenance facilities, employee parking, hotels, post office, and general aviation facilities. These roads tend to have low traffic volume with low vehicle operating speeds. They often resemble local streets and typically are one or two lanes in each direction.

One objective in designing these types of facilities is to separate large truck traffic from the passenger-related traffic as much as possible.

VII.3.6 General Guidelines for Airport Roadways

As noted in Section VII.1.2, airports vary greatly in their size and layout, making it difficult to arrive at guidelines for the development of airport roadways.

In addition to the standard roadway and traffic references (HCM, AASHTO Green Book, MUTCD, etc.), some discussion in the airport research literature may prove helpful in planning for new terminals. One summary of guidelines for airport roadways is contained in an FAA White Paper entitled, *Terminal Groundside Access Systems* (*49*). Exhibit 7 of the White Paper gives road and parking performance standards, such as lane width guidelines, terminal curb length guidelines, number of lanes, and vehicles per hour on different roadway types.

A paper presented at a TRB conference, "Intermodal Ground Access to Airports: A Planning Guide—A Good Start" (*50*), contains a table giving typical operating characteristics of airport roadways.

In terms of planning, design, and operating strategies, the following are some general approaches for airport roadways:

- Planning and Design Alternatives
  - Widening—additional travel lanes, widen shoulders to bypass stalled vehicles
  - Median and median dividers
  - Grade separation
  - Dedicated roadways
  - Exclusive turn lanes
  - Lengthening of merge/diverge areas and weaving areas
  - Lengthening of distance between decision points
  - Signage (see Section VII.6)
  - Sight distance improvement
  - Acceleration and deceleration lanes
  - Driveway consolidation
  - Conflict removal
  - Guideline development for maximum grades
  - Grade-separated interchanges
- Traffic Operations Alternatives
  - Traffic signal timing
  - Traffic information signing
  - Traffic surveillance systems
  - Highway advisory radio
  - Demand reduction
  - Alternative modes of transportation
  - Shared ride
  - Spread demand over a larger area (such as separate access points to major generators)

For additional information, consult the results of ACRP Project 07-02, "Airport Curbside and Terminal-Area Roadway Operations."

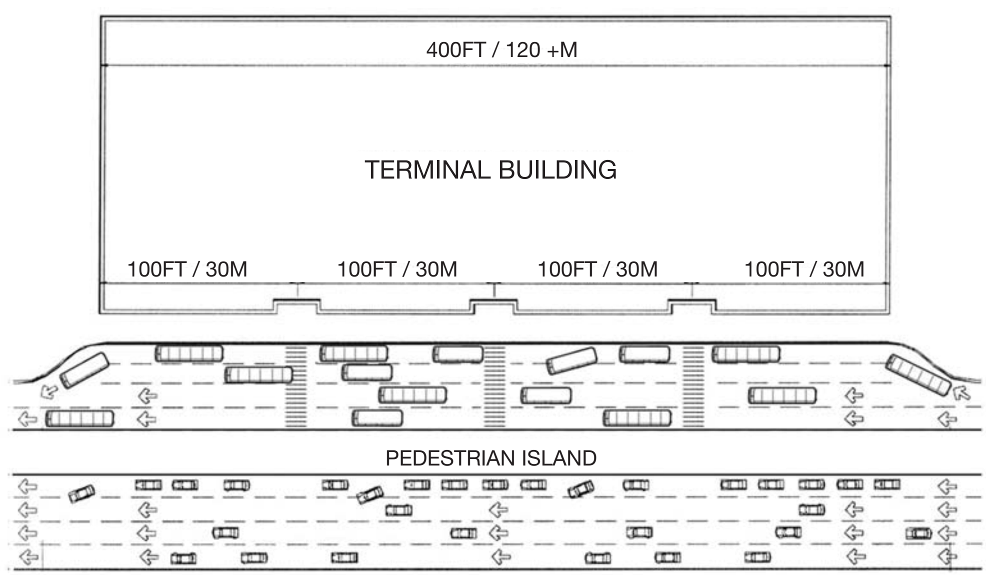
VII.4 Terminal Curb Requirements

The terminal curbfront on an airport is a complex operating environment. Many types of vehicles approach and stop at the curb, including private automobiles, taxis, limousines, parking lot buses, rental car buses, regional buses and shuttles, and shuttle buses for hotels and motels. Significant curbfront capacity is required to accommodate the maneuvering necessary for vehicles to pull to the curb, stop to load and unload passengers and luggage, and pull away from the curb to merge back into the traffic stream. The curbfront area can be divided into two sections: pedestrian facilities and vehicle facilities.

VII.4.1 Curb Pedestrian Facilities

One part of the curbfront is dedicated exclusively for pedestrians. This part of the environment is on the sidewalk in front of the terminal and on the raised curb islands between travel lanes that are present at many airports. At airports with two-level curbfronts, the upper level is typically used for departing passengers. The sidewalk here is for passenger drop-offs and for curbside check-in. The lower level curb is typically used for arriving passengers. At a minimum, the sidewalk should be wide enough to allow two pedestrians, with luggage, to pass each other comfortably, which is approximately 12 feet. If there are obstructions such as columns, signs, or benches that may impede pedestrian travel, these need to be taken into account when determining reasonable sidewalk width.

Many airports have a pedestrian island between vehicle travel lanes, particularly at the arrivals curbfront, but occasionally at the departures curbfront as well. This island separates the curb lanes into two traffic streams and enables the airport to provide two parallel curbfronts for pick-ups and/or drop-offs, in an equivalent length of terminal building. The curbfront traffic is separated into passenger cars and commercial vehicles (parking shuttles, rental car shuttles, hotel/motel shuttles, etc.) Figure VII-5 shows an example curbfront with a pedestrian island. In this example, the inner curbfront (closest to the terminal building) is designated for commercial vehicles, while the outer curbfront serves private vehicles. Crosswalks are provided between the terminal building and the pedestrian island.



Source: *Terminal Groundside Access Systems*, Fred Silverman, FAA White Paper

Figure VII-5. Curbfront with pedestrian island.

The location of terminal entrance/exit doors can have an effect on the utilization of the curb, as well as passenger LOS. Observations indicate that cars will tend to stop at the curb no more than three car lengths (50 to 60 feet) from an entrance or curbside check-in, even if this requires double parking. Thus, to make use of the full curb length, entrances should be a maximum of 100 to 120 feet apart as illustrated in Figure VII-5.

Airports vary in their treatment of pedestrian/vehicular crossings. At some airports, grade-separated crossings are provided to access parking garages/lots, rental car areas, and so forth. However, at many airports, pedestrians must cross the curbfront traffic lanes to reach the parking facilities. Well-marked crosswalks should be provided at frequent intervals, aligned with doors to the terminal buildings. Raised crosswalks, or speed tables, provide a level crossing for pedestrians, as well as making drivers physically aware of crosswalks and encouraging slow travel speeds. During peak arrival/departure times, it may be necessary to station police officers at the crosswalks to direct traffic and ensure that pedestrians have safe opportunities to cross the curbfront lanes.

VII.4.2 Curb Vehicle Facilities

The second component of the curbfront consists of the travel lanes dedicated to vehicles. These lanes serve two important purposes that are often in conflict with each other. The first purpose is to provide access to the terminal buildings for private vehicles as well as for commercial vehicles (shuttle buses, taxis, etc.). The second is to move vehicles past the curbfront to their intended destination. These two purposes cause a lot of friction in the traffic flow, resulting in low capacities for curbfront lanes.

The innermost lane (closest to the terminals) is essentially a short-term parking lane, dedicated to vehicles stopping to drop off/pick up passengers. Vehicles pull into an empty space at the curb, load/unload, and pull out. At all but the smallest, low-activity terminals, the second lane is used by both double-parked vehicles, as well as a transition lane, used by vehicles pulling in and out of the curbfront. The third lane is a transition/weaving lane. The fourth lane (and fifth, if one exists, usually at very large airports with multiple unit terminals) is used by vehicles driving past the curb. Therefore, at all but the smallest airports, the minimum number of curbfront lanes is recommended to be four, because it is expected that the second lane may be partially blocked during peak drop-off/pick-up times.

Because of the nature of curbfront facilities, throughput per lane is greatly reduced compared to typical roadway facilities with the same number of lanes. Therefore, there is a need to provide additional curbfront lanes to handle peak loads. Ideally, the roadway will provide enough capacity to accommodate expected traffic volumes even if a through lane is blocked due to maneuvering vehicles and double- or triple-parking.

Curbfront facilities work most efficiently if the curbfront is divided into sections to serve different vehicle types. This limits conflict between different types and sizes of vehicles, as well as spreading the vehicle load throughout the entire curbfront. The curbfront is typically allocated among private vehicles, buses/shuttles, and taxis/limousines. The bus/shuttle section of curbfront may be further allocated into separate areas for rental car shuttles, hotel/motel shuttles, parking shuttles, and so forth. This is particularly useful at the arrivals curbfront, so that patrons waiting for a particular shuttle know where to stand to wait for the shuttle's arrival.

The curb typically runs the length of the terminal building. Passengers tend not to use any curbfront area beyond the end doors of the building. However, some of the vehicle drop-offs (such as commercial vehicles) can be located beyond the end doors. For shorter terminals, pedestrian islands may be necessary to achieve the curbfront capacity needed.

Another important component of curbfront capacity comes in the form of dwell times. At the arrivals curbfront, vehicles will often stop to wait for arriving passengers if sufficient curbfront enforcement is not present. Most airports today enforce a policy of not allowing vehicles to stop at the curbfront unless the driver can see their arriving passenger waiting at the curb. Long dwell times are less of a problem at the departure curbfront, because most drivers drop off their passengers and depart immediately.

Analysis of curbfront facilities requires specialized techniques that take into account the particular variables that are unique to these facilities. Typical HCM techniques are not sufficient to capture the slow speeds, many decision points, dwelling, and frequent stopping/starting that happens at curbfronts. Curbfront analysis models (usually in spreadsheet format) are available that take into account traffic volumes, mode split, vehicle occupancy, and dwell times to determine if sufficient curbfront capacity exists (or is expected to exist, for future scenarios). Simulation models can also be very useful in graphically portraying curbfront operations.

For additional insight and practical help in performing the determinations and methods described in this section, go to the **Curb Requirements model** provided in *Volume 2: Spreadsheet Models and User's Guide*. This model allows the user to determine the necessary peak hour curbside frontage from observation data such as vehicle split, dwell time, frequency, and vehicle length.

Curbfront analysis can be done for the design hour using hourly traffic data or for smaller time periods, such as 15 minutes, if more detailed data is available. For example, within the design hour, there may be 15-minute peaks that represent 30% of the hourly traffic rather than more evenly distributed activity.

A primary element of curbfront LOS is the ability to find a space for loading or unloading. The probability of finding an empty curb space or having to double park is typically used to describe LOS. Curbside capacity is considered to be the double-parking capacity of the curb as depicted in Figure VII-6. This figure assumes a four-lane roadway with double parking allowed.

LOS is then based on the percentage of the double-parking capacity as follows:

A. Parking demand equal to or less than 50% of double-parking capacity.
B. Parking demand is between 50% and 55% of double-parking capacity.
C. Parking demand is between 55% and 65% of double-parking capacity.
D. Parking demand is between 65% and 85% of double-parking capacity.
E. Parking demand is between 85% and 100% of double-parking capacity.
F. Parking demand exceeds 100% of the double-parking capacity.

For terminal roadways with less than four lanes, other LOS estimating ratios are described in the results of ACRP Project 07-02, "Airport Curbsides and Terminal Area Roadway Operations." As curb parking LOS decreases, there is also a reduction in capacity of adjacent through lanes.

Traffic volumes by travel mode are airport specific and are based on the operations of the airport. Typically, travel modes such as private automobiles, taxis, limousines, and various shuttles serve the curbfront. These peak hour volumes will need to be determined to calculate the curbfront capacity at each location. These volumes can be determined three ways: (1) collect existing data at the location, (2) collect data at a similar airport facility, and (3) estimate the traffic volumes using the following formula: *Estimated Traffic Volumes* = *Originating Passengers* × *% Departures or % Arrivals* × *Curbfront Mode Split.*

Drivers experience no interference from other vehicles or pedestrians. Motorists arriving at the airport terminal can stop adjacent to the curb at preferred locations. Demand is equal to or less than 0.50 of the double-parking capacity of the curbside. Capacity of adjacent through lanes is unaffected.

Relatively free-flow conditions, although double-parking can be observed at some curbside locations (i.e., baggage check-in, major entrance/exit points). Demand is between 0.5 and 0.55 of the double-parking capacity of the curbside. Capacity of adjacent through lanes is virtually unaffected.

Double-parking near doors is common and some intermittent triple-parking may occur. This level of service is appropriate for peak period design conditions at major airports. Demand is between 0.55 and 0.65 of the double-parking capacity of the curbside. Capacity of adjacent through lanes is reduced by approximately 5% due to the increased frequency of double-parking.

Triple-parking occurs more frequently and vehicle maneuverability is somewhat restricted. Intermittent vehicle queues may form both in the through lanes and at the entrance to the curbside area. Demand is between 0.65 and 0.85 of the double-parking capacity of the curbside. Capacity of adjacent through lanes is reduced by over 20% due to the increased frequency of double- and triple-parking.

LOS E—Motorists experience delays and queues along the length of the curbside. Both congestion and double- or triple-parking are evident throughout the curbside area. Momentary breakdowns in operation occur as traffic in the through lanes is increasingly delayed by vehicle maneuvering in and out of the parking lanes. Demand is between 0.85 and 1.0 of the double-parking capacity of the curbside. Capacity of adjacent through lanes is reduced by over 35% due to the increased frequency of double- and triple-parking.

LOS F—Motorists experience significant delays at the curbside entrance and along the length of the curbside. Parked vehicles are unable to leave the curbside due to stopped vehicles in adjacent lanes. Demand exceeds 1.0 of the double-parking capacity of the curbside. The flow of vehicles in all lanes frequently comes to a halt.

Note: Assumes a 4-lane curbside roadway where double parking is allowed.

Figure VII-6. Curbfront LOS descriptions.

Table VII-1. General headway times by travel mode.

Travel Mode	General Headway Times (minutes)
Rental Car Shuttles (individual companies)	2 - 4
Rental Car Shuttles (consolidated)	3 - 5
Hotel Shuttles	5 - 10
Other Shuttles	5 - 15 (varies by type)
Buses	30 - 60

Source: Kimley-Horn and Associates, Inc., All rights reserved.

Curbfront mode split can be determined by passenger survey on mode of arrival to the airport (which is typically how they will also leave the airport) and party size. To determine the number of shuttles or other buses, the type of rental car facilities and number of local hotels providing airport shuttles and number of bus or shuttle services providing service to the airport must be established. Furthermore, there will be fewer shuttle trips if a consolidated rental car campus is planned rather than rental car companies running individual shuttles. If no specific headway data is available, the general headway data shown in Table VII-1 can be used:

To determine the curbfront traffic volume for one of these modes, multiply the number of companies servicing the airport by the headway and convert to vehicles per hour.

Dwell times should be collected during the peak hour to determine the maximum utilization of the curbfront. As stated earlier, a main component of dwell time is enforcement. When there is strict enforcement of the curbfront, dwell times are typically shorter than when enforcement is not as strict. If existing data is available, that would be best; however, data can be collected at a similar airport facility or the dwell times may be used. Table VII-2 shows dwell times presented by travel mode with the assumption of relatively strict enforcement.

One thing to consider is that arriving and departing vehicles of the same travel mode may not have the same dwell times.

Vehicle length helps determine the amount of room on the curbfront that the vehicles use when parked. Table VII-3 provides general lengths to be used in the analysis. These lengths include additional room to compensate for the space between vehicles on the curbfront.

These values can be used in the analysis instead of measuring specific lengths at the airport. However, if the airport has other travel modes at the curbfront, then specific lengths may need to be determined for that travel mode.

Before determining the curbfront length, the allowance of double parking must be considered. If double parking will be allowed, it must be factored into the curbfront utilization. The main benefit of allowing double parking is that there is more curbfront for vehicles to utilize.

Table VII-2. Dwell time by travel mode.

Travel Mode	Dwell Time (minutes)
Private Auto	2 - 4
Taxis	1 - 3
Limousines	1 - 3
Rental Car Shuttles	2 - 5
Hotel Shuttles	2 - 4
Other	varies

Source: Kimley-Horn and Associates, Inc., All rights reserved.

Table VII-3. Vehicle length by travel mode.

Travel Mode	Length
Private Auto	22FT / 7M
Taxis	22FT / 7M
Limousines	50FT / 15M
Rental Car Shuttles	50FT / 15M
Hotel Shuttles	40FT / 12M
Other	varies

Source: Kimley-Horn and Associates, Inc., All rights reserved.

For example, an airport curbfront may be designed to allow double parking during peak times to help meet the added demand. However, double or even triple parking contributes significantly to the congestion of the curbfront, sometimes blocking vehicles in inner lanes and overall impeding the through travel lane of the curbfront and increasing the vehicle congestion that pedestrians will need to travel through to access parking lots on the other side of the curbfront.

Another factor to consider is whether a multiple stop factor is appropriate for the curbfront. A multiple stop factor should be applied when a vehicle, typically shuttles, will stop multiple times along one curbfront. Multiple stops are most common at airports that have a shared curbfront between multiple terminals and the walking distance is too far to expect passengers to travel to a central location with their luggage.

Considering all of these factors, the desired curbfront utilization must be determined. Once this has been established, the required size of the curbfront can be determined by summing the demand of all modes of travel. Demand can be calculated by multiplying volume × dwell time × length of vehicle, then converting it to demand by hour for each mode. Total demand compared to the desired curbfront utilization will result in required curbfront length.

VII.5 Parking Facility Requirements

Parking facilities are typically provided for the following users:

- Passengers
- Employees and tenants
- Rental cars

VII.5.1 Passenger Parking

Demand varies greatly for airport parking by time of day, day of the week, and season. Typically demand peaks around holidays, such as Thanksgiving, Christmas, and Spring Break. Airport operators ultimately determine policies controlling the number and type of parking facilities to be provided. Typically there are five types of passenger parking facilities for an airport:

- **Terminal parking:** Close-in parking facilities, in relation to the terminal building, provide the most convenient parking spaces for passengers. These facilities can provide short-term and long-term spaces. Short-term patrons usually remain at the airport for time periods of less than 4 hours (*51*). Long-term patrons, airline passengers parking during their trip, often remain for several days. While short-term parking can account for the majority of parking activity at an airport, the higher turnover rate for space requires fewer parking spaces than the long-term facilities.

- **Remote parking:** Remote parking facilities typically cater to the long-term parking patrons but differ from the terminal parking facilities in that the lot location is at a distance away from the terminal building. Remote parking lots require on-airport transit capabilities to transport passengers to/from the terminal. Remote parking lots typically have a much lower cost than the terminal parking facilities, therefore, costing the passenger less over a longer duration stay.
- **Off-airport parking:** Off-airport parking facilities are essentially the same as remote parking facilities but are usually operated outside of airport property by a non-airport entity. Transit capabilities to/from these facilities are handled by the private operators of the lots. These private operators drop off and pick up their patrons directly at the terminal curbfront or at a GTC, if one is present and is allowed by the airport operator.
- **Valet parking:** Valet parking is provided at many airports. Departing passengers leave their vehicles to be parked either at the terminal curbfront or at one of the close-in terminal parking lots.
- **Cell phone lots:** Cell phone lots have recently sprung up at airports all over the United States, especially at airports experiencing significant traffic congestion at the curb. These lots are often placed along the entrance road to the terminal to be more visible to drivers entering the airport.

These lots provide significant advantages to the airport and to the driver. They reduce vehicles waiting on the curb and reduce recirculation traffic. The driver is able to pull off of the entrance road and comfortably wait for a call on his/her cell phone from the arriving passenger being picked up. Some airports have even installed flight information displays to let the driver know when flights are expected to arrive.

Cell phone lot size should be designed to reflect the type of users the airport has: an O&D airport will need more spaces than a primarily connecting passenger airport. These lots also need to be an easy choice for the person picking the passenger up, by being easy to access, having good signage to the location, and being in proximity to the location of flight arrivals, etc.

The number of passenger and public parking spaces at an airport varies greatly depending on the policies of each airport operator (See Table VII-4). Local conditions for each airport should determine the ultimate number of spaces to meet anticipated demand. While there is a great deal of variation based on local conditions, passenger parking demand has been demonstrated to be related to the number of originating passengers (*50*). As a general rule of thumb, parking supply should range from 900 to 1,400 spaces per million enplaned passengers, with 25% to 30% of spaces designated for short-term parking (*49*).

To avoid long walking distances for passengers, a maximum distance should be established between parking spaces and the terminal building (close-in facilities) or transit pick-up/drop-off

Table VII-4. Examples of rule-of-thumb passenger parking*.

Originating Enplanements	Parking Supply	Approximate Number of Short-Term Parking Spaces	Approximate Number of Long-Term Parking Spaces
500,000	450 - 700	100 - 200	350 - 500
1,000,000	900 - 1,400	225 - 425	675 - 975
1,500,000	1,350 - 2,100	325 - 625	1,025 - 1,475

*Exact parking space numbers depend on the type of flights the airport services

Source: Kimley-Horn and Associates, Inc., All rights reserved.

locations (remote facilities). A typical maximum walking distance for passengers is between 900 and 1,000 feet.

Parking structures and lots should be planned to enhance pedestrian safety, circulation, and wayfinding and should recognize that most parking patrons are infrequent users of the facility. To prevent runaway baggage carts and to accommodate wheeled baggage, parking areas/garages should be level. As a result, a garage configuration with parking on vertical circulation ramps is not recommended (*51*).

Pedestrian connectivity between close-in parking facilities and the terminal should avoid having passengers walk across active terminal roadways. To increase pedestrian safety and avoid pedestrians crossing roadways, a passenger walkway (elevated bridge or tunnel) that connects the parking facility and the terminal is recommended.

Revenue control plazas for both entry and exit movements at the parking facilities should provide enough lanes to accommodate the existing and future demand based on the system(s) in use. Sufficient vehicular queuing space is also needed at the control plazas to avoid conflicts with free-flowing traffic on terminal roadways (for entering vehicles) or interfering with traffic circulation within the lot (for exiting vehicles).

Parking pricing schemes are important and should be based on the facility type and on the user market. For example, long-term parking is often provided in more remote lots at a lower price when compared with hourly or short-term parking areas. Also, if prices are too high, users may not park in the closer areas; if prices are too low, users may overuse closer areas causing them to be full for users that need them.

VII.5.2 Employee/Tenant Parking

Similar to passenger parking, airport operators ultimately determine policies controlling the number and type of parking facilities to be provided for employee parking. Employee parking facilities can be either close to the terminal or in remote lots. Close-in employee parking is typically located in either the short-term or long-term passenger areas, but usually in segregated locations from passenger parking areas. Remote parking lots require the on-airport transit capabilities to transport employees to/from the terminal or other on-airport destinations. Employee transit is typically on a separate system than passenger transit in similar facilities.

Because employee parking is usually implemented on a permit basis, entry/exit plazas and vehicular queuing areas at the entry/exit locations can be significantly reduced compared to the passenger parking facilities.

The number of passenger and public parking spaces at an airport varies greatly depending on the policies of each airport operator. Local conditions for each airport should determine the ultimate number of spaces to meet anticipated demand. As a general rule of thumb, parking supply should range from one space per 2.5 to 3.0 employees or 250 to 400 spaces per million enplanements (*49*). In comparison to passenger parking ratios, the employee space ratio is lower due to the shift nature of airport employment.

VII.5.3 Rental Car Parking

Almost all airports have rental car (RAC) companies on the airport that provide drop off and pick up of rental cars. At small- and medium-sized airports, the rental car ready-return (R/R) lots are typically located within walking distance of the terminal. Depending on the number of RAC companies, R/R spaces, and lease agreements, the R/R lots may be combined or separated. Spaces may be common use or dedicated to individual companies.

At larger airports, rental car facilities are often located at remote sites on the airport, away from the terminal. This location often requires a shuttle bus to pick up or drop off passengers. There are two main types of remote rental car operations:

- The first type consists of facilities that are operated by individual rental car companies. Each company has separate office and maintenance facilities, and R/R parking for their cars. These facilities can be located near each other or can be in separate areas. Each company has its own shuttle bus to bring passengers from the terminal to the facility.
- The second type consists of a consolidated RAC campus. This facility is typically a joint project, sponsored by the airport operator and the rental car companies. Often a surcharge on cars rented at the airport is levied to pay for such a facility. The consolidated facility is typically located on airport land. All of the on-airport companies have their own counter and their R/R areas in this facility. A single bus fleet serves all of the companies on this campus. Airports that have consolidated campuses operating include Cleveland Hopkins International, Phoenix Sky Harbor International, Fort Lauderdale/Hollywood International, and Houston George Bush Intercontinental. Some airports are considering or planning for people mover access to these facilities as has been done in San Francisco.

VII.6 Roadway Circulation and Wayfinding

There are many decision points along a typical airport roadway. That, combined with the fact that many passengers and visitors do not regularly travel these roads, makes clear, understandable signage especially important. Passenger wayfinding through the airport environment brings several key factors into play, as discussed in the following paragraphs.

VII.6.1 Circulation Flow and Analysis

Development of a signage system should begin with identification of major circulation patterns through the airport environment. These patterns can be broken down as required for specific locations but can generally be divided into inbound and outbound movements for major airport users (visitors, passengers to parking, rental car users, employees, etc.). Primary and secondary circulation routes through the airport can be quickly identified through the analysis of the planned roadway network.

VII.6.2 Decision Points

Along the major circulation routes, decision points can be identified at locations requiring direction changes and path choice alternatives. Identification of these decision points helps to locate critical areas were wayfinding signage is needed to assist the roadway users in navigating the environment.

VII.6.3 Sign Locations

Based on the circulation patterns and decision point location along with sight lines for drivers, directional signs can be located before major decision points to allow for adequate time for drivers to react in a safe manner.

Wayfinding signs for airport vehicular circulation should be consistent across the property in terms of legibility, visibility, formatting, and terminology/symbology. Signage standards or guidelines within the airport environment can provide this consistency, allowing for updates to existing and future signage, and can be adapted to incorporate developing technologies. Consistent formatting, terminology for airport facilities, and symbology for airport locations can provide the driver with simplified pieces of information encountered throughout the environment.

Legibility and visibility depend primarily on assumed driver reaction times. As the number of lanes on a given roadway increases, driver reaction times tend to increase because it takes longer to accomplish a desired vehicle movement across multiple lanes. In the same manner, an increase in the speed of a given roadway facility decreases the amount of time a driver has to react. The driver needs to process the same amount of data in a shorter timeframe, therefore increasing reaction time. As anticipated driver reaction times increase, both letter heights on wayfinding signs and sign placement distance before decision points need to increase.

While signage packages can be specific and unique to each airport, traffic control devices (including signs, traffic signals, and pavement markings) installed on any street, highway, or roadway open to the traveling public are subject to the national standard for all traffic control devices as included in the MUTCD. The MUTCD is published by the Federal Highway Administration, most recently published in 2003. Additional guidance may be found in the results of ACRP Project 07-06, "Wayfinding and Signing Guidelines for Airport Terminals and Landside."

Of additional benefit in wayfinding within the airport environment is the use of Intelligent Transportation Systems (ITS). On freeway systems, usage of ITS is primarily visible to drivers through variable message signs that update drivers on traffic and congestion conditions in busy metropolitan areas. In an airport environment, this type of variable message signage system can be implemented to inform drivers of parking conditions at lots throughout the airport, identify congestion areas at the terminal curbfronts or other congested locations, and suggest alternative routes or destinations if available.

VII.7 Landside Security

VII.7.1 Access Roadway and Terminal Curbside

While approach roads are not yet within the TSA's immediate regulatory jurisdiction, any incident on or near airport property is of concern, whether for purposes of liability or its potential as a precursor to a security related or criminal event. Incidents are also of concern in areas where the airport may have direct connections with light rail, subways, buses, or other mass transit and such indirect connections as passengers and baggage arriving from marine terminals, hotels, and casinos.

The TSA has considered seeking jurisdiction to transition areas at airports served by other means of ground or water transportation, without defining the characteristics, location, and boundaries of those areas. Such areas could include public roads, but no such regulations have yet been defined or implemented.

Technical solutions here, as in the terminal lobbies, are limited by the need to keep the approach and departure roads fully open and accessible to the general public. Perimeter-monitoring technologies such as CCTV cameras can also apply to roadway security and can take advantage of video analytic capabilities. Condition-specific analytics can be applied here, with public areas having the highest variability of possible scenarios to be monitored and the resulting need to prioritize potential events and set thresholds to differentiate between normal and anomalous activities in order to limit false alarms, as well as having an alternate set of rules when threat levels and operational requirements change.

As the terminal is made more secure, the vulnerability of areas on the approach roads, parking areas, and curbs may increase. The terminal curb is the first point of direct public and passenger contact with the terminal and presents the most obvious situations and conditions that expose the airport to a VBIED.

Airports are configured for the rapid processing of large concentrations of incoming and outgoing passengers at the curbside, which presents both a security and safety concern, especially during peak times. The TSA has provided recommended procedures for passenger drop-off and pick-up at the curb, based on a limited amount of time a vehicle can be stopped at curbside. This policy provides no real security whatsoever, as an explosive-laden vehicle can stop at curbside and the driver can exit the vehicle, walk away, and detonate the explosive remotely.

Roadway vulnerabilities in high threat conditions are commonly addressed by jersey barriers that create a zigzag path for approaching high-capacity vehicles to maneuver, reducing both the speed and kinetic effect of a blast threat. Clearly, such barriers are temporary measures, not primary elements of design, although some attention may be paid to roadway layout that diminishes attack speeds, such as angular turns or high curbs.

Heavy bollards, often designed as permanent decorative planters or benches at the curbside in front of the terminal, can stop, or at least minimize, vehicle penetration into the public lobby. They should not be in the form of trash containers that can conceal explosives, particularly those made of stone aggregate, which themselves present dangers of fragmented shrapnel-type debris.

When there are multi-level roadways that are not physically protected from vehicular attacks, airports should consider hardening the lower level supporting columns or façade to prevent severe damage or collapse.

VII.7.2 Multi-modal Connections

While many airports have so-called multi-modal connections with other forms of public transport such as buses, trains, and subways, the security interface between them is relatively straightforward; there are little or no security measures imposed on those vehicles or passengers before their arrival at the airport, so all arrivals must remain on the public, non-secure landside before any security screening, and preferably well removed from the terminal. In this sense, it is no different than any curbside arrival of buses, taxis, or other unscreened persons and vehicles. Future technology advances may eventually allow procedural changes in how those arrivals are channeled into the terminal, including the possibility of remote check-in terminals with secure transport to the operational terminals. In either case, they must still first be brought into pre-screening public areas for processing of tickets and baggage, as well as separation of passengers from the general public.

The most common airport interface with another mode of transportation is when a wide range of trucks of every size and description arrive, bringing construction materials, concession goods, cargo, fuel, catering, maintenance requirements, and more. Procedural aspects of those arrivals are addressed above in the vehicle checkpoint section, but their points of arrival share some common vulnerability with other areas on the public side of the terminal:

- Loading docks and shipping/receiving areas for large unscreened vehicles are recommended to be at least 50 feet from utility rooms, utility mains, and service entrances such as electrical, telephone/data, fire detection/alarm systems, fire suppression water mains, cooling and heating mains, and so forth. When located where vehicles are driven or parked under the building, consider hardening the entire area, and venting the room outward.
- Exterior doors and window systems (glazing, frames, anchorage to supporting walls, etc.) can be hardened to mitigate effects of a VBIED causing flying glass and debris. However, hardened glazing offers little protection against an aggressor walking inside the entry doors with unscreened luggage or parcels, especially those with international flights, when passengers often travel with oversized luggage.
- Restrooms in airport public areas, as well as service spaces and unscreened access to stairwells in non-secure landside locations, should be placed to avoid concealment of criminal activities,

and if possible not be adjacent to critical facilities such as emergency UPS systems; heating, ventilation, and air conditioning systems; communications rooms; utilities; elevator shafts; and so forth.

VII.7.3 Parking Facilities

Security measures in airport parking lots tend to concentrate first on common criminal behavior such as theft, assault, and vandalism. Design approaches might include attention to such measures as appropriate lighting for CCTV, emergency alarms and call boxes, accessibility for emergency response vehicles, and minimization of concealment locations in enclosed stairwells or remote corners in parking garages.

From an anti-terrorism perspective, design of parking facilities adjacent to terminal buildings will almost certainly require coordination with a TSA risk assessment and should accommodate the potential for vehicle inspection facilities during high alerts.

Vehicle screening at elevated threat levels also introduces significant labor and operational costs well beyond the screening itself. Wherever vehicle screening occurs, it will typically create backups on the public approach roads—an early airport planning issue. Once instituted, whether remotely or close in, vehicle screening requires space for trained manpower to accomplish the process on multiple vehicles of all sizes simultaneously; weatherization and computer/communications in remote booths for people and equipment; persons, space, and equipment to deal with rejected or suspect vehicles, including alternate routes for their removal (including large trucks) away from the terminal; and additional remote parking and dedicated transport to accommodate diverted passengers and baggage. Commercial deliveries requiring screening are considered independently, at separate locations such as loading docks or perimeter gates that handle all screening of deliveries remotely.

Terminal parking facility design can address certain measures for blast mitigation up to a point, but they rapidly become cost prohibitive, labor intensive, design antithetic, and operationally intrusive. Security costs that go beyond basic principles of design and construction should be weighed against a realistic threat and vulnerability assessment, because their costs are significant, and their contribution to security are generally speculative with respect to the probability that a significant event will happen at this airport.

In December 2002, TSA reviewed the agency list of "unnecessary rules" and lifted the so-called 300-foot rule in contingency plans. It was essentially a system-wide formulaic ban on any unknown vehicle parking within 300 feet of the terminal building at Category X, I, and II airports. Category III and IV airports were not required to conduct a blast analysis or develop a Bomb Incident Prevention Plan. In its place TSA instituted a series of operating procedures intended to provide relief from the 300-foot approach by adding flexibility when tailoring an individual airport's security program. Each local plan is based on an approved blast analysis performed by a certified engineering firm and is to be instituted when the Department of Homeland Security threat level is elevated to "orange." Without such an analysis, the 300-foot rule remained in effect at larger airports.

Also, note that designs in some geographic areas can reap dual structural and security benefits when state and local building codes require earthquake resistant measures to prevent or mitigate damage from collapse.

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APPENDIX A

Checklists (for Planning and Design)

A-1 Demand Data

Passenger and Aircraft Activity Levels

- ☐ Total Million Annual Passengers
- ☐ Annual Enplaning Passengers
- ☐ Domestic
  - ○ % origin and destination
  - ○ % connecting
- ☐ International
  - ○ % origin and destination
  - ○ % connecting
  - ○ % in-transit
- ☐ Peak Month/Average Day
- ☐ Peak Hour Passengers (Rolling Clock Hour)
- ☐ Domestic
  - ○ % origin and destination
  - ○ % connecting
  - ○ % load factor
- ☐ International
  - ○ % origin and destination
  - ○ % connecting
  - ○ % load factor
- ☐ Ratio of Meeters/Greeters to Deplaning Passengers
- ☐ Ratio of Well-Wishers to Enplaning Passengers
- ☐ Average Traveling Party Size
- ☐ Ratio of Checked Bags for Enplaning Passengers
  - ○ % of passengers checking bags
- ☐ Ratio of Carry-on Bags for Enplaning Passengers
- ☐ Annual Aircraft Operations
  - ○ Domestic
  - ○ International
- ☐ Peak Hour Aircraft Movements
- ☐ Air Carriers
  - ○ Fleet mix

Current Gated Aircraft Schedule

A-2 Airside Planning Checklist

Functional Planning

- ☐ Aircraft Maneuvering
  - ○ Taxiway and taxilane separations
  - ○ Dual vs. single apron taxilanes
  - ○ Aircraft push-back zone
  - ○ Power-in and power-out operation
  - ○ Tug-in and tug-out operation

- Apron circulation
- Jet blast impacts (blast fence)

- ☐ Apron Service Roads
  - Tail-of-stand
  - Head-of-stand
  - Between aircraft
- ☐ Air Traffic Control Tower Line-of-Sight
- ☐ Passenger Loading
  - Loading bridges (single and multiple)
  - Apron ground loading (bus and walk-out)
  - Mobile lounges
  - Mobile stairs
- ☐ Ground Service Equipment Storage
- ☐ Aircraft Servicing
  - Ground service equipment staging areas
  - Ground servicing points (fueling, water, etc.)
  - Hydrant fueling and truck fueling
  - Ground service equipment aircraft operating/clearance areas
- ☐ Apron Pavement Design
- ☐ Apron Slopes Pavement Gradients
  - Drainage
  - Fueling
  - Deicing
- ☐ Aircraft Parking
  - Capacity/fleet mix
  - Contact gates
  - Remote positions
  - Wingtip clearances
  - Safety clearances (taxi-in and push-out)
  - Safety clearances (power-in and power-out)
  - Safety clearances (passenger bus operation)
  - Flexibility in multiple aircraft type
  - Impact on terminal configuration
- ☐ Apron Marking
  - Ground service equipment parking and staging
  - Taxiway/taxilane centerline
  - Service roads
  - Pedestrian walkways
  - Aircraft maneuvering
  - Aircraft nose–wheel stop marks
  - Aircraft hold lines
  - Restricted areas
- ☐ Aircraft Guidance Systems
  - Docking systems
  - Lighting
  - Marking
- ☐ Emergency Equipment Access Roads
- ☐ Aircraft Apron/Gate Access Points
- ☐ Apron Lighting

- ☐ Aircraft Deicing
  - Decentralized (at gate)
  - Centralized
- ☐ Apron Snow Removal Operation
  - Snow haul route
  - Snow melter locations and operating area
  - Snow dump sites
  - Interaction with aircraft and ground service equipment
- ☐ Miscellaneous Planning Considerations
  - To be determined

A-3 Terminal Planning Checklist

Current Passenger Aircraft Parking Positions

- ☐ Contact Gates
- ☐ Maximum Aircraft Size (determined by wingspan)
- ☐ Minimum Aircraft Size (determined by door sill height)
- ☐ Passenger Loading Bridges
- ☐ Apron Loaded Gates at Terminal
- ☐ Maximum Aircraft Size Remote Overnight

Design Aircraft (Current and Future)

Airlines with Passenger Service Currently Serving Terminal(s)

Airline Gate Assignments by Gate Number

Existing As-Built Floor Plans (in Computer-Aided Design)

Terminal Building Facilities Inventory

- ☐ Airline
  - Offices
  - Ticketing support
  - Operations and support
  - Clubs/VIP lounges
  - Departure lounges
- ☐ Passenger Ticketing/Passenger Check-in/Baggage Check-in System (square feet)
    - Number of terminal, curbside, parking, and remote passenger check-in and baggage check-in positions
  - Staffed positions
    - Number of positions
    - Linear feet of frontage
    - Area of function (square feet)
    - Queue length (number of passengers)
    - Average processing rate (by class of service in sec/passengers)
  - Self-service kiosks
    - Number of positions and locations
    - Linear feet of frontage (if in-line with regular counters)
    - Area of function (square feet)
    - Average processing rate (sec/passengers)
    - Queue length capacity (number of passengers)

- Security screening
  - Priority screening lanes
  - Regular screening lanes
    - Magnetometers
    - X-ray machines
    - Other devices
    - Area for inspection
    - Area for passenger queuing
- Concessions (see A-6 Concessions Checklist)
  - Secure concessions
  - Non-secure concessions
  - Concessions storage
- Passenger amenities
  - Paging systems and courtesy phones
  - Wi-Fi
  - Computer recharge
  - Wheelchair storage
- Baggage handling
  - Outbound
    - Check-in
    - Outbound bag make-up area
    - Checked bag screening
  - Explosives detection system
    - In-line devices
      - Number of devices
      - Type of devices
      - Processing rates (rated and observed)
      - Area of function (square feet)
    - Lobby devices
      - Number of devices
      - Type of devices
      - Processing rates (rated and observed)
      - Area of function (square feet)
  - Inbound
    - Bag claim hall area (square feet)
    - Input belt area
    - Number & type of claim devices
    - Linear feet of each device
    - Baggage service offices
- Public areas
  - General circulation
  - Ticket lobby circulation
  - Secure circulation
  - General circulation
  - Restrooms
    - Secure
    - Non-secure
  - Public seating
  - Domestic meeter/greeter lobby
  - Automated people mover/moving walk circulation area
  - Non-public circulation

- Airport administration
  - Offices/support
  - Airport police
  - Maintenance/janitorial/shops/storage
- Building systems
  - Structure/non-net/open-to-below
  - Mechanical/electrical/telephone/plumbing
- International arrivals processing (Customs and Border Protection)
  - Primary inspection
    - Number of primary inspection booths
    - Primary inspection queue
    - Primary inspection support
  - Baggage claim
    - Claim devices
    - Linear frontage
    - Baggage claim hall (square feet)
  - Secondary inspection
    - Secondary inspection area
    - Secondary inspection counters
    - Agricultural inspection stations
    - Area agriculture inspection
  - Support functions
    - Customs and Border Protection administration
    - Customs and Border Protection administrative support
  - Other functions
    - Sterile circulation
    - In-transit/sterile holding areas
    - Public restrooms
    - General circulation
    - Greeter lobby
      - Greeter waiting area
      - Tour group assembly
  - Baggage recheck
    - Number of recheck positions
    - Area of recheck positions
    - Recheck queue
- Gross terminal(s) size (square feet)

A-4 Landside Planning Checklist

General Issues

Regulations and Guidelines

- ☐ Highway Capacity Manual
- ☐ AASHTO
- ☐ Local Municipal Codes
- ☐ FAA Advisory Circulars

Planning Considerations

- ☐ Growth Rate
- ☐ Current Level of Service

- ☐ Expansion Plans
- ☐ Airport Characteristics
  - ○ Desired LOS
  - ○ Airport size

Elements

- ☐ Pedestrian Curbfronts and Sidewalks
- ☐ Vehicular Travel Lanes
- ☐ Parking
- ☐ Rail Transit
- ☐ Vehicle Staging Areas

Airport-Operated Transit Systems

A-5 Business Considerations

Strategic Positioning

- ☐ Understanding of the customer and traffic trends
- ☐ Understanding of competitive environments
- ☐ Understanding of business stakeholders
- ☐ Understanding of service and business philosophy of airport
- ☐ Understanding of trends occurring in other airport terminal developments
- ☐ Strengths/weaknesses/opportunities/threats analysis
- ☐ Airport mission and goals confirmation
- ☐ Proceed to planning and programming

Adaptability

- ☐ Identify relevant sources of future demands (e.g., types of passenger traffic and consumer demands)
- ☐ Evaluate stability of markets in relation to useful life of terminal improvements
- ☐ Consider uncertainty of technology, security, and environmental futures along with traffic and consumer uncertainty in evaluation of investments
- ☐ Evaluate alternative means of delivering services and identify facility requirements of preferred delivery means
- ☐ Consider business processes integration into building systems
- ☐ Evaluate options to increase adaptability of improvements to meet range of likely demands
- ☐ Review planning and programming decisions from perspective of adaptability

Affordability

- ☐ Establish spending limits within financial goals of airport through financial planning
- ☐ Engage airline and other tenant property representatives in program consultations early and throughout process
- ☐ Assure business voice in program scope and budget change management
- ☐ Establish and monitor cost responsibilities between airport and tenants
- ☐ Analyze tradeoffs of costs between capital costs now and future operations and maintenance costs
- ☐ Establish monitoring systems to track program costs against key metrics

A-6 Concessions

Availability of Key Commercial Data

- Financial and Other Commercial Data
  - Historic and current gross sales by shop unit, product category, operator, and location
  - Historic and current concession revenues (amounts paid by shop operator to airport operator) by shop unit, product category, operator, and location
- Commercial Terms
  - Business terms for key commercial tenants (start date, end date, description of monthly/annual minimum sales guarantee fees, percent concession fees, base monthly space rental rates, product categories allowed, other)

Terminal Facility Data

- Shop Spaces
  - Historic and current space amounts by shop unit, product category, and location
  - Site plans (shop layout plans, terminal plans, diagrams of major passenger flows, key processing facilities such as security, airline check-in counters, others)
- Storage Space
  - In-terminal
  - Off-site
- Waste Collection Points and Processing

Aviation Statistics

- Current, Sample Day (24-hour period) Departing Flight Schedule (airline, flight time, departure time, gate, aircraft type, departing passenger)
- Detailed Passenger Activity (number of monthly passengers by airline, by destination)
- Airport Passenger Forecasts (arriving and departing passenger during peak planning hour, annual passenger)

Commercial Studies

- Passenger Commercial Surveys (sales per passenger, passenger destination, landside and airside dwell times, gate location)
- Other Consumer Market Research (meeters/greeters, airport staff, others)

Space Location Strategies

- Clustering or decentralization of shops
- Locations of commercial nodes
  - Landside and airside
  - Departures and arrivals (if segregated)
  - Domestic and international
- Co-location of commercial activities with other passenger facilities (such as Flight Information Display Systems, toilets, vertical and horizontal circulation)

Facility Expansion

- Terminal Building Expansion Projects
  - Minimizing impact of construction on existing commercial activities
- Ability to Develop Commercial Clusters at New Locations
  - Locations and sizes
- Ability to Expand Individual Shops and/or Develop New Shops At Existing Locations

Shop Development Standards

- ☐ Tenant design criteria manual
- ☐ Airport management review process

A-7 Security

General Planning and Design Considerations

- ☐ Meet with airport sponsor, architect, law enforcement, Transportation Security Administration, Customs and Border Protection
- ☐ Meet with relevant airport users and stakeholders, including tenants and other local and federal government agencies
- ☐ Review master plans for flexibility to meet future expansion
- ☐ Review regulatory requirements
- ☐ Threat and vulnerability assessment
- ☐ Needs assessment of airport users and tenants
- ☐ Review information technology infrastructure to support security requirements
- ☐ Define physical boundaries between public and secure/sterile areas
- ☐ Deter public access to non-public areas—physical and visual barriers
- ☐ Minimize areas where objects or persons can be concealed
  - ○ Columns, corners, potted plants, large art works, utility tunnels, closets, storage areas, enclosed stairways
- ☐ Personnel circulation includes vertical separation (elevators, escalators, stairwells) as well as horizontal; requires secure access and passageways. Prevent public access.
- ☐ Supporting utility infrastructure (power, data, communications) for any security areas

Terminal Vulnerable Areas

- ☐ Connections from the terminal to utility services in power and communications
- ☐ Hotels, parking structures, or other internal or adjacent facilities and structures
- ☐ Loading docks and delivery areas
- ☐ Locations for person or object concealment
- ☐ People moving systems, if exposed, including underground and elevated rail
- ☐ Primary transformers and switching gear
- ☐ Secondary generating equipment and transmission facilities
- ☐ Utility tunnels or ducts entering a terminal below grade
- ☐ Walkway or bridge connections to other terminals

Security System Infrastructure

- ☐ Separation from non-security infrastructure
- ☐ Controlled physical access; access for maintenance

Blast Mitigation

- ☐ Curbside roadways
  - ○ Check-in facilities—bag check/hold areas
  - ○ Space and alternate routing for high-alert vehicle screening
  - ○ Close-in or in/on terminal parking
  - ○ Bollards
- ☐ Terminal façade—glass fragmentation

Space and Movement/Access for

- ☐ Adequate queuing space—Airport Ticket Office, lobby, at security screening checkpoints
- ☐ Airport operational personnel
- ☐ Tenants/concessions—across/behind security boundary; deliveries
- ☐ Unimpeded security and emergency response routes

New Construction vs. Alterations

- ☐ Both require the same attention to security
- ☐ Alterations at one location may affect security at downstream locations

Sterile Areas

- ☐ Refers to the area between the security screening checkpoints and the aircraft loading bridge and/or holdroom door
- ☐ Primary objective; passenger containment, preventing access to weapons or contraband after the screening process has occurred
- ☐ Number of access portals limited to the minimum operational necessity, but not to preclude physical expansion or changes of increased airline/tenant operations
- ☐ Comply with local fire and life safety codes, Americans with Disabilities Act, and so forth
- ☐ Consider "hidden" potential access pathways in restrooms, airline lounges, kitchen facilities, plumbing chases, air vents, drains, trash chutes, utility tunnels or other channels
- ☐ Consider access needs of airport and airline personnel, operations offices, crew marshalling areas, maintenance and concession staff and supplies
- ☐ Tenant personnel and airport employees who require access into the sterile area from public occupancy areas (alternate paths away from security screening checkpoints)
- ☐ Emergency response routes and pathways—in and out for off-airport response, emergency medical services and fire personnel
- ☐ Concession delivery and storage requirements beyond security, including perishables
- ☐ Built-in security-friendly fixtures (i.e., railings, pillars, bollards, open lines of sight, etc.)

Public Areas

- ☐ Curbside—points of congestion, baggage check handling and movement
- ☐ Public lobby areas (ticketing, bag claim, rental car)
- ☐ Carrier support areas requiring security considerations (lost luggage, package delivery, landside) with easy explosive ordinance disposal/law enforcement officer access
- ☐ Select furnishings and accessories—benches, ashtrays, trash cans—that avoid the concealment of explosives
- ☐ Minimal seating in ticketing lobbies will reduce congestion, push people outward
- ☐ Consider needs of international or high-risk aircraft operators with extended security measures during the passenger check-in process (i.e., El Al, Saudi). Additional queuing and processing space may be required
- ☐ Public emergency exits
  - ○ Security doors vs. fire doors
  - ○ Some exit requirements have specific widths and separation distances
  - ○ Coordinate locations closely with the Fire Marshal and/or Code officials
  - ○ Avoid moving persons from lower security areas to higher security areas
  - ○ The number of emergency exits leading into secured areas should be minimized
  - ○ Consider emergency doors with push-type panic bars with 15- to 30-second delays

- ☐ Concession areas
  - Consider moving concessions during heightened security
  - Short delivery access routes that minimize crossing security boundaries
  - Locate concessions storage areas in public or non-secured/low-risk areas (with appropriate screening when moved)

Non-Public Areas

- ☐ Service Corridors, Stairwells and Vertical Circulation—should not cross boundaries of secure areas
- ☐ Airport Personnel/Administrative Offices—connect via corridors and stairs to minimize the need to cross security boundaries; accommodate visitors and public access—potential for satellite police, ID or first aid offices
- ☐ Tenant Spaces
  - Some tenants may have their own security, and/or require tie-in to the airport access control and alarm system
  - Tenant money-handling, overnight operations, early morning concession deliveries

Security-Related Space for

- ☐ Security/Emergency Operations Center (expanded below)
- ☐ Transportation Security Administration
- ☐ Department of Homeland Security
- ☐ Federal Agencies (Federal Bureau of Investigation, Drug Enforcement Administration, etc.)
- ☐ Law Enforcement and Public Safety Areas
  - Public safety or police offices
  - Adequate space (in no particular order) for
    - Briefing/work room
    - Training classroom/offices
    - Property/evidence room(s)
    - Conference rooms—can be part of Airport Emergency Command Post/operations room(s)
    - Holding cells
    - Physical fitness area in conjunction with lockers, showers, and restrooms
    - General storage areas
    - Secured arms storage
    - Kitchen/lunchroom facilities
  - Areas requiring access for public and tenants but protected with adequate controls
    - Law enforcement officer administrative office
    - Security ID badging office
    - Lost and found
    - Security Identification Display Area/tenant training rooms
    - Medical services
- ☐ Law Enforcement Parking—direct landside/Security Identification Display Area access
- ☐ Dogs/K-9 Team Facilities
- ☐ If no on-site K-9, specify non-critical area for on-call K-9 use
  - Rule of thumb: a 4×8 indoor pen, attached to an outdoor fenced exercise run
  - Plumbing and drainage—epoxy coated for cleaning
  - Fresh air circulation, dry environment
  - Secured, and isolated from casual public contact
  - Areas for veterinarian services and training activities
  - Isolation from noise and odor sources, especially jet fuel fumes

- Secured storage for explosives test and training items; coordinated with ATF
- Consider proximity to Explosive Ordinance Disposal personnel and to threat containment units

Security Operations Center

- Consider multiple redundant communications options for police, fire, rescue, airport operations, crash/hijack alert, off-airport emergency assistance, and security of communications
- Locate close to the Airport Emergency Command Post, in a secure area
- Cabling interconnections, a central location for reasonable cable lengths
- Floor space; cabinets; power; heating, ventilation, and air conditioning; fiber optics and cabling; and conduit paths
- Rear access to console for maintenance and update
- Fire alarm monitoring, Flight Information Display System, Baggage Information Display Systems
- Airport radio and personnel paging systems
- Plan for alternate secondary site capable of supporting the basic operation.
- Direct view of the airside and the isolated parking position is desirable.
- Space needs
  - Space for crisis management team's operational group and negotiators
  - Advisory Circular 150/5200-31A regarding airport emergency planning can assist
  - Raised flooring is an option for installation of ducts and cable paths.
  - Electrical power must be uninterrupted

Customs and Border Protection/Federal Inspections Services

Federal Inspections Services agencies publish a separate document for security design requirements

- *Airport Technical Design Standards—Facility Standards for Passenger Processing at Airports and Pre-Clearance Sites*
- Also reference FAA AC 150/5360-13

Chemical & Biological

- Consider position of air vent intakes; heating, ventilation, and air conditioning system capacity for airflow management
- Consider areas for quarantine, detox, chem-bio screening of people, packages, and vehicles
- Capacity to accommodate outside mutual medical aid
- See also, "Guidelines to Improve Airport Preparedness Against Chemical and Biological Terrorism," Sandia Report SAND2005-3237
- Sources of additional bio-chem guidance: Federal Emergency Management Agency, Federal Bureau of Investigation, Department of Energy, Center for Disease Control, and Office for Domestic Preparedness Support.

Security Screening Checkpoints

- Transportation Security Administration has separate 71-page guidance document: "Security Checkpoint Layout Design/Reconfiguration Guide" (Nov. 2006)
- Elements of the security screening checkpoint
  - Prescreening preparation instruction zone
  - Queuing space
  - Walk-through metal detector
  - Non-metallic barriers
  - Non-metallic Americans with Disabilities Act gate/access
  - Carry-on baggage X-ray machine

- Divest & composure areas, tables
- Security screening checkpoint adjacent barriers
- Holding stations
- Wanding stations
- Explosive Trace Detection machines
- Egress seating area
- Supplemental X-ray
- Law enforcement officer station
- Supervisor station
- Private search area
- Closed circuit television coverage
- Data connections/cabinet
- Security screening checkpoint lighting
- Wireless access point
- Exit travel lane
- Exit lane station
- Exit lane closed circuit television
- Space for Transportation Security Administration staff
- Remote screening/monitoring room

Consider Allotting Utilities and Space Accommodations for

- ☐ Temporary security screening checkpoint during peak or emergency operations
- ☐ Space and infrastructure for expansion of existing and new security screening checkpoint locations

Access Control Systems:

Power Requirements

- ☐ Emergency power systems/battery backup for servers
- ☐ Emergency power systems/battery backup for control panels
- ☐ Emergency power systems/battery backup for operating stations
- ☐ Emergency power systems/battery backup for door hardware

Access Control at Security Portals

- ☐ Minimize number of points of access for security and cost
- ☐ Reduces cost when screening becomes necessary
- ☐ Remain flexible for future expansion

Potential Access Control Locations

- ☐ Terminal Area Access Points
    - Secure area access personnel doors
    - Air Operations Area access personnel doors
    - Sterile area access personnel doors
    - Concourse area entrances (drop-down grills)
    - Inbound/outbound baggage doors
    - Inbound/outbound baggage doors control
    - Loading dock doors to secure/sterile/Security Identification Display Area/Air Operations Area
    - Service corridor and stairwell doors
    - Administrative office doors
    - Telecommunication room doors
    - Maintenance area/equipment room doors
    - Tenant and concessions area doors

- Roof access points
- Manhole/utility access points
- Fire/emergency exit doors
- Hazardous material storage areas
- Terminal duress alarms
- Passenger screening checkpoints
- Baggage screening areas
- Ticketing/rental car counters
- Air Operations Area/Security Identification Display Area/secure vehicle gates

Surveillance and Video Detection Systems

- ☐ Lighting
- ☐ Camera Installations—derived from operational analysis of surveillance required—potential for tracking with video analytics
  - Ticket counters
  - Kiosks
  - Terminal apron
  - Security checkpoint areas
  - Throughout sterile areas
  - Public lobby areas
  - Roadway/curbside baggage areas
  - Loading dock/police parking areas
  - Administrative and tenant areas
  - Airside access doors and gates
  - Baggage handling and claim areas
  - Federal Inspection Services areas
  - Access-controlled door access points
  - Public and employee parking areas
  - Adequate night-time lighting for all appropriate camera locations
  - Alternative technologies—Airport Surface Detection Equipment radar, infrared cameras

A-8 Baggage Handling Systems

Terminal/Airport Facilities and Operations

Identify Design Team

- ☐ Baggage Handling System Designer
- ☐ Architect & Engineering Group
- ☐ Customer
- ☐ Airline Authority and/or Representatives
- ☐ Airport Authority and/or Representatives
- ☐ Transportation Security Administration Authority and/or Transportation Security Administration Representatives

Facility Type

- ☐ Separated Airline Operations
  - Inbound baggage system
  - Outbound baggage systems
- ☐ Common Use Facility
  - Inbound baggage system
  - Outbound baggage system

Carrier Type

- ☐ Legacy Carrier
- ☐ Low-Cost Air Carrier
- ☐ International Carriers
- ☐ Domestic Carriers
- ☐ Commuter/Regional Carriers
- ☐ Charter/Seasonal
- ☐ Hub Operations
  - ○ Small
  - ○ Medium
  - ○ Large

Identify Project Parameters

- ☐ Budget/Rough Order of Magnitude
- ☐ Space Requirements and Limitations for Baggage Handling System in Terminal
- ☐ Current and Future Projected/Forecasted Passenger Volume with Established Criteria Number of Bags per Passenger
  - ○ Originating
  - ○ Transfers

Baggage Handling System Parameters

Outbound Originating Baggage System

- ☐ Originating Passenger Check-in
  - ○ Traditional staffed ticket counters
    - ▪ Domestic
    - ▪ International
    - ▪ First Class
  - ○ Self-service devices
  - ○ Remote self-service devices with tag printing capabilities
  - ○ Curbside check-in facilities
  - ○ Remote/off-site check-in facilities
  - ○ Bus/train/rental car check-in facilities
  - ○ Odd sized/oversized
  - ○ Non-conveyable/special handling items
  - ○ Bagwell scales
- ☐ Sortation System
  - ○ Centralized baggage system
  - ○ Decentralized baggage system
- ☐ Sortation Components
  - ○ Automated tag reader
    - ▪ Laser scanner tag reader
    - ▪ Radio frequency identification tag reader
- ☐ Sortation Device Types
  - ○ Run-out belt
  - ○ Sloped bed make-up device
  - ○ Flat plate make-up device
  - ○ Sort piers
    - ▪ Drive-thru or manual manipulation
    - ▪ Single or double stacked

  - Tilt-tray
  - Destination coded vehicle—high-speed vehicle
- Sortation Operational Requirements
  - Flight Information Display System
  - Drive aisle/drive-thru rights-of-way
    - Common tug-cart lanes
  - Baggage cart storage
    - Single common use system
- Transfer Baggage
- Early Bag Storage System

Inbound Domestic Operations—Baggage Claim

- Separated Facility from International
- Flat Plate Claim
  - Oval configuration
  - L-shaped configuration
  - T-shaped configuration
  - W-shaped configuration
- Sloped Bed Claim
  - Single feed belt configuration
  - Double feed belt configuration
- Odd-Sized/Oversized Baggage
  - Odd-sized/oversized belt system
    - Single location or multiple locations
  - Odd-sized/oversized stainless steel slide
    - Single location or multiple locations
- Non-Conveyable/Special Handling Items

Baggage Handling System Support

- Baggage Handling System Command Center/Control Room
- Baggage Handling System Remote Monitoring Locations
- Baggage Handling System Spare Parts Room
- Baggage Handling System Maintenance Room
- Motor Control Panel Baggage Handling System Locations and/or Room

Federal Inspection Services Baggage Handling System

Inbound International Operations—International Baggage Claim/Baggage Re-Check

- Separated Facilities
- Odd-Sized/Oversized Baggage
  - Odd-sized/oversized belt system
    - Straight belt system
    - Belt system with oversized turns
  - Odd-sized/oversized stainless steel slide
- Flat Plate Claim—claim level and apron level at same elevation
- Sloped Bed Claim
  - Claim level and apron level at same elevation feed to sloped bed from overhead
  - Claim level at higher elevation than apron level and feed to sloped bed from underneath
  - Claim level at lower elevation than apron level and feed to sloped bed from overhead

- ☐ Recheck Facilities
    - ○ Odd-sized/oversized recheck baggage system
    - ○ Recheck belt system

Checked Baggage Inspection Screening System

Outbound Baggage Screening Options

- ☐ Originating Passenger Baggage Screening
    - ○ Manual Explosive Detection System Screening System
    - ○ Automated In-Line Screening System
        - ▪ Single common use system
        - ▪ Multiple common use systems
        - ▪ Separate domestic and international systems
        - ▪ Explosive Trace Device machines
        - ▪ Explosive detection system machines
            - – Federal Inspection Services lobby based
            - – Remote Secured Side System
    - ○ Odd-sized/Oversized Screening System
        - ▪ Odd-sized/oversized conveyable baggage screening system
            - – Lobby based
            - – In-line capabilities
        - ▪ Non-conveyable/special items baggage screening system
            - – Lobby-based system
            - – Secured side system
    - ○ Lobby Screening System
        - ▪ Pre-check-in
        - ▪ Post-check-in
    - ○ Remote/Offsite Check-in
    - ○ Curbside Check-in
    - ○ Transportation Security Administration—Latest Revision of Checked Baggage Inspection System Design Guidelines

Inbound Baggage Screening Options

- ☐ Transfer Passenger Baggage Screening
    - ○ International Recheck
    - ○ Canadian Transfer/Recheck
    - ○ In-Line Screening System
        - ▪ Single common use system
        - ▪ Multiple common use systems
        - ▪ Separate domestic and international systems
    - ○ Odd-sized/Oversized Screening System
        - ▪ Odd-sized/oversized conveyable baggage screening system
            - – Explosive Trace Device machines
            - – Explosive detection system machines
                - ♦ Federal Inspection Services lobby based
                - ♦ Remote secured side system
                - ♦ In-line capabilities
        - ▪ Non-conveyable baggage screening system
            - – Federal Inspection Services lobby based system
                - ♦ Explosive Trace Device machines
            - – Remote secured side system
    - ○ Federal Inspection Services Lobby Screening System

In-Line Explosive Detection System Support

- Explosive Detection System Room
- On-Screen Resolution Room
- Muxing Room
- Explosive Trace Device Room
- Explosive Detection System Spare Parts Room
- Baggage Handling System Command Center/Control Room
- Baggage Handling System Spare Parts Room
- Baggage Handling System Maintenance Room
- Motor Control Panel Locations and/or Room

A-9 Information Technology

Planning Considerations for Terminals

- Stakeholder Requirements
  - Airport Departments
  - Public Safety
  - Air Carriers
  - Cargo Carriers
  - Concessionaires
  - Other Tenants
  - Transportation Security Administration including International Arrivals
- Shared and Common Use Facilities
  - Multi-User Flight Information Display System/Flight Information Display System
  - Paging/Announcements
  - Common Use Terminal Equipment, Multi-User System Environment and Common Use Self-Service
  - Holdroom and Gate Services
  - Baggage Handling and Reconciliation
  - Physical Security including badges
  - Information Technology Cable Plant—fiber and copper
  - Information Technology Wireless Services
  - Geo-location including vehicle and personnel tracking
- Level and Quality of Service
  - Service Level Guarantees
- Expansion Plans

Information Technology System Architecture and Design

- Network Framework and Capacity
  - Ethernet Standards
  - Distributed Model
  - Quantity and Location of Nodes
  - Network Services
    - Data
    - Voice
    - Video—community antenna television, security closed circuit television
  - Bandwidth Management and Over-Subscription
    - Optimization for quality of service

- Video Management
- Storage Management
  - Storage policies
  - Storage access
  - Watermarking

☐ Network Functions and Design Requirements
- Functional Requirements
  - System redundancy and failover
  - Data segmentation and virtual private networks
  - Multicasting
  - Internet access and IPv6
  - Configuration management
  - Performance monitoring
- Server Farms
- Data Centers and Telecommunication Rooms
  - Space, power, and cooling requirements
  - Layouts and cabling
  - Backup electrical power
  - Physical security and access control
- Cable Plant
  - Cable Routing—public vs. secured areas
  - Cable Management

☐ Network Security
- Firewalls and De-Militarized Zones
- Access Management and Permissions
- Wireless Security
- Remote Access Provisions

IT System Support

☐ Operation

☐ Maintenance

☐ Training

A-10 Sustainability

Design Process

☐ Kick-off Charrette

☐ Integrated Process

☐ Project Preview and Coordination

☐ Construction Administration

Site Development

☐ Implement an erosion and sedimentation control plan

☐ Avoid developing on
- Prime farmland
- Previously undeveloped land with an elevation of 5 feet below the 100-year flood plain
- Land inhabited by endangered or threatened species
- Areas within 100 feet of any wetlands
- Previously undeveloped land within 50 feet of a water body
- Land that is or has been defined as public parkland

- ☐ Direct development to urban areas where infrastructure exists, greenfields are protected and habitats and natural resources are protected
- ☐ Remediate project areas where environmental contamination has occurred—reducing pressure on undeveloped land
- ☐ Provide access to public commuter rails, light rails, subways, or bus lines
- ☐ Provide preferred parking for low-emitting and fuel-efficient vehicles
- ☐ Install alternative fuel refueling stations
- ☐ Size parking capacity to meet but not exceed minimum local zoning requirements
- ☐ Limit site disturbance beyond the immediate project site
- ☐ Restore damaged areas within the project site with native or adaptive vegetation
- ☐ Reduce the development footprint (defined as the total area of the building footprint, hardscape, access roads, parking) by providing a high ratio of open space to development footprint
- ☐ Implement a stormwater management plan to
    - ○ Decrease the amount of stormwater runoff from the site by increasing perviousness on site (i.e., vegetated roofs, pervious pavement, rain garden, vegetated swales, etc.)
    - ○ Reduce or eliminate water pollution from runoff by increasing pervious cover on site (i.e., vegetated roofs, pervious pavement, rain garden, vegetated swales, etc.)
- ☐ Reduce site heat island effect (thermal gradient differences between developed and undeveloped areas) by utilizing sustainable design strategies:
    - ○ Provide shading for site hardscapes
    - ○ Use paving and roofing materials with a high Solar Reflectance Index (at least 29)
    - ○ Use an open grid paving system where applicable
    - ○ Provide underground parking whenever possible
- ☐ Minimize light trespass from the building and site to reduce glare and improve night-time visibility
    - ○ Decrease the amount of direct light emitting from the interior of the building to the exterior
    - ○ Incorporate lighting controls into design
    - ○ Use low-intensity, shielded fixtures on exterior lighting equipment

Water Conservation

- ☐ Reduce or eliminate the need for potable water used for irrigation purposes
    - ○ Incorporate native or adaptive species into landscape design eliminating the need for turf grasses
    - ○ Capture rain water to use for on-site irrigation purposes
    - ○ Recycle project site wastewater to use for irrigation purposes
    - ○ Use public water specifically designed for non-potable uses for irrigation
- ☐ Minimize potable water demand and maximize water efficiency within the building
    - ○ Install water-conserving fixtures (toilets, faucets, waterless urinals, etc.)
    - ○ Use captured rain water, recycled greywater, or on-site/municipally treated wastewater for non-potable water uses
    - ○ Treat wastewater to tertiary standards to be used on site

Energy Conservation and Ozone Protection

- ☐ Employ a commissioning agent early on in the design process to verify all building related energy systems are sized, installed, calibrated, and perform in accordance with the owner's project requirements

- ○ Heating, ventilating, air conditioning, and refrigeration and associated controls
- ○ Lighting and daylighting controls
- ○ Domestic hot water systems
- ○ Renewable energy systems [photovoltaic (PV), wind, etc.]

- ☐ Specify that all refrigeration equipment is chlorofluorocarbon free
  - ○ Choose refrigerant and HVAC&R with zero to low ozone depleting potential and direct global warming potential
- ☐ Demonstrate measurable increase of energy efficiency above baseline building performance using energy modeling
- ☐ Offset project site energy costs by designing and specifying renewable energy systems (solar, wind, biomass, etc.)
- ☐ Develop and implement a measurement and verification plan to evaluate project building performance
- ☐ Purchase grid-sourced, renewable energy technology power
  - ○ Enter into a 2-year contract with utility to purchase Green power
  - ○ Purchase Green-e certified Renewable Energy Certificates (www.green-e.org)

Material Procurement

- ☐ Develop and implement a construction waste management plan
  - ○ Divert a significant amount of construction, demolition, and land-clearing wastes from landfill
  - ○ Recycle cardboard, metals, brick, acoustic tile, concrete, plastics, clean wood, glass, gypsum wallboard, carpet and insulation
  - ○ Verify diverted material has been recycled or salvaged as intended
- ☐ Designate an easily accessible area that serves as a collection and storage site for non-hazardous materials to be recycled
- ☐ Reuse a significant portion of an existing building's structure and envelope in order to reduce waste and reduce the impact that building a new building has on the environment
- ☐ Reuse non-structural elements to conserve resources, reduce wastes, and reduce the impact that building a new building has on the environment
  - ○ Interior walls
  - ○ Doors
  - ○ Floor coverings
  - ○ Ceiling systems
- ☐ Reuse building materials and products
  - ○ Use salvaged, refurbished, or reused materials in the construction of the project for non-specialty items
  - ○ Materials include but are not limited to posts and beams, flooring, paneling, frames and doors, cabinetry, furniture, brick, decorative items
- ☐ Specify materials with post-consumer/post-industrial recycled content
  - ○ Steel, concrete, gypsum board, acoustical ceiling tile, carpet, ceramic tile
- ☐ Specify materials or products that have been extracted, harvested, recovered, or manufactured within 500 miles of project site
- ☐ Specify rapidly renewable building materials and products
  - ○ Materials made from plants that are typically harvested within a 10-year cycle
- ☐ Specify wood-based material and products be certified in accordance with the Forest Stewardship Council

Indoor Environmental Quality

- ☐ Develop and implement a construction indoor air management plan
  - ○ This section includes requirements for the development of a construction indoor air quality management plan (alternately referred to as "the Plan"). Develop the Plan for approval by the owner and architect. The Plan shall be implemented throughout the duration of the project construction, and shall be documented as outlined in the Submittal Requirements of Item 1.08 below. The Plan is included as part of the Leadership in Energy and Environmental Design building requirements for the project.
- ☐ Prohibit smoking within the project buildings
  - ○ Locate designated smoking areas at least 25 feet from entryways, outdoor air intakes, and operable windows
- ☐ Install monitoring equipment on ventilation systems to ensure that the system will maintain minimum ventilation requirements
  - ○ Monitor CO_2 concentrations within all densely populated areas
  - ○ Monitor airflow in all project spaces
- ☐ Specify the use of low volatile organic compound materials to be used on the interior of the building (defined as inside the weatherproofing system and applied on-site):

ARCHITECTURAL APPLICATIONS:	GRAMS/LITER
Shall not exceed the limits defined in Rule 1168 – "Adhesive and Sealant Applications" of the South Coast Air Quality Management District (SCAQMD), of the State of California.	
Indoor carpet adhesive	50
Carpet pad adhesive	50
Wood Flooring adhesive	100
Rubber floor adhesive	60
Subfloor adhesive	50
Ceramic tile adhesive	65
VCT and asphalt tile adhesive	50
Drywall and panel adhesive	50
Cove base adhesive	50
Multipurpose construction adhesive	70
Structural glazing adhesive	100

SPECIALTY APPLICATIONS:	GRAMS/LITER
PVC welding	510
CPVC welding	490
ABS welding	325
Plastic cement welding	250
Adhesive primer for plastic	250
Contact Adhesive	80
Special Purpose Contact Adhesive	250
Adhesive Primer for Traffic Marking Tape	150
Structural Wood Member Adhesive	140
Sheet Applied Rubber Lining Operations	850
Top and Trim Adhesive	250

SUBSTRATE SPECIFIC APPLICATIONS	GRAMS/LITER
Metal to metal	30
Plastic foams	50
Porous material (except wood)	50
Wood	30
Fiberglass	80

SEALANT VOC LIMITS:	GRAMS/LITER
Architectural	250
Single Ply Roof Material Installation/Repair	450
Non-membrane Roof Installation/Repair	300
Other	420
Sealant Primer:	
Architectural – Nonporous	250
Architectural – Porous	775
Other	750

PAINTS, PRIMERS, AND COATINGS	GRAMS/LITER
Shall not exceed the limits below as defined in GreenSeal Standard 11 (GS-11), First Edition, May 20, 1993	
Flat Finishes	50
Non-Flat Finishes (i.e. satin, gloss)	150
Anti-Corrosive Paint Finishes	250
Shall not exceed the limits defined in GreenSeal Standard 03 (GS-03), Anti-Corrosive Paints, Second Edition, January 7, 1997	

ARCHITECTURAL COATINGS:	GRAMS/LITER
Shall not exceed the limits defined in Rule 1113 – "Architectural Coatings". Rule in effect January 1, 2004. South Coast Air Quality Management District (SCAQMD), State of California, www.aqmd.gov	
Clear Wood Finish: Varnish	350
Clear Wood Finish: Lacquer	550
Stains	250
Floor Coatings	100
Water Proofing Sealers	250
Sanding Sealers	275
All Other Sealers	200
Shellac: Clear	730
Shellac: Pigmented	550

- ☐ Carpet systems shall meet the testing and product requirements of the Carpet and Rug Institute Green Label Plus program
- ☐ Composite wood and agrifiber wood products (i.e., particle board, medium density fiberboard, plywood, wheatboard, strawboard, panel substrates, door cores, etc.) used on the interior of project building shall contain no added urea-formaldehyde substances
- ☐ Provide comfortable thermal environment for all building occupants using American Society of Heating, Refrigerating, and Air Conditioning 55-2005
    - ○ "This standard specifies the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space. The environmental factors addressed are temperature, thermal radiation, humidity, and air speed; the personal factors are those of activity and clothing."
- ☐ Specify implementing a thermal comfort survey of the project building's full-time and part-time employees
    - ○ Take corrective action if survey shows more than 20% of full-time and part-time employees are dissatisfied with thermal comfort levels
- ☐ Design and build project building to maximize interior daylighting

Construction Practices

- ☐ Construction Waste Management Plan
- ☐ Construction Indoor Environmental Quality Plan
- ☐ Low-Emitting Equipment

APPENDIX B

Other Pertinent ACRP Studies

The following table lists the other ACRP research studies currently being conducted that have relevance to the *Airport Passenger Terminal Planning and Design* Guidebook (ACRP 07-05). One of the underlying premises of ACRP 07-05 was to coordinate with and, when possible, reference and draw on significant findings and recommendations stemming from these other airport terminal–related ACRP research projects. Table B-1 provides an overview of 16 relevant ACRP studies.

Table B-1.

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
1.	ACRP 11-02, Task 2/ *ACRP Report 4*	Ground Access to Major Airports by Public Transportation	Matthew A. Coogan	Matthew Coogan
Objective				
The objectives of this task were to (1) improve the documentation of all airport ground access projects, with an emphasis on those that have occurred since the publication of *Transit Cooperative Research Program (TCRP) Report 62* in 2000; (2) improve the documentation of changes in airport access strategies since the publication of both reports with a review of recent developments in such areas as downtown check-in, automation of the check-in process, and integration with existing regional rail infrastructure; (3) provide airport managers with user-friendly, concise, and accurate documentation concerning trends in the area of airport ground access; and (4) support and facilitate the dissemination of the latest information relative to airport managers through media such as printed reports and PowerPoint presentations to relevant professional organizations. The research created new and updated, timely documentation of the characteristics of ground access markets in a manner that builds on existing products already produced under TCRP.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
2.	ACRP 11-02, Task 1/ *ACRP Research Results Digest 2*	Model for Improving Energy Use at U.S. Airport Facilities	Texas A&M Energy Systems Laboratory	Dan Turner
Objective				
The objective of this task was to demonstrate the potential for energy savings in U.S. airports by conducting a study of Terminals B and D at Dallas/Fort Worth International Airport regarding operations and maintenance (O&M), commissioning of energy-consuming systems, and energy conservation retrofit measures. This objective was accomplished by conducting airport surveys and engineering analyses and producing a model energy report and informational brochure that focuses on pro-typical operations, building commissioning, and energy conservation retrofit opportunities.				

Table B-1. (Continued).

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
3.	ACRP 11-03, S03-02/ *ACRP Synthesis 5*	Airport Ground Access Mode Choice Models	Aviation System Consulting, LLC	Geoffrey D. Gosling
Objective				
This synthesis report examines the characteristics of existing ground access mode choice models and explores the issues involved in the development and use of such models to improve the understanding and acceptance of their role in airport planning and management.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
4.	ACRP 11-03, S10-02/ *ACRP Synthesis 8*	Common Use Facilities and Equipment at Airports	Barich, Inc.	Rick Belliotti
Objective				
This synthesis report provides meaningful information to aviation stakeholders in the airport environment considering how common-use facilities and practices may impact finances, technology, operations, facilities, business decisions, and policies. The synthesis report focuses on facilities, systems, and practices that compose the common-use environment and includes advantages and disadvantages of common-use systems, business and operational practices that require modification to implement common use, and actual experience to date.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
5.	ACRP 11-03, S02-02/ *ACRP Synthesis 10*	Airport Sustainability Practices	Ove Arup & Partners California Ltd.	Jean Rogers
Objective				
The initial compilation of sustainable practices from this synthesis could be used in several ways: (1) to document and serve as guidance to sustainable operations for airport operators; (2) to evaluate and rate airports' progress toward sustainability; (3) for use as a planning tool for airport operators in developing specific sustainability plans; and (4) to identify research needed to accelerate the adoption of sustainable practices.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
6.	ACRP 03-02/ *ACRP Report 23*	U. S. Airport Passenger-Related Processing Rates	HNTB Corporation of Arlington, VA	Joseph Navarrete
Objective				
The objectives of this research were to (1) compile a unified database on passenger-related processing rates in an electronic spreadsheet or database format that is useful to planners, designers, and other interested parties and (2) provide guidance on how best to collect passenger-related processing point data.				

Table B-1. (Continued).

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
7.	ACRP 03-05	Passenger Space Allocation Guidelines for Planning and Design of Airport Terminals	TransSolutions	Gloria Bender
Objective				
The objective of this project is to develop passenger space allocation guidelines for terminal functional areas. The guidelines are to be based on level of service (LOS) scales developed from a sample of data collected at 10 airports. The guidelines will be used by airport operators, planners, and consultants in making decisions on development of new terminals and renovation of existing facilities.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
8.	ACRP 03-06	Guidebook for Planning and Implementing Automated People Mover Systems at Airports	Lea + Elliott	David Little
Objective				
The objective of this research is to prepare a comprehensive guidebook for planning and implementing automated people mover (APM) systems at airports. The guidebook should include, as appropriate, a CD-ROM with interactive tools that will assist airports to plan and implement an APM system. The scope of this research includes APM systems that provide transportation on airport grounds as well as access to remote facilities (e.g., airport parking, car rental facilities, hotels, off-airport public transportation, and other related activity centers).				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
9.	ACRP 03-07	Guidebook for Measuring Performance of Automated People Mover Systems at Airports	Lea + Elliott	Chris Gambla
Objective				
The objective of this research is to develop a user-friendly guidebook for measuring performance of APM systems at airports. The guidebook should identify a set of performance measures and associated data requirements for APM operators at airports to assess and improve performance, compare APM systems, and plan and design future APM systems. The performance measures should address the efficiency, effectiveness, and quality of APM systems at airports, particularly focusing on affects on APM passengers and on airport performance.				

(continued on next page)

Table B-1. (Continued).

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
10.	ACRP 03-14	Airport Passenger Conveyance System Usage / Throughput	RFP IN PROCESS	RFP IN PROCESS
Objective				
The objective of this research is to prepare a comprehensive guidebook that will serve as a decision-support tool for planning, designing, and evaluating passenger conveyance systems at airports. The scope of this research should examine how passenger conveyance systems operate and provide service to different areas within the airport environment. For the purpose of this research project, passenger conveyance components include, but are not limited to, escalators, elevators, moving walkways, wheelchairs, and passenger assist vehicles/carts.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
11.	ACRP 07-01/ *ACRP Report 10*	New Concepts for Airport Terminal Landside Facilities	Corgan Associates, Inc. of Dallas, TX	Philip Mein
Objective				
The objective of this research was to develop new concepts that will stimulate design innovation for terminal landside facilities at FAA-designated large- and medium-hub airports to improve passenger accessibility and LOS between ground transportation and the secure parts of the terminal.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
12.	ACRP 07-02	Airport Curbside and Terminal-Area Roadway Operations	Jacobs Consultancy	Peter Mandle
Objective				
The objective of this project is to develop a guide to analyze the operation of the airport curbside and the terminal area roadways, including the effects of direct access points (e.g., on-airport commercial parking, rental car operations, and hotels).				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
13.	ACRP 07-04/ *ACRP Report 25, Volume 2*	Spreadsheet Models for Airport Terminal Planning and Design	Landrum & Brown	Matthew H. Lee
Objective				
The objectives of this research were to (1) develop a user–friendly spreadsheet model (or models), with an accompanying manual, to analyze issues common to airport passenger terminal planning and design and (2) produce a compendium that identifies the types, scopes, and availability of spreadsheet and discrete event models that can be used by airport operators for airport passenger terminal planning and design. The prime users of this project's products are intended to be employees of airport operators who are involved in terminal planning and design.				

Table B-1. (Continued).

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
14.	ACRP 07-06	Wayfinding and Signing Guidelines for Airport Terminals and Landside	Gresham, Smith and Partners	James R. Harding
Objective				
The objective of this research is to develop a handbook for airport operators containing up-to-date wayfinding and signing guidelines for the airport terminal and landside. The purpose of the handbook is to facilitate the safe and efficient movement of passengers within each airport and from one airport to another through the uniform application of the guidelines. The guidelines should address the following areas: (1) terminal including concourses/gates, ticketing/check-in, security checkpoints, Federal Inspection Services, baggage claim; (2) curbside/ground transportation; (3) parking; and (4) on-airport roadways/off-airport access roads.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
15.	ACRP 10-02	Planning Guide for Offsite Terminals	MarketSense Consulting, LLC of Charlestown, MA	Evelyn Addante
Objective				
The objective of this research is to provide a guide for airport operators and others to use in planning offsite terminals. The research shall address topics such as warrants for offsite terminals and factors that influence their success, cover the range of services provided, and identify potential stakeholders and partners.				

S.No.	Project/ Publication	Name	Research Agency	Principal Investigator
16.	ACRP 10-05/ *ACRP Report 30*	Understanding Common-Use Approaches at Airports	Barich, Inc.	Rick Belliotti
Objective				
The objective of this research is to develop a reference guide for airports, airlines, and other stakeholders to identify and understand the financial, operational, liability, safety, customer service, and competitive elements of a common-use approach to the utilization of airport facilities and the provision of services. The guide should provide detailed analyses and information enabling individual airports and airlines to evaluate the feasibility and applicability of implementing a common-use approach. It should also provide common practices for evaluating, implementing, operating, and maintaining common-use facilities and services.				

APPENDIX C

FAA White Papers

Topic Paper

Management and Financial Considerations in Terminal Planning and Design

Prepared for
U.S. DOT/Volpe National Transportation Systems Center
By Mark W. Nagle
March 2004

Introduction

Today more than ever, management and financial considerations are essential to the planning and design of airport passenger terminals. While most commercial-service airports and passenger terminals in the United States are publicly owned and operated, management practices increasingly resemble private sector enterprise. In formulating terminal development programs today, management's objectives often emphasize revenue maximization, efficiency, and flexibility. Meeting these objectives requires coordination between terminal planners and designers, financial planners, concession planners, and other practitioners involved in the process.

Clearly, a basic understanding of management and financial considerations will enhance the terminal planner's ability to make informed planning decisions that capture the desired program's purpose, need, and scope. Moreover, the terminal planner's appreciation of the needs and perspectives of management and financial planners will further enable all participants to work together in achieving expedited program acceptance, approvals and implementation.

Airport management and airport finance are topics of considerable scope involving specialized fields of training and practice. More often than not, the terminal planner's/designer's training and background is not in either of these fields, but in a technical discipline such as engineering or architecture. This paper provides an overview discussion intended to help the terminal planner/designer gain a basic understanding of some of the fundamental management and financial considerations that will facilitate informed and fruitful participation in collaborative terminal development efforts.

Airport Management Overview

Airport management is a uniquely challenging undertaking. Airports provide important public benefits as integral parts of the national transportation network, and as vital elements of local and regional economies. Most airports that serve airline passenger traffic in the United States are publicly owned and operated by local or state governments, or by quasi-public authorities created by local or state jurisdictions. Airports are subject to numerous local, state and federal regulations designed to address environmental issues, safety issues, and other concerns of vital public interest.

At the same time, airports typically are expected to be self-financed with revenues obtained from airlines, concessionaires, passengers, and other airport users and tenants. In addition, airports must constantly adapt to an ever-changing operating environment driven by various, and often unpredictable, forces and events beyond management's control.

Airport Stakeholders

Airport management typically deals with a diverse range of stakeholder groups with various direct and indirect interests in the airport. The range and mix of stakeholders varies from airport to airport; however, the same four basic categories of stakeholder constituencies are typically common to all.

Internal business stakeholders. This group is comprised of both commercial and non-commercial enterprises, including their employees, that have interests directly tied to the airport. Most prominent within this group are the airlines. Also included are commercial enterprises such as terminal concessionaires whose customer base is made up of airport users. Non-commercial enterprises such as FAA, Customs, Immigration & Naturalization, the TSA [and] their employees are also included.

External business stakeholders. This group includes the flying public and all other customers for services offered on the airport.

Internal employee stakeholders. This group includes all employees of the airport and its parent organization.

External general stakeholders. This group includes local citizens, taxpayers, nearby residents, community members, and others who may or may not actually use the airport but may vote on airport issues or elect representatives who can influence airport policy and decisions.

Types of Management Objectives

Management's objectives for undertaking a terminal development program can encompass a broad range reflecting the unique mix of stakeholders and characteristics of the air travel market it serves. Among the types of objectives that may be included are the following:

- Enhancing or expanding capacity in response to changes in air service and levels of demand;
- Enhancing passenger amenities and levels of service;
- Maintaining or attracting air service;
- Maximizing non-airline revenues;
- Promoting competition among airline tenants;
- Enhancing aviation security;
- Enhancing the image and attractiveness of the local community as a travel destination;
- Upgrading or modernizing obsolete facilities;
- Maximizing or preserving operational flexibility;

Pricing of Airport Facilities and Services

Two basic approaches are used in the pricing of an airport's facilities and services reflecting the airport's dual role with respect to its internal business stakeholders. With respect to non-airline or non-aeronautical users, the airport operates like a private landlord and can set prices on a market basis. With respect to airlines and other aeronautical users, the airport must charge on a cost-recovery basis. Under a cost-recovery approach, airlines' rates and charges are based on their allocated share of costs associated with running the airport. These costs typically include 1) costs for maintenance operations, and administration; 2) debt service, or capital cost recovery; and 3) debt service coverage.

Airport Use and Lease Agreements

The financial and operational arrangements between an airport and its internal business stakeholders are usually formalized in legally binding use and lease agreements. These agreements define both the airport's and stakeholders' rights and obligations and specific terms and conditions governing the stakeholders' use of facilities owned by the airport. An airport may cover all of its facilities and services in a single use and lease agreement, or negotiate separate agreements covering use of the airfield, the terminal area, and other separate airport cost centers.

An airport can operate without a use and lease agreement. In such cases, rates and charges are usually set by ordinance. Among the key issues addressed in lease and use agreements are:

(1) *Rate Setting Method.* The method used to determine the rents and fees paid by airlines and other tenants.
(2) *Airline Rights to Review/Approve.* The degree of influence and control that the signatory airlines may have regarding capital investments and other policies that may affect their rates.
(3) *Length of Term of Use.* The length of time that an airline or other tenant is granted use of a facility. Terms of use can be as high as 30 years or can run on a month-to-month basis.

Use and lease agreements can be classified into three categories based on the approach taken in setting airline rates. These categories include residual, compensatory, and hybrid agreements.

Residual agreements. Under a residual agreement, the signatory airlines collectively assume most of the financial risk of operating the airport. The basis for calculating airline rates is the difference, or residual, between the costs identified for all airport users and revenues from non-airline sources. In signing a residual agreement the airlines essentially provide the airport operator with a guarantee of financial solvency. However, the airport forgoes the opportunity to accumulate income from non-airline sources since these revenues are, in effect, credited to the airlines in setting their rates. In return for assuming greater risk, airlines are granted a considerable degree of influence over investment and other policy decisions at the airport. The majority of residual agreements include so-called majority-in-interest (MII) provisions. MII provisions give signatory airlines representing a majority of the airport's traffic rights to review and, possibly, approve or veto capital projects that may significantly increase their rates. In addition, residual-cost airports typically provide airlines with longer terms of use for the facilities they use and occupy, with leases that can run 20 years or more.

Compensatory agreements. Under a compensatory agreement, most of the financial risk of operating the airport is assumed by the airport itself. Airlines pay only for the facilities and services they actually use based on their allocated share of costs. Any deficit, or surplus, between total airport costs and revenues is assumed by the airport. By assuming less risk airlines are granted less influence on capital investments and other policy decisions, than is typically granted in a residual agreement. This allows the airport significantly more latitude in the uses and sources of funds. The airport is also allowed to accumulate potential surpluses from non-aeronautical revenue sources such as concessions or parking. Most often, there are no MII provisions included in a compensatory agreement. Also, the length of term of use provided in a compensatory agreement is also typically less than under a residual agreement.

Hybrid agreements. A hybrid agreement combines aspects of both residual and compensatory agreements. For example, a hybrid agreement may involve the use of a residual approach for recovering airfield costs while a compensatory approach is used for the terminal area. This form of agreement usually imposes greater limits on an airport's control of its sources and uses of funds than a pure compensatory agreement. However it can significantly reduce the financial risk an airport faces since recovery of its airfield costs is guaranteed.

Financial Management Trends

Deregulation of the airline industry in 1978 significantly changed the business environment for both airlines and airports. Before deregulation airlines were considered to be relatively stable business enterprises involving less financial risk than the airports they used. Since deregulation, that perception has undergone a reversal, particularly for airports in large urban markets. It is now widely recognized that an airport's financial stability and revenue generating capacity is determined by the strength of the local air travel market, not by long term airline contracts. Several trends in airport financial management which first began to appear in the post-deregulation period continue today. These include (1) shorter terms for use agreements and more frequent adjustments to rates and charges, (2) greater use of compensatory or hybrid agreements including modification or weakening of MII provisions, and (3) increased focus on maximizing and diversifying revenues.

Airline Use and Lease of Terminal Facilities

Airport management is usually responsible for operating and managing passenger terminals which may accommodate a number of different airlines with individual leaseholds. Less frequently, but not uncommonly, a terminal may be leased to a single airline or a third party which also assumes primary responsibility for management of day-to-day terminal operations. In other cases, an airline, or third party may negotiate a long-term ground lease of terminal area property, and assume more comprehensive responsibility for the facility including its planning, design, construction, financing, maintenance and day-to-day operations. The types of terminal facilities typically used and/or leased by airlines include:

- Ticket counters
- Ticket offices
- Aircraft gates and holdrooms
- Airline club rooms
- Baggage handling space
- Baggage claim devices
- Baggage offices
- Operations and maintenance space

Use of certain terminal facilities such as gates, for example, can be granted to airlines on an exclusive-use, preferential-use, or common-use basis. Gates leased on an exclusive-use basis cannot be used by another airline without the leaseholder's permission. For gates leased on a preferential-use basis, the leaseholder is given priority but other airlines are allowed access during periods when the gates are not needed by the leaseholder. Gates assigned on a common-use or joint-use basis can be used by any airline as needed.

By committing more gates than are actually needed to an airline under a long-term lease on an exclusive-use basis, an airport risks underutilization of its gate capacity. At airports where the supply of gates is constrained this practice can have a chilling effect on airline competition. For these reasons, airports are increasingly negotiating agreements with preferential rather than exclusive-use provisions. In addition, so-called "use-or-lose" provisions are becoming more common. With "use-or-lose" provisions, an airline that does not maintain a certain number of daily flights from its leased gates can have its right to use any underutilized gates revoked by the airport.

Ticket counters are usually leased on an exclusive-use basis, particularly if the airline schedules departures with sufficient frequency to justify dedicated counter frontage. Ticket counters can also be leased on a common-use basis. Managing and operating common-use facilities often involves supporting IT infrastructure known as a Common Use Terminal Environment (CUTE). CUTE systems allow gates or ticket counters to be easily reallocated to different airlines as needed. In this context, the word terminal refers to a computer terminal that can be shared by gate agents or ticket agents of different airlines. At airports in the United States, CUTE systems are most commonly found in terminals that accommodate international carriers or charter carriers.

Planning for Management Flexibility

CUTE systems can provide flexibility needed to efficiently accommodate day-to-day operations in a terminal. Providing management with the flexibility to accommodate different future scenarios is also an important consideration. While planning always involves a certain degree of uncertainty, the effects of airline deregulation, and other industry trends, have only increased the uncertainty involved in anticipating future terminal facility requirements.

Airlines may initiate or terminate service, change routes, or modify hubbing activity with little or no advance notice. A low-cost carrier may enter a new market temporarily stimulating rapid growth in air travel demand. Established carriers with a significant presence at an airport can struggle and go out of business. Aircraft fleet mixes can change significantly. Airports with multiple unit terminals may need to reallocate airlines among terminals to balance demand and capacity. For these and other reasons, the mix of airlines, types of aircraft, and passenger characteristics anticipated at the beginning of a terminal planning effort may prove to be obsolete soon after opening day.

A scenario-based planning approach can help ensure a sufficient degree of flexibility. Instead of relying on narrowly defined planning assumptions based on relatively simple extrapolations of current trends and patterns, a scenario-based approach explores alternative "what-if" scenarios. These alternative scenarios can help establish a range of possible future requirements that may be reasonably anticipated for a terminal. For example, by defining alternative fleet mix scenarios, an aircraft parking and apron layout can be developed which accommodates any of the alternative scenarios. The resulting envelope may provide a "loose-fit" for any one scenario, or for the fleet mix that is eventually realized over the planning horizon. The desired flexibility may therefore involve additional costs. The terminal planner will need to assist management in (1) establishing the degree of flexibility that should be reasonably anticipated, and (2) evaluating the financial and operational trade-offs involved.

Terminal Concessions

Concessions include all of the various non-airline commercial enterprises that operate in the terminal. Starting in the late 1980's, the industry's approach to terminal concessions underwent significant rethinking as airports, and others, recognized a largely untapped potential for generating revenue while enhancing passengers' quality of experience at the airport. As a result, terminal concessions now typically receive considerably more attention as a terminal planning and design issue, and from a financial perspective, as a significant source of non-airline revenue. Types of terminal concessions include:

- Food and beverage
- Merchandise
- Passenger services
- Amusements
- Display advertising

Airport and terminal operators today frequently rely on concession planning specialists in developing, implementing, and managing terminal concession programs. The concession planner typically provides a detailed program identifying the mix and types of concession space, floor area requirements, support spaces, and other design requirements. In developing the concession program, passenger surveys are used to determine the unique market characteristics of the airport, thus ensuring higher revenue productivity, and satisfaction of passenger preferences and demands. Terminal concession contracts are usually awarded on the basis of competitive bids and are structured to provide the airport with a minimum annual guaranteed payment, or a specified percentage of gross revenues.

Coordination and collaboration between the terminal planner/designer and the concession planner is required to ensure that the concession program is well integrated into the terminal's layout and design. Generally, concessions should be located to provide maximal visibility and accessibility along key passenger flow corridors. Recent changes in security requirements have significantly altered pedestrian circulation patterns in terminals thereby impacting terminal concessions. Restricting post-security access to ticketed passengers and employees only has reduced the potential customer base of some concession in post-security locations. Other pre-security locations now receive greater traffic. These changes in circulation patterns will likely be permanent and will need to be factored into any new terminal concession planning programs.

Management and Financial Implications of New Security Requirements

The Aviation and Transportation Security Act (ATSA) signed into law in November 2001 has had a major impact on all aspects of terminal operations, planning, and development. The full implications of ATSA, particularly with respect to terminal management and financial practices, are still evolving. The following provides a general discussion, based on the current (October 2003) situation.

ATSA's creation of the Transportation Security Administration (TSA), charged with responsibility for overseeing all aspects of airport security, has introduced a major new stakeholder into the mix of participants involved in terminal management and operations. The TSA must not only approve individual airport security programs, it must also assist in their development and implementation through a federal airport security manager stationed at all major commercial-service airports.

Airports, the airlines, and the TSA, all share a common interest, and a common challenge, in balancing the need for security with the need for acceptable passenger levels of service. Currently, with the exception of five pilot program airports, the TSA manages passenger and baggage security screening capacity at all of the nation's commercial-service airports. TSA control and direction covers the screening procedures involved, and the deployment of staff and equipment resources. Deficiencies in screening capacity, even for short periods, can rapidly increase delay and congestion in the terminals, creating significant problems for the airports and airlines. Recently, under budget pressure, the TSA has been forced to reduce the total number of screeners that were originally deployed nationwide.

ATSA included a provision allowing airports to "opt out" of federalized screening, and manage their own force of private screeners. Beginning in November 2004 airports can apply to opt out of the federalized program. Airports electing to exercise this option will assume a significant new management responsibility. However, they may be attracted by the opportunity to gain more direct control over the deployment of screening staff, and with it, the possibility of maintaining more acceptable levels of service for their flying public.

ATSA-mandated security enhancements have raised significant financial issues for airports. Resolution of these issues is still evolving and probably will continue to do so for some time. Generally speaking, the capital costs of Explosive Detection System (EDS) equipment and the operating costs of TSA screeners are funded as part of the TSA's operating budget. Other costs including the capital costs to modify terminal baggage systems to incorporate EDS equipment will also require funding. The TSA has established a letter-of-intent program that allows airport operators to borrow funds now for eligible security projects and repay bonds or loans or reimburse themselves with TSA funds later. However, LOI's do not obligate the TSA to make future payments unless adequate funding is approved by Congress.

Economic and Financial Considerations

Assessment of the economic and financial aspects of a proposed terminal program is a critical part of the planning process. Key tasks involved in making these assessments include determining the program's funding requirement, identifying the uses and sources of funds, and evaluating the program's economic and/or financial feasibility.

Funding Requirement

The funding requirement is the total estimated capital costs needed to implement the program. Capital cost estimates are typically developed and updated at key stages in the program's definition from conceptual through final design. Program capital costs include construction costs and associated "soft costs" such as architectural and engineering fees, overhead for construction administration, allowance for contingencies, and allowance for interest expenses during construction. If the project will be implemented in stages, the capital cost estimate will identify anticipated expenditures for each incremental stage of development. If the airport does not already own the land on which the terminal will be located, land acquisition costs will also need to be included.

Capital Funding Sources

Airport capital projects can draw on a variety of funding sources including the bond market, private lenders, federal and state grants, charges to passengers, and airport revenue. Three sources most often relied on are the bond market, federal grants issued under the Airport Improvement Program (AIP), and passenger facility charges (PFC's).

Revenue bonds are the most commonly used type of bond financing for airport improvements. With revenue bonds, funds are borrowed to develop specific capital improvements. Principal and interest is repaid from revenues generated from operating facilities developed with the bond proceeds. For terminal projects the borrower, or bond issuer, is typically the airport. Individual airlines may also issue bonds to finance the development of dedicated terminal or other facilities at an airport. The interest cost for a particular bond issue is determined in a competitive bidding process. Potential bond buyers will require lower interest costs for issues involving less financial risk. In evaluating a particular bond issue's potential merits and risks, buyers will rely on reports prepared by feasibility consultants hired by the issuer, and on appraisals from independent rating agencies.

Under the Airport Improvement Program (AIP) federal grants are issued for airport development projects. AIP funds are allocated among five different categories of airports by the FAA based on a variety of criteria. AIP-funded projects must meet eligibility requirements. Terminal development eligible for AIP funding is essentially limited to public or non-revenue generating areas.

Legislation enacted in 1990 authorized operators of commercial service airports to impose a Passenger Facility Charge (PFC) on enplaning passengers to fund certain airport planning and development costs. Operators seeking to impose PFC's must prepare a capital plan and financing strategy which are presented to the airlines serving the airport, and to the FAA as part of a formal application. The operator may propose a $1, $2, or $3 charge per enplaned passenger. If approved, PFC collections can be used to fund airport projects on a "pay-as-you-go" basis or can be leveraged as debt service payments for bond issues. Projects funded with PFC's are subject to similar eligibility requirements as AIP-funded projects. PFC eligible terminal development is limited to non-revenue generating areas and development to provide gates and related passenger handling areas.

Economic Feasibility

An assessment of economic feasibility is often required for projects funded with federal grants. Economic feasibility is based on an analysis of the quantifiable benefits and costs associated with the project. Economic feasibility may consider measures such as the cumulative value of passenger time saved by the project's reduction of delays. A project is considered economically feasible, or economically justified, if the benefits provided exceed the total project costs. Various methods exist for comparing benefits and costs. These methods involve developing annual projections of both benefits and costs over a certain number of years. Economic costs include capital costs, costs of maintenance operation and administration, and any other quantifiable costs, including social costs. Benefits may include reductions in aircraft or passenger delays, improved operational efficiency, and other desirable results. The present value of costs and the present value of benefits expected during the planning period are each calculated based on an appropriate discount rate and other economic measures such as the value of passengers' time, for example. Economic feasibility is demonstrated if the ratio of present value of benefits to present value of costs is greater than one. The more this ratio exceeds one, the greater the economic feasibility.

Financial Feasibility

An assessment of financial feasibility is essentially an analysis to determine if the project can generate enough net revenue to make it attractive as an investment. Feasibility assessments are a standard feature of the bond financing process and are typically performed by persons or firms with specialized expertise in airport finance. Financial feasibility assessments involve detailed analyses of annual traffic forecasts, and projections of capital costs, operating costs, and revenues. A project is considered feasible if projected revenues cover projected capital and operating costs by a sufficient margin.

In assessing feasibility, revenue projections are developed based on forecasts of demand, and the rates and charges established for different revenue categories. These categories include airline charges, lease rents, and concession revenues. Once the project's revenue and cost projections are developed, financial feasibility can be assessed based on net revenues, or gross revenues minus costs. One generally accepted measure of financial feasibility is the coverage ratio, the ratio of net revenues to debt service requirements. For an investment to be attractive to bond holders, a coverage ratio of 1.25 or more is usually required. If the feasibility assessment indicates that projected revenues will provide insufficient coverage, elements of the program may need to be revised, or adjustments made to rates and charges paid by the terminals users.

White Paper

Operational and Maintenance (O&M) Considerations in Terminal Planning and Design

(A background paper in consideration of updating FAA AC 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities*)

By Norman D. Witteveen, PE, AAE
October 2003

Introduction

Airport passenger terminal planning and design encompasses a very broad range of guidelines, best practices and considerations that should be approached with the objective of meeting the airport operator's stakeholders' needs related to functionality, capacity, operational efficiency, customer level of service, cost effectiveness, and design creativity. Although there are numerous major inter-related planning and design considerations for a new or expanded terminal complex, this white paper focuses only on operational and maintenance (O&M) consideration. It is assumed that white papers prepared by others will address those other inter-related planning and design considerations and best practices.

It has been the author's observation over the last three decades that, too often, O&M considerations have been deferred to the latter stages of the terminal design process resulting in late design scope and cost increases or changes during construction, or worse yet, changes by the owner's O&M staff after project acceptance and commissioning to satisfy their O&M needs not originally addressed by the designer. O&M needs and requirements deserve an early assessment and understanding of the multitude of activities required by the airport owner/operator, its tenants and user stakeholders. This assessment will result in dedicated O&M spaces and systems requirements to be incorporated into the design and construction process and the project budget that meets the owners and stakeholders O&M needs. It should also enhance the owner's satisfaction of the completed project.

Background

Airport passenger terminals are very complex facilities that include many stakeholders, such as the airport owner/operator and its several internal organizational units; government agencies such as TSA, INS, Customs, FAA; airlines; a whole family of concessionaires (retail, food/beverage, specialty); rental car agencies; commercial ground transportation providers; and more. They all have unique O&M needs to operate and manage their respective facilities and systems efficiently and effectively, thus creating the need for O&M considerations early in the planning and design process.

Terminal designers normally set up a project management framework early in the project to research, analyze and receive input regarding the needs and requirements of all stakeholders. This can be in the form of various workshops, working groups, brainstorming sessions, technical committees, or individual interviews. An important element of this process, and what is often excluded, is the staff, or owner's maintenance contractors, who will be responsible for the terminal's physical plant operation and maintenance after the project is delivered to the owner. The possible consequences of not engaging the O&M staff early in the design phase could be delivery of a physical plant that the owner's O&M staff is not qualified or trained adequately to manage, does not conform to existing facilities and systems they are used to, requires new staff or contractual expertise and experience to operate and maintain, or they simply don't like. All of these possible consequences risk systems reliability, efficiency, maintainability, compatibility, O&M and life cycle cost, and stakeholder customer service.

Terminal Operations and Maintenance Organization

Each airport has its own unique internal management organization and business model with various roles, responsibilities, authorities, and relationships. Additionally, it has contractual arrangements with many terminal tenants who lease space to conduct business and provide goods and services to airport users. This business environment, coupled with the fundamental role of moving passengers, baggage, vehicles (including rail or transit in some airports) and airplanes in a safe, secure, efficient, cost effective and friendly manner, creates the need for a complex terminal physical plant and infrastructure to operate and maintain. (These systems are identified below under the O&M Checklists.) Based on these contractual lease arrangements with tenants, it is typical for some exclusive leased terminal spaces and systems to be furnished, operated and maintained by the leasee, and in other cases the O&M is provided by the airport owner/operator. Additionally, utility agencies may be an O&M provider for their dedicated systems such as water, sanitary sewer, primary power and gas, telecommunications and electronic data networks. The point is, that each airport is different in its approach to terminal infrastructure O&M, which requires the terminal design team to conduct its "due diligence" early in the design process.

Customer Service

One of the airport owner/operator's key objectives is to provide [a] safe, secure, convenient and friendly level of service to its customers. This includes both leasee tenants and the traveling public. Some O&M considerations to improve or enhance customer service include:

- Lighting illumination levels in all public and non-public work areas to enhance safe, secure and comfortable environments.
- High, but not excessive, level of wayfinding (both static and dynamic signage and graphics).
- Strategically and conveniently located vertical circulation systems that enhance passenger functional flow.
- Optimal use of ambient lighting, heating, cooling and ventilation. (However, glare mitigation should be addressed if considered an issue.)
- Adequate HVAC in non-public work areas.
- High level dedicated ventilation system in designated smoking areas.
- High level smoke detection and fire suppression system in all kitchen areas, including convenient grease trap cleaning provisions.
- Architectural treatments and/or plantings that absorb noise and create "warm" spaces.
- An Intelligent Telecommunication (IT) system to be made available to all tenants and airport operations and one in which modifications and changes can be made expeditiously.
- Adequate space in non-public work areas for storage of maintenance equipment, supplies, restrooms for employees, and electric carts and their battery chargers.
- Spare radio channels and frequencies to be available and dedicated for emergency and crisis management.
- Backup provisions to implement the airport's operational contingency plans, such as temporary signage, barricades and stantions with conveniently located storage facilities; staging areas; press room with electronic news media access; etc.

Terminal Planning and Design O&M Checklist

This comprehensive checklist, which should not be considered all-inclusive, serves as a guide to the terminal planner/designer in addressing many of the O&M planning and design considerations. It is arranged by functional operational area and is intended to assist the designer in addressing most O&M issues. Based on the specific functional area, the designer should address the typical questions of:

(1) Who is responsible for O&M of this area or system?
(2) How is it expected to be operated and maintained?
(3) Who are the customers to be served?
(4) What level of service is expected?
(5) Is there an opportunity for systems standardization?
(6) Is the technology current and proven, with convenient spare parts inventory?
(7) Are spare parts or materials off-the-shelf and easily available?
(8) Are systems and equipment user friendly to the operators?
(9) Has the highest level of safety and security provisions been provided?
(10) Are the facilities and systems easily expandable and do they lend themselves to convenient modifications and changes?
(11) Are adequate provisions made for the O&M staff (work areas, break and restrooms, environmental conditions)?
(12) Are customer service issues, described previously, addressed adequately?
(13) How will these areas and systems be accessed for emergency response staff, vehicles and equipment?
(14) Are all work areas screened and transparent to the public?
(15) Is life-cycle performance and cost incorporated into the design?

1. Curbside
    - No. of traffic lanes: loading, unloading, bypass, vehicle checkpoint
    - Medians/islands: loading, unloading, shelters, obstructions to users
    - Pedestrian crosswalks: types and marking
    - Passenger check-in stations: skycap shelters, systems and amenities
    - Outbound baggage system, appurtenances, and system operation/security
    - Passenger seating
    - FIDS and BIDS
    - Signage and graphics
    - Ventilation (if covered above)
    - Telecommunications, public address and electronic systems
    - “Smartecartes”
2. Parking Garage
    - Ingress/egress strategically located for traffic efficiency
    - Ramp types
    - Parking stall configuration and size
    - ADA provisions
    - User friendly ticket dispensers
    - Revenue control system
    - Manager/staff facilities, systems and amenities
    - Skycap check-in facilities (if desired in garage)
    - Vertical circulation
    - Signage and graphics (consistent with roadways)
    - Lighting for safety, security and public comfort
    - Provisions for heightened security levels
    - “Smartecartes”
3. Ticketing Area
    - Type of counters and baggage wells
    - Ticketing system: airline exclusive, preferential, or CUTE
    - ADA provisions

- Outbound baggage system: type, scales, checked bag security screening system, operation, weather screens, oversized/oddsized bag provisions, access for maintenance
- Non-glare lighting for agents
- Telecommunications, public address, and electronic systems
- Automated E-ticketing provisions
- Interior architectural and building finishes
- "Smartecartes"

4. Airline Ticket Offices (ATO)
   - Interior architectural building finishes
   - Telecommunications and electronic systems
   - Convenient access to ticketing areas
   - Pneumatic cash tube system (if desired by airlines)
5. Outbound Baggage Make-up Area
   - Vertical and horizontal clearances: baggage equipment, tugs, carts, dolleys, emergency response vehicles and equipment, utilities, expandability
   - Storage areas: tugs, carts, dolleys, equipment, maintenance staff
   - Floor finish: non-slip in work areas
   - Baggage handling system type and control system
   - Checked bag security screening system and support infrastructure
   - System maintenance provisions: catwalks, platforms, equipment and materials storage, system access, staff amenities
   - Protective bollards and guard rails
   - Floor drains that do not conflict with work areas
   - Telecommunications and electronic systems
   - High level lighting illumination in work areas
   - Ventilation appropriate for vehicle operations: diesel, gas, CNG, electric
   - Battery charges and storage for electric tugs and carts
   - HVAC appropriate to site and functional operations
6. Baggage Claim Area
   - Claim device type and system operation/safety provisions/numbering system
   - BIDS
   - Secured access to non-public areas
   - High level lighting illumination over claim devices
   - Telecommunications, public address and electronic systems
   - Type of hotel/ground transportation/information kiosks
   - Rental car provisions
   - ADA provisions
   - Baggage service offices and systems
   - Baggage storage provisions
   - Interior architectural building finishes
   - "Smartecartes"
7. Passenger Security Screening Checkpoint
   - Layout, configuration and functional flow space and arrangements per TSA requirements/approval
   - ADA provisions
   - Infrastructure to support screening devices
   - Telecommunications, public address and electronic systems
   - TSA office support, search areas and rooms, and employee break amenities
8. Departure Lounges
   - Interior architectural building finishes
   - Seating furnishings
   - Type of check-in counters and inserts, back-screening inserts

- Telecommunications, public address and electronic systems
- Passenger check-in system: airline exclusive, preferential, or CUTE
- Passenger boarding pass readers and power/IT connecting interface
- Passenger carry-on bag security search provisions
- Baggage conveyance to ramp: stairs, conveyor, slide, dumbwaiter
- Non-glare lighting for agents
- FIDS
- Cable TV
- Passenger loading bridges and alternate ramp access
- Advertising

9. Airline Clubs and Special Group Waiting Room
   - Interior architectural building finishes
   - Restrooms
   - Kitchen, bar, lounge, conference rooms, furnishings
   - Cable TV
   - FIDS
   - Telecommunications, public address and electronic systems
   - ADA provisions
10. Public Areas and Passenger Amenities
    - Interior architectural building finishes
    - Convenient vertical circulation and standardization
    - Seating furnishings
    - ADA provisions
    - Restrooms, nursery
    - Telecommunications, public address and electronic systems
    - FIDS/BIDS
    - Cable TV
    - Information counters, travelers aid
    - Children's play area
    - Medical emergency access
    - Museum and art display areas
    - Military lounge
    - Smoking lounge(s)
    - Advertising spaces and displays
11. Concessions
    - Food and beverage
    - News and gifts
    - Retail and specialty shops
    - Concessions warehousing and access: off-site bulk deliveries and on-site supplies deliveries
    - Business center and conference rooms
    - ADA provisions
    - Hotel/tourism reservation center
    - Bank ATMs and currency exchange
    - Flight insurance, travel agency
    - Post office and express mail
    - Barbershop and shoeshine
    - Video game arcade
    - Newspaper kiosks
    - Baggage storage (in secured areas)
    - Vending machines

- Advertising
- “Smartecartes”

12. Ground Transportation
    - Taxi
    - Buses: public, employee, private, charter
    - Shuttles: on-site and off-site parking, transfer, hotels, rental cars
    - Limousine
    - Transit: on-airport, off-airport
    - Valet parking
    - Holding lots with driver amenities
    - Support offices for above
13. Operations Areas
    - Offices and control/command centers, and their furnishings
    - Special equipment and systems: O&M control/command centers, O&M radio system, emergency response and management systems, maintenance equipment
    - Telecommunications, public address and electronic systems
    - Interior architectural building finishes
    - Hazardous materials use, storage and disposal facilities
    - Clearances and overhead doors for O&M and emergency response vehicles
    - Protective bollards and guard rails
    - Electrical system capacity and provision for electric cart battery charging and block heaters
    - Utilities expandability, modifications and changes
    - Conveniently located restrooms and breakrooms
    - FIDS/BIDS
    - Convenient and secure O&M vehicle parking areas with assigned signage
14. Signage and Graphics
    - Directional, wayfinding, informational, regulatory
    - Static, dynamic, changeable messages, electronic
    - Convenient modifications and changes
    - ADA provisions
15. Electrical
    - Emergency power for essential and contingency uses
    - Uninterrupted power supply
    - Backup (second source)
    - Extra capacity and redundancy for all essential specialty systems: security, baggage, aircraft support, emergency management
    - Support for all Operations Contingency Plans
16. Telecommunications and Electronic Systems
    - Data and telephone to all functional spaces
    - Public address (multi-zoned)
    - Airport radio systems: Operations, maintenance, police, fire, and emergency management
    - Airline operations
    - Cable TV
    - News media broadcast equipment access
    - Point-of-use concessions financial mgmt. system
    - Equipment, switch rooms, buildings, and related offices for above
    - Airport vs. commercial systems
17. Mechanical and Fire Protection
    - HVAC/Ventilation in all work areas and equipment rooms
    - Smoke detection/evacuation and deluge sprinkler systems (per fire code)

- Equipment/systems standardization
- Central Plant: boilers, chillers, cooling towers, piping expansion joints, control/monitoring systems, work areas, shops, staff amenities

18. Special Facilities
    - Vehicle checkpoints and amenities for heightened security levels
    - Police and fire
    - Drug enforcement agency
    - Federal Inspection, Customs, Immigration, Naturalization Services and TSA
    - Emergency and crisis management control/command center
    - News media room with broadcast equipment access
    - Hardened facilities for high-threat terrorist mitigation
    - Isolation/protection of essential critical infrastructure and systems for terrorist mitigation
19. Solid Waste Management and Building Services
    - Loading docks
    - Solid waste holding, removal, recycling facilities
    - Vehicle and service access
    - Delivery access, staging and storage
20. Aircraft Support Systems
    - Passenger loading bridges and types (if furnished by airport rather than airlines): apron drive, fixed, foundations, power, building interface, hurricane tie-down anchors
    - 400 Hz power and pre-conditioned air: centralized or point-of-use
    - Potable water system
    - Triturators
    - Incinerators
    - Electrical power with convenient access
    - Telecommunications and electronic systems
    - Building doors with panic hardware
    - Task lighting for ramp operations, safety and security
    - Aircraft docking system
    - GSE staging and storage
    - Service/emergency roads and access
    - Gate numbering system
21. Utility Systems
    - Verify specific limits of O&M responsibility between the airport and the respective utility provider
    - Coordinate design standards for each system with provider and building/fire codes

Summary

This white paper attempts to highlight the O&M considerations to be addressed by the airport passenger terminal planner/designer based on observations and experiences by the author as both an airport consultant and an airport owner/operator manager. If [O&M is] not considered in the planning and early design phases some adverse consequences are at risk to the designer, all airport stakeholders and users. A comprehensive checklist of facilities and systems is provided to assist the terminal planner/designer in identifying the many functional operational areas that require O&M considerations in the design process to enhance a successful project for the airport owner/operator, its tenants and public users. The underlying objective is enhanced functionality, capacity, efficiency, cost effectiveness, level of service, flexibility and customer service to all airport stakeholders.

Airport Terminal Fire/Life Safety & Emergency Evacuation

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Abstract

Emergency evacuation for airport terminals, or concourses, must consider the special conditions associated with the operation of an airport. The modern day airport terminal and concourse has a combination of airside and landside operations, security, and unique building features. Traditionally the model building, fire codes and nationally recognized standards used for regulating most buildings do not specifically address the unique conditions of airport terminals, especially as related to the emergency evacuation of the occupants. Fire protection and life safety considerations must be a part of any terminal design project from the initial planning and concept design through the development, implementation, and construction of the facility. Flexibility in terminal functionality and security operations must also be considered for both the present and future needs of the airport terminal facility.

This paper addresses concerns associated with an effective terminal design while providing for the life safety of the occupants with a focus on emergency evacuation. It provides guidance for use in terminal planning and design, components of life safety and fire protection systems, and effective emergency evacuations, as well as the protect-in-place concept for maintaining the safety of the occupants. Ideally an approach would be to develop an engineered life safety program while meeting mandated security requirements that protects the life safety of the occupants yet maintains the architectural program requirements of the airport facility. Features to be addressed in this document include describing the components of the modern airport terminal and what is best described as a system approach to the fire protection, life safety and security needs of the users and occupants of these facilities.

The systems approach to safe terminal design must consider the structural fire protection components, automatic sprinkler systems, exiting systems and means of egress, fire alarm and voice communication systems, smoke management or smoke control systems, and other fire protection systems as well as the response capability of the local fire department.

Modern Airport Terminal Designs

For the past several decades, air travelers have become accustomed to sharing a unique architectural experience in airport terminals. This unique experience is the result of collaboration between the design team, municipality, and the airlines, and provides a balance between function, security, safety, and the landmark qualities expected of a regional gateway. Such facilities typically will attempt to make a statement to the uniqueness of the culture and environment of the local region or market that the terminal facility serves. One example of this is the Denver International Airport terminal, which invokes the appearance of a mountain range. This is accomplished by a very large open air volume of space with glazing to the exterior and openness, interconnection between terminal and concourse and communicating floor levels or atrium spaces.

An airport terminal operationally has some very complex and unique functions that the average traveler may never see. In a terminal there are numerous occupancies including large assembly spaces with waiting and queuing areas, mall or retail spaces, restaurants and food courts, automated train or people mover systems, automobile parking structures, vehicle access, baggage handling and storage of combustible and hazardous materials. All these occupancies and functions occur literally within feet of aircraft fueling and support operations. This combination of unique architecture and multiple uses results in one of the most complicated building types that is not regulated through the availability of a single document supported by a nationally recognized code or standard making body. This results in a challenging building type that requires significant involvement by the design team, as coordinated by the architect.

Building Codes for Fire Protection & Life Safety

The building design and construction of any building is typically regulated by the local municipality or governmental body. That regulatory agency, or Authority Having Jurisdiction (AHJ), is known in most communities as the building department or fire department. These agencies are empowered by the adoption of local or state building and fire codes for enforcing the requirements of those codes on the design and construction of an airport terminal. These codes and standards are usually based upon a "model code" or industry standard, which is developed by a consensus process. The consensus process involves various representatives of the industry: building officials, fire officials, architects, engineers, manufacturers, designers, and owners.

Examples of model codes and standards that would regulate an airport terminal include:

- 2003 edition of the *International Building Code* (IBC)—The first draft of the IBC was prepared by committees representing the *Uniform Building Code* (ICBO), the *Standard Building Code* (SBCCI) and the *National Building Code* (BOCA). The IBC is a consolidated building code incorporating various sections and provisions from each of these previously recognized model codes. Since this is a new document the majority of existing terminal facilities have been designed and built based on a building code other than the IBC. Additionally the other codes referenced by the International Code Council are referred to as the "I Codes" and include current editions of the *International Fire Code* (IFC), *International Mechanical Code* (IMC) and *International Plumbing Code* (IPC).
- 2003 edition of the *Building Construction and Safety Code* (NFPA 5000)—This document is a building code developed by the National Fire Protection Association (NFPA) and also has a companion set of documents known as "C3" or the Comprehensive Consensus Codes and includes current editions of the *Uniform Fire Code* (UFC), *Uniform Mechanical Code* (UMC) and *Uniform Plumbing Code* (UPC).
- Other codes and standards produced by NFPA that are used to regulate an airport terminal include the current editions of NFPA 70 the *National Electrical Code* (NEC), NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage and Loading Walkways* and NFPA 130 *Standard for Fixed Guideway Transit and Passenger Rail Systems.*
- Local municipalities, airport authorities or special jurisdictions can also adopt local amended versions of these codes and standards or create a local building and fire code specific to the airport in that jurisdiction.
- There are also numerous codes and standards that will regulate an airport terminal with respect to accessibility, environmental quality and other special equipment such as elevator or conveyance equipment.
- The Federal Aviation Administration (FAA), Department of Homeland Security (DHS), and the Transportation Security Administration (TSA) also have requirements contained in federal regulations, advisories, and policy guidelines for the design and operation of an airport terminal.

Building codes and standards contain provisions related to the building including occupancy classification (e.g., assembly, business, mercantile, storage, factory), construction type (e.g., non-combustible, combustible or fire resistive structural elements), area and height limitations, fire protection and life safety systems, means of egress, structural fire resistance, and other relevant requirements to the building. These basic provisions are very similar throughout the various model codes, although specific provisions may differ. Building codes are enforced by the local or state building department.

Fire codes address building issues that are related to fire prevention and response, and include fire department access, fire flow or water supplies for manual fire fighting, fire protection systems, hazardous materials, fuel storage and dispensing and specific use provisions for storage and industrial processes. Fire codes are enforced by the local fire department or state fire marshal's office.

Design Process

The design process for an airport terminal is not much different than for other buildings, with the exception that many airport terminal projects are actually additions or modifications to existing facilities. Regardless of whether or not the project is an expansion of an existing facility or a new building, the design process and terminology follows the description of design phases as identified and defined by the American Institute of Architects. These definitions break the project into the Conceptual Design or Planning Phase, Schematic Design, Design Development, and ultimately the Construction Documents phase. There also is a design process that has become popular in the design and construction industry known as Design-Build. This process is an efficient method of combining the design process through the architect with a contractor that assists in pricing and value engineering of the design concepts prior to the actual completion of the design and construction documents. This method permits the evaluation of systems and components as well as actually ordering some special equipment with long lead times prior to actual start of construction. This expedites the construction schedule by allowing the project to maintain a fast track schedule.

Upon completion of the design process, the project is bid to qualified contractors, contracted, submitted to the jurisdiction for review, approved, permitted and then constructed.

Application of Building and Fire Codes to Airport Terminal Design

The model codes do not include airport terminals as a specific occupancy group or classification. Airport terminals may contain several different uses, and are best categorized as a mixed-use occupancy, including assembly, business, mercantile, and storage uses, often arranged similarly to a covered mall. Because the codes do not include special provisions for airport terminals, the architect, design team, and AHJ are often left to determine the best application of the various code provisions to meet the airport terminal design.

Some of the model codes have recognized the unique areas or occupancies of an airport terminal and provided guidance by assigning occupancy definitions and occupant load factors for areas such as baggage claim, baggage handling, and waiting areas (such as at airport terminal gates). There is also some cursory mention of transportation terminals or facilities for applying some code provisions to airport terminals.

One of the most important aspects of an airport terminal that must be understood in the design process is the unique characteristics of airside, landside, secure, non-secure and sterile or non-sterile areas of the terminal. For purposes of clarification, this document provides a common definition of each of these unique terms.

- Landside—That portion of the building accessible to the public and employees that has not been screened through a security check process. Airport terminal landside includes the airline ticketing lobby, baggage claim, services areas, retail/mall, and restaurant areas. These areas are usually open to the airside, sharing the same volume, but are separated by Security Screening Check Points (SSCP), which serve as the border between airside and landside.
- Airside—That portion of the building accessible only to the public or authorized employees that have been screened through security (SSCP) and authorized to proceed to an aircraft or other authorized areas of the terminal. These areas include airline service areas, gates, waiting or holding areas, retail/mall, and restaurant areas.
- Secure versus Non-secure—That portion of the building that relates to the delineation of the space that has been secured or cleared by airport operations and security and all persons entering that area have successfully passed through a security screen checkpoint.
- Sterile versus Non-sterile Area—The sterile portion of the airport or terminal building is the most restrictive portion of the building that permits only "badged" personnel and no public access. The sterile area of an airport terminal has been screened to higher level of security by special inspectors and equipment. This area is under continuous supervision and employees in this area must maintain their badged identification and special security regulations at all times.

These terms become especially important when discussing the emergency evacuation of an airport terminal, a potential breaching of any of these delineations. With respect to exiting an airport terminal's occupants, the emergency evacuation of occupants on the landside, non-secure or non-sterile portion of the building are not regulated by any special requirements or regulations. Conversely, occupants evacuating on the airside, secured or sterile portion of an airport terminal will have a significant impact on the security of the airport facility and require the re-screening and re-sterilization of the portion of the facility prior to the airport resuming normal operations. Additionally, occupants evacuating onto the airside portion the terminal where aircraft are operating will be subject to the danger of aircraft servicing, fueling operations and support operations. This concern for evacuating occupants onto the airside of the terminal from a safety as well as a security standpoint helps justify the "protect in place philosophy" utilized in most airport terminals.

Another unique aspect of airport terminals taken into consideration is the desire to provide an open environment in the airside or secure portion of the concourse or terminal. Many modern airport terminals resemble a covered mall building, with a multiple level central concourse bounded by retail, dining, and entertainment tenants. The difference between a typical mall building and an airport terminal having these features is the presence of large assembly areas at gate holding areas. Most building codes limit the area provided for assembly uses in covered mall buildings. This presents a dilemma for designers and AHJs, with regard to applying the covered mall provisions to airport terminals. Although the covered mall provisions may provide useful guidance for design of exiting systems, fire protection systems, and smoke control systems, they cannot be applied in their entirety without addressing the shortfalls associated with the operations and layout of an effective terminal.

A portion of the airport terminal also can typically accommodate an Automated People Mover (APM). The APM is a motorized train system on a fixed rail guided remotely by train operators. The APM might connect the terminal and concourse above or below grade and can be located on the interior or exterior of the airport terminal. The concourse is very similar to an airport terminal and is typically seen as the building that passengers move directly through to an enclosed walk-way, which leads to an aircraft. These concourses have similar occupancies to that of an airport terminal and also have multiple floor levels designed to be open to each other with support functions and baggage handling directly below the occupants, all within a few hundred feet of aircraft that are being serviced and fueled.

Special Fire Protection and Life Safety Provisions

It is critical that airport terminal designers utilize a systems approach to fire protection and life safety, with a goal of implementing a "protect in place concept" for the occupants. This [is] important for balancing the operational requirements, security requirements, and to address the unique arrangement of large volume communicating spaces with large occupant loads, surging passenger volumes, and adjacent hazardous occupancies and processes. Those special provisions identified in the model building and fire codes, which are utilized in this systems approach, typically include the following:

Structural Fire Protection Requirements

Due to the area and height of an airport terminal, building construction is typically of non-combustible, fire resistive construction throughout. Structural frames, exterior walls, floor/ceilings, and roof/ceilings will be fire rated according [to] the construction type.

For example, the ratings associated with Type I construction are typically three-hour fire resistive structural frame, with two-hour fire resistive floors. Exterior wall ratings and opening protection depends on the distance to adjacent structures, property lines, and/or airfield operations such as refueling.

Automatic Sprinkler Systems

Due to the mixing of occupancies, desired openness of the airport terminal, associated fire loads and the philosophy of protecting the occupants in place, most airport terminals will be protected by an automatic sprinkler system installed in accordance with the National Fire Protection Association's *Standard for the Installation of Automatic Sprinklers* (NFPA 13).

Standpipe Systems

Buildings are required to have a standpipe system for fire department or occupant use in buildings that are more than 30 feet or 3–4 stories in height. These systems can be combined with the building sprinkler system or they can be an independent system available for fire department use only. These standpipe connections are located at the stair enclosures, and may have hoses provided at the connection if required by the fire department. A fire pump may be required to be installed to augment the operation of both the automatic sprinkler system and the standpipe system, and depending on local water supplies.

Fire Detection and Alarm Systems

A fire alarm system to notify occupants of any emergency condition should be provided. The fire alarm system should either be a stand-alone fire alarm system or work in conjunction with the airport public address system to notify occupants and direct them during an emergency and emergency evacuation. Assembly-use areas should be provided with a voice communication system, designed to initiate a pre-recorded announcement for emergency evacuation. The voice communication system is usually integrated into a public address system for use by the fire department or other emergency responders for making announcements to direct an evacuation event. The fire alarm system should also be monitored by an off-site central monitoring station that in turn report directly to the municipal fire department. If the airport terminal is protected by an automatic sprinkler system, the building will have a limited amount of system smoke detection devices. If such system smoke detection is provided, it should be strategically placed for early fire alarm system activation or activation of special systems such as access/egress control (releasing of egress control doors), closing of fire doors or activation of a smoke management or smoke control system. Fire alarm systems should be designed and installed in accordance with the National Fire Protection Association's *National Fire Alarm Code* (NFPA 72). Flexibility is a key issue when approaching fire alarm design.

Smoke Management Systems

Smoke management or smoke control is not normally required for an airport terminal or concourse building. However, with the desire for openness of an airport terminal or concourse, the result is usually an atrium space or arrangement similar to a covered mall building, as defined and regulated by the building code. It is for this reason that a smoke management system (also known as smoke control systems) is usually required. A smoke control system in an airport terminal helps ensure an added life safety benefit for the occupants during the emergency evacuation of the building and helps support the use of protect in place philosophy. This approach provides a safe haven or refuge area for occupants of the building, maintaining tenable conditions in the exiting systems and concourses, and permitting the occupants to move safely in the building without evacuating it. Successful smoke control is typically accomplished through the use of smoke control zones, usually corresponding with the fire sprinkler and alarm zones, in which the mechanical exhaust ventilation of a zone is accomplished via fans for exhaust and supply. Depending on the smoke management methodology selected, the system may also pressurize zones of the building to prevent smoke spread from the area of fire origin. Activation of a smoke control zone occurs automatically upon smoke detection, sprinkler waterflow, or manually at the control panel. The design of smoke management systems must be carefully considered early in the design process, and depends on successful coordination between architectural design, mechanical systems (HVAC), electrical, and life safety systems.

Smoke management systems are intended to be used during a fire emergency to evacuate smoke and control smoke migration. These systems are provided with automatic activation as well [as] a manual control system for use by the fire department.

The use of the manual control for the smoke management system is available for non-fire emergency conditions and could be used for removal of smoke or odors not related to a fire condition. It is important to note that the smoke management systems are designed to be utilized for smoke and hot fire gases. The use of such mechanical equipment could be used as part of a strategy for removal of toxics or poisonous gases or chemical emergencies. However, the equipment would not be rated for such use and significant damage to the equipment may result from the use of this equipment for non-fire emergencies. The use of the smoke management system for non-fire emergencies should only be considered and implemented by qualified emergency personnel after evaluation of the situation or based on an emergency operations plan.

Fire Command Room—Monitoring/Control of Life Safety Systems

The complexity of an airport and the related life safety systems lends support to the use of a fire command room at a location approved by the fire department. The fire command room would be located in each airport terminal or concourse at a fire department response point and could be interconnected to other concourses or airport facilities via a fiber optics backbone. Such a system would connect the fire command rooms in each concourse, terminal and airport operations/security center and other strategic locations. The fire command room should include monitoring and control of the fire protection and life safety systems for that particular area of the airport terminal.

The fire alarm control panel, smoke control panel, voice communication system controls, public address system controls, and building drawings should be provided in the fire command room.

Emergency Communications Systems

Airport terminals and concourses are typically large area buildings that, when constructed of steel and concrete, pose significant communication problems for the use of fire department radios in the building. Emergency communications for fire department personnel can be accomplished through the use of an emergency phone communications system as part of the fire alarm system. In some large jurisdictions the fire department has required by local amendment the installation of a radio repeater or amplification system throughout the airport terminal. This type of system permits the fire department as well as other emergency agencies and airport operations and security to also utilize this type of emergency communication system.

Closed Circuit Cameras and Monitoring

With the increased security needs found in an airport and the use of numerous monitored closed circuit cameras from a security control area, information used for security purposes could be very useful to the fire ground commander when evaluating an evacuation emergency. Access to these closed circuit cameras/monitors could be accomplished by providing monitors in the fire command rooms.

Means of Egress and Special Requirements for Exits

Means of egress for the airport terminal must be designed to comply with the applicable building code, and must address occupant loads, exit capacity, egress component dimensions, and travel distances. Code requirements for exit capacity are based upon the design occupant load for the building. Occupant loads are calculated based upon floor area served and the appropriate occupant load factor for the type of use. For example, the occupant load factors for airport terminals recommended in NFPA 5000 are 100 ft^2/occupant for concourses, 15 ft^2/occupant for waiting areas, and 20 ft^2/occupant for baggage claim areas (NFPA 5000, Section A.11.3.1.2). Maximum travel distances to exits will vary depending on the building code utilized, but are generally on the order of 250 feet for buildings protected with automatic sprinkler systems.

A means of egress analysis must be conducted during the design process to evaluate the architectural layout of the building for compliance with the building code. This means of egress analysis will usually result in a graphical egress plan, or “Life Safety Plan,” for inclusion in the construction documents, and is a requirement for permit in most jurisdictions.

In some cases, an alternative method of egress analysis may be necessary to support an alternative design concept utilizing horizontal exits with associated areas of refuge, extended travel distances to exits, the use of open exit-access balconies in the concourse, or alternative basis of design for smoke control systems. Alternative methods to the traditional means of egress analysis include timed egress analysis, which may utilize computer-based dynamic evacuation modeling tools. A timed egress analysis is usually a necessary component of a hazard analysis conducted to support an alternative design. A timed egress analysis may also be a useful tool for evaluating different evacuation scenarios based on a life safety or security evacuation.

Emergency Exits—If emergency exits discharge airside or directly onto an airport ramp or service area, the doors should be clearly marked “Emergency Exit Only” and numbered on both sides, as approved by the Building and Fire Department.

This permits the fire department to identify the emergency exits from the exterior, but also permits the security operators to identify the emergency exits while viewing the area from the closed circuit cameras.

Special Egress Control—Building codes have special provisions for exiting occupants from a controlled area. Controlled egress would typically occur at emergency exits from an airport terminal building that discharges airside onto an airport ramp, service area or secured area and would be equipped with delay panic hardware. The locking device should release when activated by fire alarm initiating devices, by a loss of power to the locking mechanism or upon activation by authorized security or fire department personnel. The systems put in place to allow a delay of egress from a building must be approved by the building department and fire department.

Areas of Refuge or Rescue Assistance—Such areas have a very limited use as guided by the current building and fire codes. Refuge areas are used in conjunction with the use of horizontal exits in the egress system. The intent of such refuge areas is to protect occupants in place while waiting to egress, or while waiting for specific direction or assistance from the fire department. These areas typically require large areas for occupants to wait in. The use of areas of refuge or rescue assistance may also serve as an area for disabled occupants to go into and wait for specific direction or assistance in being evacuated from the building in a fire emergency. There has been some limited use of what could be considered a refuge area for people to be directed from a concourse or terminal area on the airside portion of the building. The intent of such an area is to maintain people in a controlled area outside of the building. However, there are no requirements or guidelines in current building or fire codes requiring such an area.

Fire Department Access

All fire codes require that the building be provided with access for fire department apparatus and fire fighters. This requirement is difficult to implement on most airport terminals due to the airside and landside delineation dividing the building. This delineation results in portions of the building not being accessible for normal fire department operations. This results in the need for duplicate access points to the buildings and duplicate fire hydrants or fire department connections.

With the use of such a systems approach to the fire protection and life safety of the occupants at an airport terminal the occupants are provided the highest security available, as required by FAA regulations, while interfacing with the life safety components of the building. This approach also provides choices based on the conditions encountered: the occupants can safely exit the building or move to adjacent refuge areas to await instruction during an evacuation emergency.

Evacuation and Life Safety Issues in Airport Terminal Buildings

As discussed above, airport terminals present unique challenges to effective design for life safety while maintaining emergency evacuation. These challenges include occupancy and evacuation issues.

One occupancy issue is designing for peak loads and surge operations at certain times of the day. The use of the adopted building and fire codes will mandate the anticipated occupant loads. These are determined by utilizing the recognized occupant load factors to determine occupant loads and required egress capacity. The occupant loads are conservative in nature and take into account how the space will actually be loaded with occupants. In some limited cases, the building or fire department official may consider the use of actual occupant loads based on peak occupant loading in lieu of the nationally recognized occupant load factors contained in the codes. Typically, these peak occupancy loading figures are permitted to be used only when the figures provide a realistic occupant load that is significantly less than that required in the building code.

The use of this approach is very limited and typically requires significant discussions between the airport, the design team, and the local building and fire department.

Effective operational use must be balanced with design for life safety, means of egress, and site limitations, such as area available for development. Compounding these problems are the potential that over the life of the terminal, operational requirements will likely change. The most effective designs will consider such potential changes in use and operations over the life of the terminal, which may be difficult to predict. In the post 9/11/2001 elevated security environment, it became apparent that many airport terminals were designed with insufficient area landside to process travelers and guests, especially at peak travel times, and with additional security screening measures being retrofitted into the ticketing lobbies. For example, many airports saw the relocation of retail and dining venues to the ticketing and baggage claim lobbies to capitalize on the additional non-ticketed occupants waiting for arriving or departing travelers, who otherwise could not get through security.

In a terminal evacuation, either for a security-related issue or a life safety issue, consideration must also be given to providing adequate means of egress from the airside (secure) and landside (non-secure) locations. For ticketing and baggage-claim lobbies, the obvious choice is to provide direct egress to the public way via the terminal building front. For occupants in the secure portions of the terminal, means of egress must be provided towards the front of the terminal, as well as to airside. The landside facing portion of the terminal building is usually designed to allow free-flow of occupants into and out of the terminal. These areas are usually not secured, and are often constrained in terms of available space due to the proximity of roadways and operations such as curbside check-in, taxi stands, and other ground transportation. These are often the same areas likely to be occupied by responding emergency vehicles. Travel distance limitations of the building code often preclude an evacuation plan solely reliant on exiting to the front of the building.

For these reasons, it is impractical and often impossible to achieve code compliance without evacuating to the terminal apron. This introduces the obvious concern of discharging large numbers of occupants to a potentially dangerous environment where aircraft, fuel trucks and operating jet engines or propellers abound. The demands on apron space are many, including locations for baggage handling, fueling, clearance for aircraft (including safety zones for engines), and maintenance and safety vehicles.

Weighing Emergency Evacuation Requirements with Security

A terminal evacuation must be carefully considered in the context of providing security for the terminal, aircraft, occupants, and the airport as a whole. Whereas life safety systems are designed to allow safe egress from the building, security systems are designed to restrict movement from some portions of the building to others, and from the terminal to airside. Thus, life safety systems and security systems must be designed with integration in mind, at the very least, from the standpoint of design philosophy and system response.

Egress doors from the terminal to airside must be monitored to provide adequate security for airside operations. Likewise, doors separating public areas of the terminal from back-of-house and airport operations, such as baggage handling areas, must restrict free flow from one to the other. Systems integration between fire alarm, access control and monitoring, and building automation systems is a must for most modern terminals. Design must also consider interaction with smoke control systems and provisions for disabled access.

In recent times, the frequency of terminal evacuations due to a security screening failure has increased. This fact results in a need to design terminals to be safety evacuated in the event of a security related incident. Whereas the essence of evacuation time in these scenarios is not as important from a fire/life safety perspective, time is still of the essence to effect an orderly evacuation while security screening is resumed.

Conclusion—Designing for Fire Protection/Life Safety and Evacuation

In conclusion, the special requirements for fire protection and life safety for airport terminals must be considered in the design for any new terminal, renovation, modernization, or expansion. It is recommended to include consideration of these issues beginning in the planning phases of the project, and continuing through design and construction phases. The systems approach to design should be a central component of this process.

The main issues to be considered during planning are:

- Local conditions and requirements of the AHJ
- Establishing the applicable building and fire codes for the project
- Fire Department Access
- Building construction type
- Design concepts for egress systems, based on building size, associated travel distances, and operational requirements
- Determination of the need for smoke management systems, based on the layout of the terminal building (i.e., multiple levels open to a central concourse)
- Integration of life safety systems with security systems
- Consider if the project is a candidate for performance-based design, especially for design alternatives not fitting within the building code
- Costs associated with the issues listed above

During the design and construction phases of the project, the following main issues should be considered:

- Building construction type, based on area, height, and use
- Occupancy and uses for various areas in the terminal
- Specific provisions for fire protection systems such as automatic sprinkler, standpipe, fire detection and alarm systems, and smoke control systems
- Means of egress, evacuation planning, and safe refuge areas utilizing the “protect in place” concept
- Alternative designs for means of egress, smoke management, or unique building features, including requirements for engineering analyses to support alternate design concepts, and submittal requirements of the local AHJ
- Requirements for special inspection during construction, such as for smoke control systems, special fire protection and life safety systems, and unique designs
- Construction management issues, such as construction phasing, provisions for fire/life safety during construction, systems integration, systems installation, and acceptance testing

Planning and design phases should also consider the potential for changes in operations and uses for the terminal over the life of the building. Careful planning and design will contribute to the overall goal of providing a careful balance of safety and security for travelers, staff, and emergency responders now and in the future.

Resources

The *International Building Code,* 2003 Edition, International Code Council (ICC), Falls Church, VA, http://www.iccsafe.org/. The ICC also publishes other model codes such as the *International Fire Code,* the *International Performance Code,* and the *International Urban-Wildland Interface Code.*

The *Building Construction and Safety Code,* NFPA 5000, 2003 Edition, National Fire Protection Association, Quincy, MA, http://www.nfpa.org/. The NFPA publishes many other codes and standards, including the *National Electrical Code* (NFPA 70), *Life Safety Code* (NFPA 101), *Uniform Fire Code* (NFPA 1), *Standard for the Installation of Sprinkler Systems* (NFPA 13), *National Fire Alarm Code* (NFPA 72), *Standard for Fixed Guideway Transit and Passenger Rail Systems* (NFPA 130), and *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways* (NFPA 415).

The Transportation Security Administration (TSA), http://www.tsa.gov/

The Federal Aviation Administration (FAA), regulations and policy guidance, http://www1.faa.gov/regulations/index.cfm

The Authors:

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FAA White Papers consulted in the development of the Guidebook

1. Gloria G. Bender (TransSolutions)
   "Programming Domestic Air Terminal Passenger Processing Areas Using Computer Simulation"

2. Peter Bianconi (PDK Airport Planning)
   "Recent Experience in the Sizing of Airport Terminals and Some Suggestions for Future Considerations"

3. Edward G. Blankenship (Landrum & Brown)
   "The Process of Terminal Planning"

4. Thomas H. Brown (Ricondo & Associates)
   "Accommodating Changing Airline Requirements in Terminal Design"

5. Thomas H. Brown (Ricondo & Associates)
   "Airline Terminal Performance Perspectives"

6. Greg Casto (AvAir Pros)
   "Developing a Space Program for Airport Passenger Terminals"

7. David A. Daileda (Gensler)
   "Considerations for Selecting a Terminal Configuration"

8. Richard de Neufville (MIT)
   "Dealing with Uncertainty in Planning and Design of Airport Passenger Buildings"

9. Richard de Neufville (MIT)
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10. Paul Dorsey (Southwest Airlines)
    "Airport Terminal Performance: The 'Low-Cost' Carrier Perspective"

11. Paul Dorsey (Southwest Airlines)
    "The Air Carrier Perspective on Airport Security"

12. Daniel J. Feil (Metropolitan Washington Airport Authority)
    "Conceptual Guide to Airport Terminal Public Concourse Planning and Design"

13. Andrew Grenier and Steve Rondinelli (Rolf Jensen & Associates)
    "Airport Terminal Fire/Life Safety and Emergency Evacuation"

14. Joel B. Hirsh (Hirsh Associates)
    "Developing a Space Program for Airport Passenger Terminals"

15. Joel Hirsh (Hirsh Associates)
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16. Robert Hornblower and Michael O'Brien (IATA)
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17. Robert Jones (Architectural Alliance)
    "Developing a Building Concept for Airport Passenger Terminals: Non-Public Areas"

18. Art Kosatka (TranSecure)
    "Security Considerations in Airport Terminal Planning"

19. David Lind (Corgan Associates)
    "Developing a Building Concept for Airport Passenger Terminals: Considerations for Hub Operations"

20. Peter B. Mandle (Leigh Fisher Associates)
    "Planning Landside Facilities at Major Airports"

21. Douglas M. Mansel (Oakland International Airport)
    "Airport Terminal Performance: The Airport Operator Perspective"

22. Ted McCagg (Gresham Smith Partners)
    "Human Factors Considerations in Terminal Design"

23. Francis X. McKelvey (Michigan State University)
    "Forecasting for Airport Terminal Building Planning"

24. Phil Mein and Ralph Bauer (Corgan Associates)
    "Developing a Space Program for Airport Passenger Terminals"

25. Eric E. Miller (TransSolutions)
    "Developing a Building Concept for Airport Passenger Terminals: A Simulation-Based Perspective"

26. Mark W. Nagle (Leigh Fisher Associates)
    "Management and Financial Considerations in Terminal Planning and Design"

27. Michael O'Brien (IATA)
    "Passenger Flows at Airports—The Human Element"

28. Colleen E. Quinn (Ricondo & Associates) and Frederick R. Busch (Orlando Int. Airport)
    "Airport Terminal Apron and Gate Areas"

29. James M. Robinson (Leigh Fisher Associates)
    "Implementation and Phasing Considerations in Terminal Planning"

30. James M. Robinson and Derrick Choi (Leigh Fisher Associates)
    "Terminal Planning Implications of Emerging Passenger Processing Technologies"

31. LaVern D. Rollet (Leo A. Daly)
    "Boarding Gate and Holdroom Facilities for Airport Passenger Terminal"

32. Joseph F. Romano (Gensler)
    "Developing a Building Concept for Airport Passenger Terminals"

33. Fred Silverman (PB Aviation)
    "Terminal Groundside Access Systems"

34. Ron Steinert (Gensler)
    "Developing a Building Concept for Airport Passenger Terminals: Terminal Configuration"

35. Marilyn Taylor (Skidmore Owings Merrill)
    "The Air Terminal: Program to Concept Design"

36. Keith Thompson (Gensler)
    "Developing a Space Program for Airport Passenger Terminals"

37. Keith Thompson (Gensler)
    "Interdependence of Security and Terminal Design: An Overview"

38. Tony Vacchione (Skidmore Owings Merrill)
    "Flexibility in Airport Terminal Design"

39. Regine Weston (Weston-Wong Aviation Consultants)
    "Developing a Space Program for Airport Passenger Terminals"

40. Regine Weston (Weston-Wong Aviation Consultants)
    "Passenger Flow Dynamics and Level of Service in Airport Terminal Buildings"

41. Norman D. Witteveen (HNTB)
    "Operational and Maintenance (O&M) Considerations in Terminal Planning and Design"

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    "Accommodating Aging Population Needs in Airport Terminals"

APPENDIX D

Aircraft Types and Key Dimensional Criteria

Aircraft Design Group	FAA Aircraft Design Group	ICAO Aeroplane Design Code	Aircraft Type	Typical Maximum Passenger Capacity	Fuselage Length		Wingspan		Wing Tip Vertical Clearance[1/]		Tail Height		Passenger Door Sill Height above Ground			
													Fwd.		Second	
					ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
Small Regional	I	A	Cessna 172	4	26’-10”	8.2	36’-1”	11.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Large Regional	II	B	EMB 120	30	61’-6”	18.7	64’-11”	19.8	7’-3”	2.2	21’-6”	6.5	4’-10”	1.5	5’-2”	1.6
			ERJ 135	37	80’-0”	24.4	65’-9”	20.0	6’-7”	2.0	22’-5”	6.8	4’-11”	1.5	7’-3”	2.2
			ERJ 140	44	87’-0”	26.5	65’-9”	20.0	6’-4”	1.9	22’-4”	6.8	4’-10”	1.5	n/a	n/a
			ERJ 145	50	91’-8”	27.9	65’-9”	20.0	6’-4”	1.9	22’-2”	6.7	4’-10”	1.5	n/a	n/a
			ERJ 145XR	50	91’-8”	27.9	68’-11”	21.0	6’-7”	2.0	22’-3”	6.8	4’-9”	1.5	n/a	n/a
			CRJ 200	50	87’-10”	26.8	69’-7”	21.2	n/a	n/a	20’-5”	6.2	5’-4”	1.6	n/a	n/a
			CRJ 700	78	106’-8”	32.5	76’-3”	23.2	n/a	n/a	24’-10”	7.6	5’-8”	1.7	n/a	n/a
			CRJ 705	75	n/a	n/a	81’-6”	24.9	n/a	n/a	n/a	n/a	5’-8”	1.7	n/a	n/a
			CRJ 900	86-90	119’-4”	36.4	81’-6”	24.9	n/a	n/a	24’-7”	7.5	5’-8”	1.7	n/a	n/a
			CRJ 1000	100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Narrowbody	III	C	Q200	37-39	n/a	n/a	85”-0”	25.9	n/a	n/a	n/a	n/a	3’-7”	1.1	n/a	n/a
			Q300	50-56	n/a	n/a	90’-0”	27.4	n/a	n/a	n/a	n/a	3’-7”	1.1	n/a	n/a
			Q400	68-78	n/a	n/a	93’-3”	28.4	n/a	n/a	n/a	n/a	4’-1/2”	1.2	5’-1”	1.6
			EMB 170	78	98’-1”	29.9	85’-4”	26.0	n/a	n/a	31’-10”	9.7	8’-4”	2.5	8’-0”	2.5
			EMB 175	86	103’-11”	31.7	85’-4”	26.0	n/a	n/a	31’-9”	9.7	8’-4”	2.5	7’-11”	2.4
			EMB 190	106	118’-11”	36.2	94’-3”	28.7	n/a	n/a	34’-4”	10.5	8’-6”	2.6	9’-11”	3.0
			B737-600	108-130	97’-9”	29.8	112’-7”	34.3	11’-11”	3.6	41’-8”	12.7	8’-6”	2.6	9’-8”	3.0
			A319	124	111’-1”	33.5	111’-10”	34.1	12’-2”	3.7	39’-11”	12.2	11’-4”	3.5	11’-6”	3.5
			B737-700	128-148	105’-7”	32.2	112’-7”	34.3	11’-11”	3.6	41’-7”	12.7	8’-6”	2.6	9’-8”	3.0
			A318	136	103’-2”	31.5	111’-10”	34.1	12’-11”	3.9	42’-5”	12.9	11’-4”	3.4	11’-9”	3.6
			B737-400	146-159	115’-7”	35.2	94’-9”	28.9	10’-0”	3.1	36’-4”	11.1	8’-7”	2.6	8’-9”	2.7
			B737-800	160-184	124’-9”	38.0	112’-7”	34.3	12’-0”	3.7	41’-5”	12.6	8’-6”	2.6	9’-9”	3.0
			B737-800W	160-184	124’-9”	38.0	117’-5”	35.8	13’-4”	4.1	41’-5”	12.6	8’-6”	2.6	9’-9”	3.0
			MD 80	172	136’-5”	41.6	107’-10”	32.9	8’-7”	2.6	30’-2”	9.2	7’-3”	2.2	8’-10”	2.7
			B737-900W	177-186	133’-5”	40.7	117’-5”	35.8	13’-4”	4.1	41’-5”	12.6	8’-6”	2.6	9’-9”	3.0
			A320-100	180	123’-4”	37.6	111’-3”	33.9	13’-5”	4.1	39’-1”	11.9	11’-4”	3.5	11’-0”	3.4
			A321-100	220	146’-0”	44.5	111’-10”	34.2	12’-8”	3.8	39’-9”	12.1	11’-8”	3.5	11’-6”	3.5
Widebody	IV	D	B757-200	186	154’-1”	47.0	124’-10”	38.1	15’-4”	4.7	45’-1”	13.7	12’-5”	3.8	12’-7”	3.8
			B767-200	216	159’-2”	48.5	156’-1”	47.6	16’-3”	5.0	52’-11”	16.1	13’-5”	4.1	13’-4”	4.1
			A310	237	150’-7”	45.9	144’-0”	43.9	14’-9”	4.5	52’-4”	16.0	14’-10”	4.5	15’-4”	4.7
			B757-300	243-279	178’-7”	54.4	124’-10”	38.1	16’-1”	4.9	44’-9”	13.6	12’-5”	3.8	12’-7”	3.8
			B757-200W	n/a	n/a	n/a	134’-9”	41.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			DC 8-63	259	182’-11”	55.8	148’-5”	45.2	15’-4”	4.7	43’-0”	13.1	10’-6”	3.2	12’-2”	3.7
			DC 8-71	259	182’-11”	55.8	142’-5’	43.4	15’-0”	4.6	43’-5”	13.2	10’-6”	3.2	12’-1”	3.7
			B767-300	261	180’-2”	54.9	156’-1”	47.6	16’-1”	4.9	52’-7”	16.0	13’-7”	4.1	13’-8”	4.2
			B767-400ER	243-409	197’-2”	60.1	170’-4”	51.9	19’-11”	6.1	55’-10”	17.0	13’-7”	4.1	14’-6”	4.4
			A300-600	289	177’-6”	54.1	147’-1”	44.8	17’-8”	5.4	54’-8”	16.7	14’-10”	4.5	15’-2”	4.6
			DC 10	270-399	170’-6”	52.0	155’-4”	47.4	14’-5”	4.4	58’-5”	17.8	15’-6”	4.7	15’-6”	4.7
			B787-300	317	n/a	n/a	170’-5”	51.9	n/a	n/a	55’-6”	16.9	n/a	n/a	n/a	n/a
			MD 11	323-410	192’-5”	58.6	170’-6”	52.0	12’-4”	3.8	58’-10”	17.9	15’-9”	4.8	15’-8”	4.8
Jumbo	V	E	B787-800	224-375	183’-5”	55.9	197’-3”	60.1	25’-2”	7.7	55’-6”	16.9	14’-2”	4.3	14’-7”	4.5
			B787-900	280	n/a	n/a	207’-10”	63.3	n/a	n/a	55’-11”	17.0	n/a	n/a	n/a	n/a
			A340-200	303	194’-10”	59.4	197’-10”	60.3	19’-8”	6.0	55’-11”	17.0	14’-9”	4.5	15’-6”	4.7
			A330-200	253-293	188’-8”	58.8	197’-10”	60.3	19’-10”	6.1	59’-10”	18.2	15’-2”	4.6	15’-9”	4.8
			A340-300	295	n/a	n/a	197’-10”	60.3	19’-6”	6.0	55’-9”	17.0	14’-10”	4.5	15’-5”	4.7
			A330-300	295-335	208’-10”	63.6	197’-10”	60.3	19’-11”	6.1	56’-5”	17.2	14’-11”	4.6	15’-6”	4.7
			B777-200	305-375	206’-6”	62.9	199’-11”	60.9	23’-6”	7.2	61’-6”	18.8	15’-5”	4.7	16’-0”	4.9
			B777-200LR	279-301	206’-6”	62.9	212’-7”	64.8	23’-6”	7.2	61’-6”	18.8	15’-5”	4.7	15’-11”	4.9
			A340-500	313	216’-8”	66.0	208’-2”	63.5	19’-9”	6.0	57’-6”	17.5	14’-10”	4.5	15’-7”	4.8
			B777-300	368-451	239’-9”	73.1	199’-11”	60.9	23’-6”	7.2	61’-6”	18.8	15’-5”	4.7	16’-0”	4.9
			B777-300ER	339-370	239’-9”	73.1	212’-7”	64.8	23’-11”	7.3	61’-10”	18.9	15’-9”	4.8	16’-2”	4.9
			A340-600	384	241’-0”	73.5	208’-2”	63.5	19’-6”	6.0	58’-11”	17.9	14’-11”	4.5	15’-9”	4.8
			B747-400	416-524	225’-2”	68.6	213’-0”	64.9	16’-9”	5.1	64’-0”	19.5	15’-6”	4.7	15’-9”	4.8
			B747-800	467	n/a	n/a	224’-7”	68.5	n/a	n/a	63’-6”	19.4	n/a	n/a	n/a	n/a
Super Jumbo	VI	F	A380-800	555	231’-0”	70.4	261’-9”	79.8	17’-4”	5.3	79’-4”	24.2	16’-8”	5.1	16’-9”	5.1

1/ The dimension is measured from underneath of the wing to ground/apron.

Source: Aircraft Manufacturers Technical Specifications

Disclaimer: The information contained in this table is provided as a courtesy for general airport planning purposes and should be verified against the manufacturer’s aircraft technical specifications.

APPENDIX E

Dimensions of Airline Equipment (Bag Carts and Containers, etc.)

Airside Vehicles

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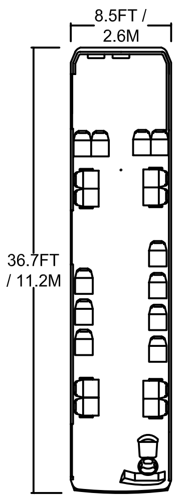
<td>
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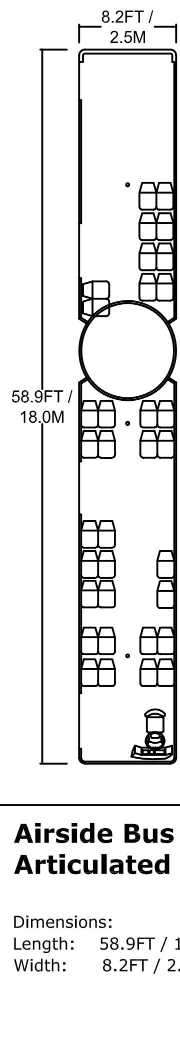
<td>
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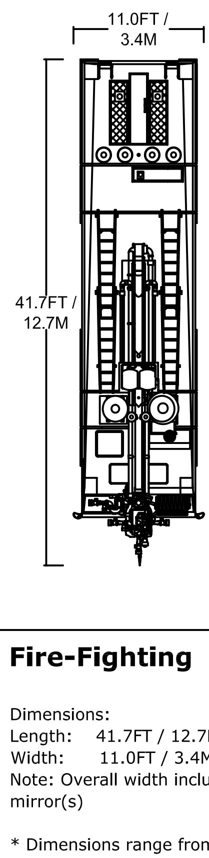
<td>
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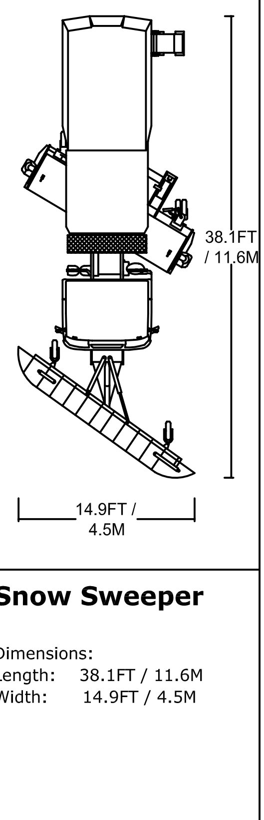
<td>
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<td>Airside Bus - Standard

Dimensions:
Length: 36.7FT / 11.2M
Width: 8.5FT / 2.6M

* Dimensions range from:
Min. Length: 28.5FT / 8.7M
Max. Length: 53.3FT / 16.2M
Min. Width: 7.8FT / 2.4M
Max. Width: 15.7FT / 4.8M</td>
<td>Airside Bus - Articulated

Dimensions:
Length: 58.9FT / 18.0M
Width: 8.2FT / 2.5M</td>
<td>Fire-Fighting

Dimensions:
Length: 41.7FT / 12.7M
Width: 11.0FT / 3.4M
Note: Overall width includes mirror(s)

* Dimensions range from:
Min. Length: 38.5FT / 11.7M
Max. Length: 51.3FT / 15.6M
Min. Width: 9.7FT / 3.0M
Max. Width: 11.0FT / 3.4M</td>
<td>Snow Sweeper

Dimensions:
Length: 38.1FT / 11.6M
Width: 14.9FT / 4.5M</td>
</tr>
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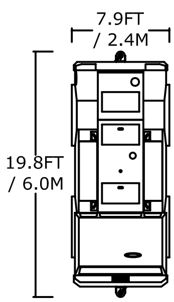
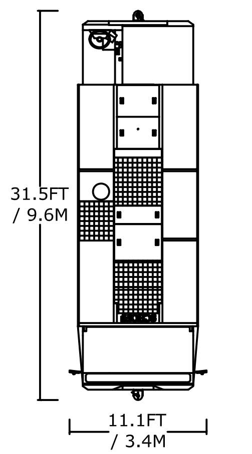
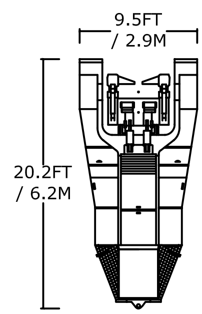
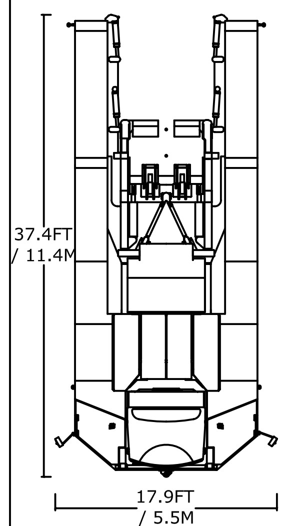
* Vehicle models vary in length and width. These values are taken from different models.

Source: Pathplanner A5, Simtra AeroTech

Disclaimer: The information contained in these tables are provided as a courtesy for general airport planning purposes and should be used as a “rule of thumb” for designing airport terminal apron layouts.

Aircraft Movers

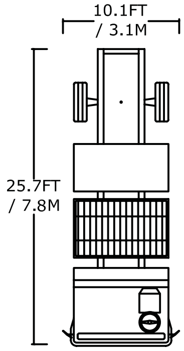
			
Aircraft Tugs - Conventional Dimensions: Length: 19.8FT / 6.0M Width: 7.9FT / 2.4M	**Aircraft Tugs - Conventional** Dimensions: Length: 31.5FT / 9.6M Width: 11.1FT / 3.4M Note: Overall width includes mirror(s)	**Aircraft Tugs - Towbarless** Dimensions: Length: 20.2FT / 6.2M Width: 9.5FT / 2.9M	**Aircraft Tugs - Towbarless** Dimensions: Length: 37.4FT / 11.4M Width: 17.9FT / 5.5M Note: Overall width includes mirror(s)

Note: Conventional tugs use tow bars to connect to the nose wheel of the aircraft, then they push the aircraft to a position from which it can safely move under its own power before disconnecting it. The tow bar can be connected at the front or the rear of the tractor, depending on whether the aircraft will be pushed or pulled.

Towbarless tractors do not use towbars but instead scoop up the nose wheel of an aircraft and lift it up off the ground, allowing the tug to maneuvre the aircraft. This allows more secure control of the aircraft, allowing greater speeds, and lets aircraft be moved without anyone in the cockpit. However, a towbarless tractor may be usable for fewer aircraft types than a conventional tractor.

Source: Pathplanner A5, Simtra AeroTech
Disclaimer: The information contained in these tables are provided as a courtesy for general airport planning purposes and should be used as a “rule of thumb” for designing airport terminal apron layouts.

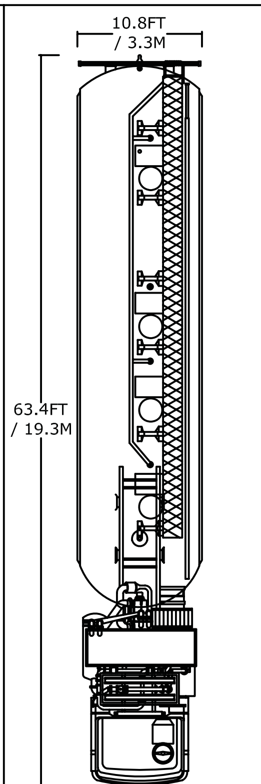
Ground Support Equipment



Hydrant Vehicle

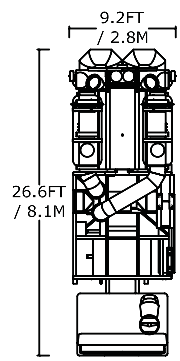
Dimensions:
Length: 25.7FT / 7.8M
Width: 10.1FT / 3.1M
Note: Overall width includes mirror(s)

* Dimensions range from:
Min. Length: 21.5FT / 6.6M
Max. Length: 30.8FT / 9.4M
Min. Width: 8.8FT / 2.7M
Max. Width: 10.1FT / 3.1M



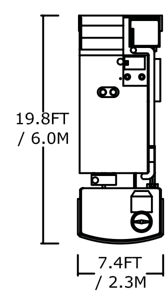
Fuel Tanker

Dimensions:
Length: 63.4FT / 19.3 M
Width: 10.8FT / 3.3M



Glycol Recovery Vehicle

Dimensions:
Length: 26.6FT / 8.1M
Width: 9.2FT / 2.8M



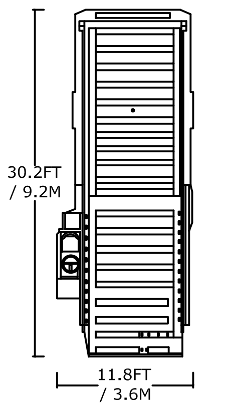
Lavatory Vehicle

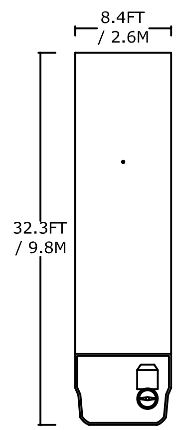
Dimensions:
Length: 19.8FT / 6.0M
Width: 7.4FT / 2.3M

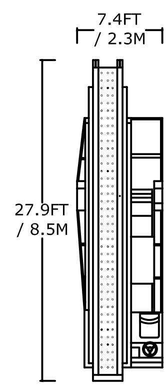
* Vehicle models vary in length and width. These values are taken from different models.

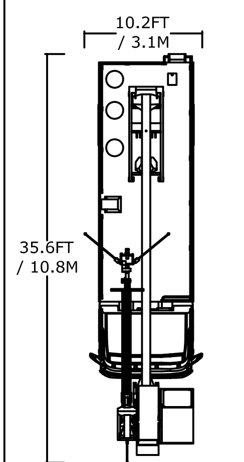
Source: Pathplanner A5, Simtra AeroTech
Disclaimer: The information contained in these tables are provided as a courtesy for general airport planning purposes and should be used as a “rule of thumb” for designing airport terminal apron layouts.

Ground Support Equipment









Container Loader	**Catering Vehicle**	**Conveyor Belt**	**Deicing**
Dimensions: Length: 30.2FT / 9.2M Width: 11.8FT / 3.6M	Dimensions: Length: 32.3FT / 9.8M Width: 8.4FT / 2.6M	Dimensions: Length: 27.9FT / 8.5M Width: 7.4FT / 2.3M	Dimensions: Length: 35.6FT / 10.8M Width: 10.2FT / 3.1M Note: Overall width includes mirror and nozzle.

Source: Pathplanner A5, Simtra AeroTech

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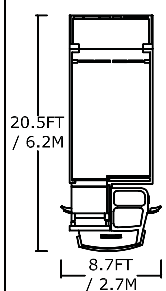
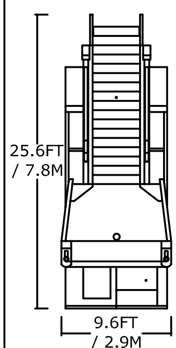
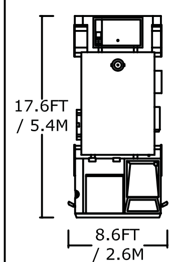
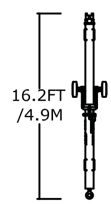
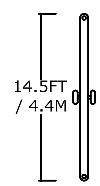
Ground Support Equipment

				
Passenger Loading - Lifting Unit for Handicapped Dimensions: Length: 20.5FT / 6.2M Width: 8.7FT / 2.7M Note: Overall width includes mirror(s)	**Passenger Loading - Passenger Ramp** Dimensions: Length: 25.6FT / 7.8M Width: 9.6FT / 2.9M	**Potable Water Vehicle** Dimensions: Length: 17.6FT / 5.4M Width: 8.6FT / 2.6M	**Tow Bar including Adapter** Dimensions: Length: 16.2FT / 4.9M Connection Length:15.5FT / 4.7M * Dimensions range from: Min. Connection Length: 12.2FT / 3.7M Max. Connection Length: 23.5FT / 7.2M	**Tow Bar** Dimensions: Length: 14.5FT / 4.4M Connection Length:13.8FT / 4.2M * Dimensions range from: Min. Connection Length: 9.5FT / 2.9M Max. Connection Length: 28.4FT / 8.7M

* Vehicle models vary in length and width. These values are taken from different models.

Source: Pathplanner A5, Simtra AeroTech
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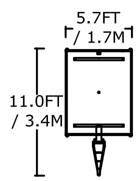
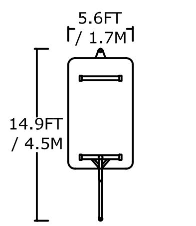
Baggage and Cargo Handling



Baggage Cart

Dimensions:

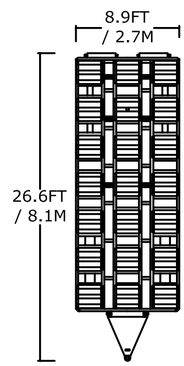
Length:	11.0FT / 3.4M
Width:	5.7FT / 1.7M



Baggage Cart

Dimensions:

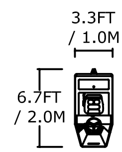
Length:	14.9FT / 4.5M
Width:	5.6FT / 1.7M



Cargo Pallet Trailer

Dimensions:

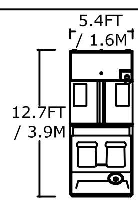
Length:	26.6FT / 8.1M
Width:	8.9FT / 2.7M



Baggage Tug

Dimensions:

Length:	6.7FT / 2.0M
Width:	3.3FT / 1.0M



Baggage Tug

Dimensions:

Length:	12.7FT / 3.9M
Width:	5.4FT / 1.6M

Source: Pathplanner A5, Simtra AeroTech

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APPENDIX F

Regulations

Occupational Safety and Health Administration Regulations

The Occupational Safety and Health Administration (OSHA) is the agency in the U.S. Department of Labor that enforces safety and health regulations in private workplaces to ensure safe and healthy working conditions.

The Occupational Safety and Health (OSH) Act assigns to OSHA two principal functions: setting standards and conducting workplace inspections to ensure that employers are complying with the standards and providing a safe and healthful workplace. OSHA standards may require that employers adopt certain practices, means, methods, or processes reasonably necessary to protect workers on the job. It is the responsibility of employers to become familiar with standards applicable to their establishments, to eliminate hazardous conditions to the extent possible, and to comply with the standards. Compliance may include ensuring that employees have and use personal protective equipment, when required, for safety or health. Employees must comply with all rules and regulations that are applicable to their own actions and conduct.

Even in areas where OSHA has not promulgated a standard addressing a specific hazard, employers are responsible for complying with the OSH Act's "general duty" clause. The general duty clause of the OSH Act [Section 5(a)(1)] states that "each employer shall furnish to each of his employees employment and a place of employment which is free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."

States with OSHA-approved job safety and health programs must set standards that are at least as effective as the equivalent federal standard. Most of the state-plan states adopt standards identical to the federal ones (two states, New York and Connecticut, have plans which cover only public sector employees).

Federal OSHA Standards

Standards fall into four major categories:

- General Industry (29 Code of Federal Regulations (CFR) 1910)
- Construction (29 CFR 1926)
- Maritime—shipyards, marine terminals, longshoring (29 CFR 1915–19)
- Agriculture (29 CFR 1928)

Each of these four categories of standards imposes requirements that are targeted to that industry, although in some cases they are identical across industries. Among the standards that impose similar requirements on all industry sectors are those for access to medical and exposure records, personal protective equipment, and hazard communication. For more information on the regulations, please visit the OSHA website: www.osha.gov.

ADA Regulations

The Americans with Disabilities Act (ADA) is a landmark law that protects the civil rights of persons with disabilities. It prohibits discrimination on the basis of disability in employment, state and local government services, transportation, public accommodations, commercial facilities, and telecommunications.

ADA covers facilities in the private sector (places of public accommodation and commercial facilities) and the public sector (state and local government facilities). Standards issued by the Department of Justice (DOJ) apply to all ADA facilities except transportation facilities, which are subject to standards maintained by the Department of Transportation (DOT). DOJ is in the process of adopting new ADA standards, and further information on this update is available on DOJ's website at www.ada.gov. DOT has adopted new ADA standards which apply to bus stops, rail stations, airports, and other transportation facilities.

ADA STANDARDS

	Facility	**Standards to Follow**
	Places of Public Accommodation and Commercial Facilities (private sector)	DOJ's ADA Standards (1991, reprinted 1993) *These standards are contained in DOJ's title III regulation (28 CFR Part 36) as Appendix A*
	State and Local Government Facilities (except transportation facilities)	DOJ's ADA Standards or UFAS *DOJ's title II regulation (28 CFR Part 35) allows use of the original ADA standards (with some exceptions) or the Uniform Federal Accessibility Standards (UFAS)*
	Transportation Facilities	DOT's ADA Standards for Transportation Facilities (updated) *These standards took effect November 29, 2006, as indicated in a notice published by DOT*

Source: http://www.access-board.gov/ADA-ABA/guide.htm

Fire Regulations

The National Fire Protection Association (NFPA), an international nonprofit organization, has a mission to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education.

The world's leading advocate of fire prevention and an authoritative source on public safety, NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks.

NFPA codes include some of the world's most referenced and respected, including:

- NFPA 1, Uniform Fire Code™: Provides requirements to establish a reasonable level of fire safety and property protection in new and existing buildings.
- NFPA 54, National Fuel Gas Code: The safety benchmark for fuel gas installations.
- NFPA 70®, National Electrical Code®: The world's most widely used and accepted code for electrical installations.

- NFPA 101®, Life Safety Code®: Establishes minimum requirements for new and existing buildings to protect building occupants from fire, smoke, and toxic fumes.

Building Codes

A building code, or building control, is a set of rules that specify the minimum acceptable level of safety for constructed objects such as buildings and non-building structures. The main purpose of the building code review board is to protect public health, safety, and general welfare as they relate to the construction and occupancy of buildings and structures.

The International Code Council (ICC), a membership association dedicated to building safety and fire prevention, develops the codes used to construct residential and commercial buildings, including homes and schools.

ICC is the developer of the International Codes™ (or I-Codes) used throughout the U.S., and is the organization that represents the state and local government code officials who enforce these building codes. The I-Codes are a complete set of comprehensive, coordinated, building safety and fire prevention codes. Building codes benefit public safety and support the industry's need for one set of codes without regional limitations. Fifty states and the District of Columbia have adopted the I-Codes at the state or jurisdictional level.

The ICC has developed and made available the following inventory of International Codes:

- *International Building Code®*
- *International Energy Conservation Code®*
- *International Code Council Electrical Code Administrative Provisions®*
- *International Existing Building Code®*
- *International Fire Code®*
- *International Fuel Gas Code®*
- *International Mechanical Code®*
- *ICC Performance Code™*
- *International Plumbing Code®*
- *International Private Sewage Disposal Code®*
- *International Property Maintenance Code®*
- *International Residential Code®*
- *International Urban-Wildland Interface Code™*
- *International Zoning Code®*

All of these codes are comprehensive and coordinated with each other to provide the appropriate package for adoption and use. There are instances when some local jurisdictions choose to develop their own building codes. Because having its own building code can be very expensive for a municipality, many have decided to adopt model codes instead.

APPENDIX G

Issues and Trends

As part of the Airport Cooperative Research Program (ACRP) Project 07-05 research, the Landrum & Brown (L&B) Team conducted an industry survey in order to identify current issues and potential emerging trends as they relate to the planning and design of airport passenger terminals. During the months of November and December 2007, e-mails were distributed to over 200 industry stakeholders throughout the United States. The stakeholders group included airport directors, airport planners, consultants, and various industry organizations including members of the terminal committee of the Airport Consultants Council. The intent was to provide an opportunity for a broad cross section of the industry to provide input to focus the L&B Team on the most pressing concerns and developing trends.

Participants in the survey were asked to rank in importance a variety of areas of interest relative to current issues and trends.

General Terminal Planning Issues and Trends

We have organized our general terminal planning comments about current issues and emerging trends into the eleven major categories ordered in the manner they were ranked in our industry survey:

- Capacity
- Construction Costs
- Level of Service
- Security
- Revenue Maximization
- Common Use Facilities
- Sustainability
- Low Cost Carriers
- Self-Service Processing
- Remote Processing
- Information Technology

These items then formed the general structure for this appendix and were then supplemented with additional information and comments based on the knowledge and experiences of the L&B Team.

Capacity

Balancing Airside, Terminal, and Landside Components of the Terminal Complex—A fundamental principle that is often an issue on terminal facility projects is to ensure that what is currently in operation and projected for the future is in balance with the airside and landside facilities capabilities. A current popular trend is to measure the capacity throughput of the airfield, gates, terminal, curb, parking, and roadways using simulation modeling that accurately reflects the level of service (LOS) and/or capacity desired. Aircraft operations and minutes of delay, turns per gate, passenger throughput, and International Air Transport Association (IATA) LOS, curb vehicular capacity, roadway flow LOS, and parking vehicle capacities are all important factors in balancing airside, terminal, and landside capacities.

Planning for Variable Aircraft Fleet Mixes, Variability of Schedules, and Changing Airlines—A key challenge for every terminal plan is to incorporate the flexibility to appropriately accommodate a variety of aircraft types and operation scenarios. In today's economic environment it is more important than ever to make effective utilization of aircraft gates. This is best accomplished by planning aircraft parking positions and passenger loading bridges to accommodate the widest range of aircraft types anticipated at the airport. Additionally, when appropriate, it is important that the control of the gates' operation ensures that multiple airlines have the ability to use gates when their demand requires. While exclusive gate use may be appropriate for an airline with significant activity throughout the day, airports should maintain sufficient control to promptly reassign gates if the airline's schedule no longer warrants exclusive use. Further, some gates should be equipped to readily be facilitated by multiple airlines so that the number of turns per gate can be maximized and new service more easily accommodated. Use permits and agreements, and gate management protocols are key to assuring that well-planned gates are effectively operated.

Accommodating Flexibility in Design—Preserving flexibility should always be an objective in terminal planning. The airport industry goes through cycles for both growth and types of service required, and in recent years, changing security requirements. Although the low cost carrier (LCC) model seems to be the dominant trend most recently, it may not be the controlling paradigm in the future. Even among LCCs, there are differences in the degree of customer service and methods of operation which would not be suitable for a 'one size fits all' approach. For example, one airline may place a greater emphasis on having passenger service agents at kiosk check-in counters than other carriers, and the arrangement of check-in kiosks may vary by carrier. Several themes emanate from the notion of flexibility, including a need of considerations such as: (1) whether the market is sufficiently stable to warrant development, for example, of a 50-year terminal or a far less expensive 15-year terminal; (2) the extent to which airline proprietary systems, equipment, and finishes are suitable when compared to more pliable shared use systems; and (3) if available space allows a design with economically alterable demising conditions.

Phasing Flexibility—An important aspect of the viability of any Master Plan is its ability to adapt to changes in mission by providing flexibility in how the ultimate Terminal Area Master Plan can be achieved. This flexibility attribute is accomplished by developing several phasing plan patterns or options that are driven by certain "trigger point" events and passenger activity levels (PALs). Assuring that assets will not need to be prematurely wasted to implement future phases needs to be integral to sound phasing decisions.

Phasing Trigger Points—The identification of "trigger points" that use realistic PALs serves as the theoretical benchmark to begin development of additional capacity for various components of the terminal complex. Most critical passenger processing functions are based on peak hour or peak surge (10- to 20-minute timeframes). It is typically necessary to translate the peak period activity statistics into an annual PAL since actual peak period statistics are difficult to monitor and collect. Identifying the relevant "passenger" information for the PALs is critical.

Application of Sustainability and Demand Management Concepts—One means of successfully achieving sustainability objectives is to minimize the amount of building construction required to meet the Master Plan's passenger demand levels. This places additional emphasis on understanding how far the efficiencies of the existing terminal complex can be pushed through demand management concepts that provide an acceptable LOS (such as IATA's LOS "C"). For example, Terminal LOS analysis would provide an objective of trying to reduce the amount of future construction required and/or to defer needed future construction. The sustainability and demand management concept objectives increase the importance of identifying terminal capacity on a function-by-function basis for major passenger processing activities. The PAL "trigger point" information for additional passenger processing capacity will need to be determined.

Importance of Incremental Expansion—An important challenge in planning terminal facilities is that there are expansion paths that incrementally add more capacity without significant interruption to ongoing operations.

Construction Costs/Affordability

Construction Cost Escalation—The rapid economic growth in Asia, particularly China, has resulted in significant increases in the cost of steel, concrete, asphalt, copper, and other raw materials that have escalated construction costs of airport terminal facilities. This rapid change in costs has made it difficult to accurately estimate project costs. The escalation in construction costs has put additional pressure on increasing all sources of airport revenues, in particular, non-airline revenues, given the current pressures on the airlines' cost of doing business.

Impact of Airlines Cost Factors on Affordability—Unprecedented increases in the cost of jet fuel and high labor costs have significantly contributed to the cost per passenger, especially for the legacy carriers. This has opened the door for the establishment and success of the LCC with lower operating costs. Both of these trends have in turn placed additional pressure on keeping terminal project costs aligned with expected and needed benefits.

A Rising Need for Terminal Capacity During a Time of Limited Revenues—In the post 9/11 environment, the demand for air travel has increased while economic pressures have tempered increases in airlines rates and charges. Growing competition for federal budget dollars and concerns about the effect of higher charges on airline ticket sales are limiting the ability to increase funding options such as additional Airport Improvement Program grant funds or Passenger Facility Charges that are used by airports as an effective path to capital development funds.

Accelerating Commercial Revenue in Phasing Approach—Airports are keenly committed to developing potential non-airline revenue sources. It is important that, when possible, commercial revenue generation opportunities such as terminal concessions or adjacent commercial development be accelerated to provide additional Capital Improvement Program funding leverage.

Level of Service

Industry Need to Identify Level of Service Standards—While international LOS standards have been identified by the IATA, there has not been an official U.S. source or an authoritative treatise on LOS for airport terminals. ACRP has several research projects in addition to this Airport Passenger Terminal Planning Guidebook that will touch on LOS including ACRP 03-05, "Passenger Space Allocation Guidelines for Planning and design of Airport Terminals."

Domestic Arrivals Meeter/Greeter Areas—Existing airport terminals are still adjusting from pre-9/11 configurations that do not provide designated spaces for meeters/greeters to congregate. Most often this area in existing terminals is physically very constrained. Depending on the specific characteristics of an airport's passengers and its ratio of meeters/greeters to arriving passengers, it may improve passenger service to provide a meeter/greeter lobby with seating and access to some landside concessions.

Security

Increased Spatial Requirements and Flexibility to Meet Changing Security Procedures—Countering the potential reduction in check-in time and space for check-in through technological improvements is the steadily increasing complexity of and process time for security, both for passengers and bags. Security at airports has always functioned in a reactive mode, for example, the recent liquids ban. The example of the liquids ban resulted in a short-term spike in checked baggage which overwhelmed many airport baggage systems. It is most likely that reactive measures will continue and that the space and processes for passenger and bag screening will continue to require changing types of equipment and configurations. For instance, new passenger screening technologies like backscatter and millimeter wave are being tested in some U.S. airports like Phoenix Sky Harbor International Airport (PHX), John F. Kennedy International Airport (JFK), and Los Angeles International Airport (LAX) and may see wider use if personal privacy issues caused by the clarity of body images can be overcome. These new devices may add to spatial requirements at security checkpoints. Thus, there is a need for flexibility in these areas, as well as in other portions of the terminal. The ability to have sufficient and easily convertible space around critical security screening functions is one of the best insurance policies to allow a quick and less expensive adaptation to new procedures or added technologies. Astute terminal planning calls for recognition of passenger screening as a major "pressure point" in the terminal.

It should be mentioned that the Transportation Security Administration (TSA) has recently published a new standard entitled, *Recommended Security Guidelines for Airport Planning, Design and Construction,* revised in June of 2006.

Multiple vs. Single Security Checkpoints—There are various aspects to this issue. Because of the continued pressure on the TSA to control staffing costs, there appears to be a preference for focusing staff resources on fewer checkpoints rather than multiple checkpoints. Conversely, some airport operators have suggested that they prefer having more than a single checkpoint because this basically forces the TSA to actually have sufficient staff to provide a satisfactory LOS for security screening. Another important aspect to this issue is the potential for security breaches that requires closing down areas beyond the security checkpoint to isolate the potential threat. Having multiple checkpoints associated with a limited and contained area of exposure (i.e., a concourse) allows the option to close down the terminal in sections.

Behavior Detection—The TSA has recently launched a new security program that uses behavior detection officers, trained at recognizing "micro-expressions" to identify potential suspicious airline passengers. There are also indications that TSA is looking at automating this effort by using video cameras and computers to measure and analyze heart rate, respiration, body temperature, and verbal responses, as well as facial micro-expressions. This new program may require configuration adjustments and additional spatial requirements at existing Security Screening Checkpoints.

Explosive Detection System in-line Baggage and Handling Systems for Screening Checked Baggage—The TSA is continuing to push for in-line baggage processing systems for checked luggage to increase throughput efficiencies and reduce TSA staff resource requirements. Its objective continues to focus on working with the Department of Homeland Security (DHS) to develop technologies that increase throughput capacity and overall detection capabilities. While indicating that it is accelerating and facilitating the installation of cost-effective checked baggage screening systems, there are some sobering realities about the funding available to provide Explosive Detection System (EDS) Baggage and Handling Systems (BHS) to the nearly 280 Category X through Category III airports in the United States. In-line screening has many advantages from a passenger service standpoint, but it usually requires significant increases in terminal area.

Blast Resistant Structures—Each terminal design needs to be carefully reviewed relative to its susceptibility to possible terrorist threats using explosives. While there still are operational guidelines relative to keeping vehicles 300 feet away from the face of a terminal during severe (Red) and high (Orange) national alert levels, each terminal design needs to be carefully assessed relative to mitigating blast construction. A blast analysis can be performed to explore mitigation measures if the distance from parked vehicles is less than the 300 feet. Mitigation measures might include special designed spaces or construction materials to absorb the blast, structural reinforcement, and coated glass.

TSA Travel Document Program—The TSA has implemented a program which is assuming the duties of checking travel documents/boarding passes at several major U.S. airports. The TSA believes that this will provide an additional deterrent to terrorism because TSA officers will be used to check the travel documents which allow: spotting fraudulent IDs and boarding documents, examining passengers for suspicious behavior, and checks against watch-list data.

Registered Traveler Program—Currently, six airports are involved in the U.S. Registered Traveler (RT) Program which is aimed at eliminating hassles and delays at security checkpoints. It is estimated that the RT security lines are capable of processing as much as three times as many travelers as regular airport security lines and can substantially reduce security-line wait times. This potentially adds an additional lane to the security screening checkpoints or possibly replaces the premium airline customer lane.

Secure Flight—This TSA program is designed to conduct uniform prescreening of passenger information against federal government watch lists for all flights of U.S. aircraft operators. Aircraft operators are generally defined as passenger airlines that offer scheduled and public charter flights from commercial airports. The TSA proposes to implement this rule in two stages. The first stage would include covered flights between two domestic points in the United States and the second stage would include covered flights to or from the United States, flights that overfly the continental United States, and all other flights (such as international point-to-point flights) operated by covered U.S. aircraft operators not covered in the first stage. Basically this is the TSA taking over from the airlines the inspection process of travel documents and boarding passes.

Revenue Maximization

Concessions Revenue Maximization—One of the most important current trends is concessions development (i.e., relying on concessions to provide a higher revenue stream for airports and providing a level of amenity for passengers as their dwell times increase in terminals). Concessions also require flexibility to be able to react to changes in passenger tastes and needs. For example, if the current domestic airline model of minimal in-flight food service reverses toward providing meals (as a competitive advantage), there could be a need to change the mix of concessions in a terminal.

Concessionaire Logistic Centers—The general trends for the development of airport concessionaire logistics centers include more efficient use of information technology to better balance the arrival and delivery of goods. Integration with airport shop POS (point of sales) systems enables the logistics center providers with the ability to better predict the demand for merchandise deliveries to the terminal building.

The development of concessionaire logistics centers is expected to increase in popularity as airports expand further the size and complexity of their concession programs. With a trend away from master concessionaires and to a greater number of concession providers, the need for airport operators to consolidate and streamline the delivery of merchandise to terminal buildings becomes increasingly important.

Wireless Passenger Check-in—Rental car companies have for many years used wireless devices to check in and invoice returned cars at remote sites. This concept can be extended to passenger check-in by equipping wireless tablets to perform passenger identification functions and transmit this data, in encrypted form, to readers at screening checkpoints in the terminal. A wireless device, such as a portable tablet, could be configured to perform fingerprint scan, iris scan, and facial recognition of a passenger, and also to scan the bar code of the passenger's preprinted boarding pass. The passenger could then be given a temporary match-on-card token containing the required biometric identifier(s) and proceed, by an airport bus, to an area of the terminal equipped with biometric readers. Once the passenger has done a biometric match with the token at a checkpoint reader, passed through the checkpoint, and the event recorded, the biometric data on the passenger's token would be erased and the token recycled for use by other passengers.

Airside/Landside Concessions Allocation—In light of current TSA security screening procedures, most passengers prefer to pass through security prior to using any discretionary time to shop. This current passenger behavior pattern has placed a priority on situating the majority of concessions beyond the security checkpoints. In general, a rule of thumb is to provide upwards of 80% to 90% of the available concessions on the secure airside of the terminal, especially in airports with large shares of connecting passengers. Even if an airport's passengers are mostly Origin and Destination (O&D), concessions located past security screening on the airside typically outperform similar landside concessions.

Focusing Passenger Flows for Maximum Revenue Return—The most productive concessions programs focus the primary flow of departing passengers through a significant block of concessions once they have cleared security screening. Examples of these "grand hall" concession malls include Seattle-Tacoma International Airport's Central Terminal Pacific Marketplace and Dallas/Fort Worth International Airport's Terminal D shopping areas. Some existing terminals have also been able to successfully provide a similar shopping mall configuration but prior to security screening such as at PHX's Terminal 4.

Centralized vs. Decentralized Facilities—For some airports the decision between planning a terminal configuration that is centralized vs. decentralized can affect the revenue generation and quality of concessions offerings. Maximized revenues are best achieved by exposure to a centralized flow of passengers as compared to a dispersed pattern of passenger flows. A decentralized facility typically requires the concessionaire to duplicate concession locations, which in turn increases the cost of doing business at the airport. In addition, the breadth of products that can be offered, and the associated increase in total average spend per passenger, is greatest when concessions do not require unnecessary duplication.

Impact of In-Flight Service Reductions by Air Carriers on Concession Revenues—Reductions in the availability of in-flight amenities offered to passengers onboard aircraft, both complimentary and for sale, have generated increased demand for food and beverage and other take-away products at airport facilities. As a result, the provision of grab-and-go food and beverage facilities, especially those provided in locations proximate and directly visible to gate holdrooms, has become particularly popular.

Impact of Changes in Security Processing on Concession Layout Strategies—As many concession facilities, both landside and airside, are located on primary passenger flows adjacent to passenger security checkpoints, concession layout plans should ensure flexibility in their design to provide for potential future changes in passenger processing technologies and security screening. For example, both the depth and width of security checkpoints could change in the future as new security screening technologies are introduced.

Flexibility to Accommodate Future Concessions Demand—The concessions layout plan should recognize and assess the effect that terminal renovations/expansions will have on current and future passenger flows. Potential changes in the levels of passenger and aircraft activity, especially in the first years after expansion areas open, will affect demand for commercial and service facilities in existing facilities. As a result, the location, sizing, and timing for the building's commercial facilities must be flexible, because passenger destinations and dwell times will depend on the airlines operating there.

Common-Use Facilities

Impacts of Common Use Terminal Equipment (CUTE) and Common Use Self-Service (CUSS)—The operational characteristics of the specific airlines servicing an airport have a significant effect on the quantity of gate and passenger processing capacities that the future terminal complex must deliver. The more airlines that operate in a common-use manner the more it will help to reduce the overall size of the terminal complex. This also helps to meet the sustainability objective of minimizing the consumption of building materials and hence natural resources, as well as minimizing construction activity effects to the environment. To identify each airline's operational policies and potential conversion to CUTE and potential utilization of CUSS kiosks requires interviews with both corporate and local airline station managers. It may also affect existing leases and operating agreements.

Common Use Provides Adaptability and Flexibility—Advances in information technology have allowed the introduction of common-use kiosks that allow multiple airlines to use a common kiosk platform. On an operational front, common use of aircraft gates can assist in minimizing capital construction costs.

Airlines' Resistance to Common-Use Facilities—Historically airlines have often resisted the implementation of common-use terminal equipment in deference to their own marketing and business priorities. This has been changing as economic realities begin to usher in cost-saving measures, and airports and airlines become increasingly familiar with the risks, risk mitigations, benefits, and costs of these systems.

Sustainability

Sustainability—Concepts of sustainability were initially conceived in the 1980s and began to gain true application toward the beginning of 2000. The sustainability trend has gained additional momentum with airport terminal projects to the point that achieving Leadership in Energy and Environmental Design (LEED) certification is not whether LEED should be pursued but whether the appropriate LEED target is Silver, Gold, or Platinum. It is reported that only one airport terminal has achieved LEED certification to date, Terminal A at Boston Logan International Airport. L&B did the initial planning at Terminal A for Massport and Delta, and through the subsequent architectural design and construction of the project, achieved a LEED Certified award certification. These LEED certifications look at a multitude of factors including site ecosystems, effect on building occupants, building systems, and sustainable materials performance. Thirty-four credits and up to 69 points are awarded for: sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, and innovation and design.

Green Building Technologies—The term "Green Building" is synonymous with sustainable building design. The U.S. Green Building Council has developed and conducts the LEED certification process. Environmentally friendly approaches, such as recycled and recyclable materials, natural lighting, energy conservation, use of low-emitting materials, building reuse, and various system controls, all assist in making a building "green."

Gate Electrification—As part of a "green" initiative the FAA has provided Detroit Metro's North Terminal project with a $5.1 million grant to provide gate electrification for preconditioned air to save fuel consumption by aircraft not having to run auxiliary power units at 26 gates. This is also a trend at many other airports.

Central Utility and Co-Generation Plants—Because airports typically require a substantial amount of electricity and steam 24 hours a day, seven days a week, the operational concept of a centralized co-generation plant that produces steam for both the production of electrical power and heating works well at airports. The combination of reducing the cost of electric and heating, along with the elimination of sulfur dioxide emissions, if natural gas is used as the fuel source, is why co-generation plants are becoming more of a trend at airports.

Low-Cost Carriers

Changes to the Terminal Business Model—The aviation industry continues to experience change in the form of new air service concepts and uncertainty about various issues like fuel prices. New air service entries offering no frills services (LCCs) are changing the traditional terminal model. Airport terminals that rigidly anticipate a status quo almost always result in diminished flexibility. Since the early 1970s, but more recently over the last 15 years, LCCs have continued to capture additional market share from traditional airlines. The operating formula for the LCCs has been a business performance model that includes simplifying all aspects of their operations. Characteristics of this business model include providing one class of service (typically without reserved seating), selecting a single aircraft type, simplifying fare structures, focusing on quick ground turns of aircraft, and operating from airport terminal facilities that provide minimal levels of service at low costs to the airline. Southwest Airlines in the United States and easyJet Airline Company in Europe immediately come to mind as examples of LCCs, but others in the United States include Air Tran Airways, JetBlue Airways, and Spirit Airlines. Of a similar nature but providing even lower base fares are the "ultra" LCCs like Ryanair in Europe and, recently, the launch of Skybus Airlines, an ultra LCC based in Columbus and actually modeled after Ryanair. While low fares are a characteristic of both LCCs and ultra LCCs, the ultra LCCs allow passengers to select only the services and options appropriate to their travel needs through costing options that add to a very low base price.

LCC Impact on Terminal Facilities—The LCC concept is having a profound effect on the airport/airline industry as a whole and has begun to have an effect on U.S. terminal designs. Because of the recent financial plights of the traditional service legacy carriers and the success of the LCC concept, there is increasing pressure on airport operators to provide terminals that reflect the same austere quality of the business model used by the LCCs. Low-cost, simple terminals providing minimal services with a low rent base for the airline operator help these types of LCCs achieve their business model performance objectives. In turn, these LCCs are also acting as a catalyst in the development of secondary airports and metropolitan multi-airport systems. Because the primary objective of the LCC is to get its aircraft into and out of the terminal quickly, the apron needs to be conducive to efficient aircraft positioning and fast aircraft turnarounds, with easy access to primary-use runways. Quicker turnarounds mean more flights can be processed at each gate, thereby requiring fewer total gates. Depending on the package of services being offered by the particular LCC, the terminal may be designed around ground level passenger loading with passenger loading bridges being an option. Providing this option allows the flexibility for the LCC to add bridges at a later time and to raise their LOS package. It also allows the airport operator more flexibility for using the facility should a legacy carrier need gates. Because these types of LCC operations are fairly self contained, there is usually no need for an interline baggage system. A simple flat bag belt feeds to the airside, and flat plate claim device for inbound bags is normally sufficient. Building dedicated low-cost facilities, specifically designed and constructed at a minimal cost that can then be used to justify a lower cost lease arrangement for the low-cost class of carrier, may help to resolve this potential conflict. It may be necessary to also offer any new low-cost facilities to the legacy carriers, as well, in order to avoid being accused of discriminatory practices.

LCC Effect on Level of Service—The interior design of an LCC terminal will also reflect a similar low-cost approach. LOS targets are generally below the IATA suggested LOS C, such as D or E, but for only short durations. The LCC business model demands quick aircraft turns and limited dwell times for passengers. Most often these terminal designs include common holdrooms, sometimes with plastic seating (Singapore Changi Airport), containing fewer seats and relying on people standing for short periods of time, sharing contingent holdroom areas, and even occupying some concession areas. Although these facilities are low cost there are potential concessions revenue opportunities to be capitalized on. LCC passengers still spend some money on concessions. This trend has been reported at Southwest's new terminal at Baltimore/Washington International Thurgood Marshall Airport (BWI).

Self-Service Processing

Electronic Check-in—Advances in computer technologies and the Internet have revolutionized the check-in procedures at airports around the globe. In the United States, a boarding pass is required to board an aircraft and to pass through airport security checkpoints. Having an electronic ticket that can be printed prior to coming to the airport allows a passenger with only hand-carried luggage to bypass the traditional check-in counters and proceed directly to the security screening process. On airlines without online check-in, the check-in may take place at a self-service kiosk in the airport, or at the check-in counter.

Expanding Use of Self-Service Check-in Kiosks—This includes both airline-dedicated and CUSS, and is associated with other forms of electronic check-in (whether via Internet, off-site locations, mobile devices, etc.). All have effects on the size and configuration of the check-in lobby. These technological advances can also have potential capacity effects on down-stream processes such as security, if the amount of time required for that process is reduced and passengers find that they can arrive at the terminal closer to departure time. Arriving later at the airport but processing more quickly through the check-in process places a more peaked demand on the down-stream security screening process.

Remote Processing

Remote Passenger Processing from Off-Airport Locations—A potential exception to the previously mentioned concessions centralization principle is the potential for a secondary location to be established in a higher passenger traffic and economic yield demographic. Establishing a remote passenger processing facility in a central business district, with fast and convenient access to the airport's air travel services, may also improve revenue generation. Some airports around the world have taken advantage of opportunities to develop commercial facilities downtown (in some cases including duty-free sales) with convenient rail access or, conversely, immediately adjacent to the airport terminal (i.e., Hong Kong International Airport's Kowloon Station and SkyCity facilities respectively).

Information Technology

Building Information Modeling (BIM)—Is a software product that is gaining momentum in the planning and design of airport terminal facilities. BIM builds a database of project information that exists in a multi-dimensional graphic format. As the project moves from initial planning to a more refined design, the BIM program files increase in detail, becoming the repository of information about the entire project. This database of information allows cost estimates to be prepared at any time during the project commensurate with the level of detail of the graphic drawings. BIM is also proving to be an excellent presentation tool that facilitates project understanding on many different levels, early in the project.

APPENDIX H

Acronyms

AAAC	Airport/Airline Affairs Committees
AACC	Airport Authorities Coordinating Council
AASHTO	American Association of State Highway and Transportation Officials
AC	Advisory Circular
ACI	Airports Council International
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
ADAAG	ADA Accessibility Guidelines
ADG	Aircraft Design Group
ADPM	Average Day of the Peak Month
ADRM	Airport Development Reference Manual
AIP	Airport Improvement Program
ALP	Airport Layout Plan
AOA	Air Operations Area
AOC	Airport Operations Center
AODB	Air Operations Database
APHIS	Agricultural and Plant Health Inspection Service
APM	Automated People Mover or Airport People Mover
APU	Auxiliary Power Unit
ARC	Airport Reference Code
ARFF	Aircraft Rescue and Fire Fighting
ASDE	Airport Surface Detection Equipment
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASP	Airport Security Program
ASPM	Aviation System Performance Metrics
ATA	Air Transport Association
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
ATM	Automated Teller Machine
ATO	Airport Ticket Office or Airline Ticket Office
ATR	Automated Tag Reader
ATSA	Aviation and Transportation Security Act
BHS	Baggage Handling System
BIDS	Baggage Information Display Systems
BIM	Building Information Modeling
BIPP	Bomb Incident Prevention Plan
BMP	Best Management Practices
BOCA	Building Officials and Code Administrators

BOT	Build, Operate, and Transfer
BSO	Baggage Service Offices
BTS	Bureau of Transportation Statistics
CAD	Computer Aided Design
CASE	Canadian System Airport Evaluation
Cat-Ex	Categorical Exclusion
CATV	Community Antenna Television
CBIS	Checked Baggage Inspection Systems
CBP	Customs and Border Protection
CBR	Chemical, Biological, and Radiological
CCTV	Closed Circuit Television
CDC	Center for Disease Control
CEQ	Council on Environmental Quality
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
CIP	(Airport) Capital Improvement Program
CMU	Concrete Masonry Units
CNG	Compressed Natural Gas
CP	(Airport Emergency) Command Post
CPE	Cost per Enplanement
CUPPS	Common Use Passenger Processing System
CUSS	Common Use Self-Service
CUTE	Common Use Terminal Equipment
CWA	Clean Water Act
CWM	Construction Waste Management
CZMA	Coastal Zone Management Act
DCV	Destination Coded Vehicle
DDFS	Design Day Flight Schedule
DEP	Department of Environmental Protection
DER	Departure End of Runway
DHS	Department of Homeland Security
DOT	Department of Transportation
EA	Environmental Assessment
ECP	Equivalent Check-in Positions
EDS	Explosives Detection System
EIA/TIA	Electronic Industries Alliance / Telecommunications Industry Association
EIS	Environmental Impact Statement
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EQA	Equivalent Aircraft
ESA	Endangered Species Act
ESC	Erosion and Sedimentation Control
ETD	Explosives Trace Detection
FAR	Federal Aviation Regulations
FBO	Fixed-Base Operator
FEMA	Federal Emergency Management Agency
FIDS	Flight Information Display System
FIS	Federal Inspection Services

FOD	Foreign Object Debris or Foreign Object Damage
FONSI	Finding of No Significant Impact
fpm	Feet per Minute
FPPA	Farmland Protection Policy Act
FSC	Forest Stewardship Council
FSD	Federal Security Director
FTP	Fictitious Threshold Point
FWS	Fish and Wildlife Service
GPA	Glidepath Angle
gpf	Gallons per flush
GPM	Gallons per minute
GPU	Ground Power Unit
GSE	Ground Service Equipment
GTC	Ground Transportation Center
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
HMI	Human Machine Interface
HVAC	Heating, Ventilation, and Air Conditioning
HVAC&R	Heating, Ventilation, Air Conditioning, and Refrigeration
Hz	Hertz (cycles/sec)
IAQ	Indoor Air Quality
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICE	Immigration and Customs Enforcement
ID Badge	Identification Badge
IDF	Intermediate Distribution Frame
IED	Improvised Explosive Device
IESNA	Illuminating Engineering Society of North America
INS	Immigration and Naturalization Service
IP	Internet Protocol
IT	Information Technology
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LDCS	Local Departure Control System
LEED	Leadership in Energy and Environmental Design
LEO	Law Enforcement Officer
LOS	Level of Service
LRTP	Long-Range Transportation Plan
LTP	Landing Threshold Point
LVIED	Large Vehicle Improvised Explosive Device
MAP	Million Annual Passengers
MARS	Multi-Aircraft Ramp System
MCP	Motor Control Panel
MDF	Main Distribution Frame
MERV	Minimum Efficiency Reporting Value
MPO	Metropolitan Planning Organization
MSL	Mean Sea Level
MUBIDS	Multi-User Baggage Information Display System
MUFIDS	Multi-User Flight Information Display System
MUSE	Multi-User System Environment
MUTCD	Manual on Uniform Traffic Control Devices

NAAQS	National Ambient Air Quality Standards
NAS	National Airspace System
NBEG	Narrowbody Equivalent Gate
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
O&D	Origin and Destination
OAG	Official Airline Guide
OCR	Optical Character Recognition
OCS	Obstacle Clearance Surface
O.D.	Outside Dimension
OFA	Object Free Area
OSHA	Occupational Safety and Health Administration
OSR	On-Screen Resolution
PAL	Planning Activity Level
PAPI	Precision Approach Path Indicator
PAX	Abbreviation for passenger(s)
PCD	Program Criteria Document
PDA	Personal Digital Assistant
PDS	Premises Distribution System
PFAF	Precision Final Approach Fix
PFC	Passenger Facility Charge
PHADPM	Peak Hour of an Average Day of the Peak Month
PHS	Public Health Service
PLC	Programmable Logic Controller
PMAD	Peak Month Average Day
PMAWD	Peak Month Average Weekday
PRT	Personal Rapid Transit
RAC	Rent-a-Car or Rental Car
RASP	Regional Airport System Plan
RECs	Renewable Energy Certificates
RFID	Radio Frequency Identification
ROM	Rough Order of Magnitude
RON	Remain Overnight
R/R	Ready/Return Rental Car Parking
RTP	Regional Transportation Plan
SHPO	State Historic Preservation Office
SIDA	Security Identification Display Area
SMACNA	Sheet Metal and Air Conditioning National Contractors' Association
SMGCS	Surface Movement Guidance & Control System
SOC	Security Operations Center
SRI	Solar Reflectance Index
SSCP	Security Screening Checkpoint
SSD	Self-Service Device/Kiosk
STA	Scheduled Time of Arrival
STD	Scheduled Time of Departure
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAF	Terminal Area Forecast
TAMP	Terminal Area Master Plan

TC	Transport Canada
TCH	Threshold Crossing Height
TCU	Threat Containment Unit
TERPS	United States Standard for Terminal Instrument Procedures
TRACON	Terminal Radar Approach Control
TRB	Transportation Research Board
TSA	Transportation Security Administration
TSR	Transportation Security Regulations
TWOV	Transit Without Visa
UBC	Uniform Building Code
UEC	Universal Encoding Console
ULD	Unit Load Device
UPS	Uninterruptible Power Supply
USACE	United States Army Corps of Engineers
USCIS	United States Citizenship and Immigration Services
USCS	U.S. Customs Services
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
VALE	Voluntary Airport Low Emissions
VBIED	Vehicle-Borne Improvised Explosive Device
VDC	Volt DC
VE	Value Engineering
VLAN	Virtual Local Area Network
VOC	Volatile Organic Compound
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network
Wi-Fi	Wireless-Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WTMD	Walk Through Metal Detector

APPENDIX I

Glossary

TERM	DEFINITION
Access Control	A system, method, or procedure to restrict and control access to areas of the airport. Certain airports are required by 49 Code of Federal Regulations 1542 to provide for such a system.
Access Point	Any means of entry into a controlled security area, typically consisting of an electronic card reader, monitor contacts and/or latches, with access points wired to an access control system. Some access points may be physically controlled by guards, with or without a supporting electronic installation.
Adaptive Plants	Plants that typically grow well in a given habitat with minimal human intervention in the form of frost protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adaptive plants are considered to be low maintenance but not invasive.
Advisory Circular (AC)	A publication issued externally by the FAA providing non-mandatory, non-regulation-based guidance and information on aviation topics of current interest and/or concern to the industry.
Air Carrier	Generally accepted as being airlines operating larger aircraft of more than 90 seats, as distinct from commuter or regional airlines.
Air Quality Conformity	A process that ensures federal funding. Conformity approval goes to transportation activities that are consistent with air quality goals. This process applies to both the long-range Regional Transportation Plan and the Transportation Improvement Program.
Air Traffic Control (ATC)	A service operated by a government or government-regulated body to manage and oversee the safe, orderly, and expeditious flow of air traffic through the airspace under its jurisdiction.
Air Traffic Control Tower (ATCT)	An elevated facility located at a position on the airport which offers a 360° view of all parts of the airfield and aircraft movement areas.
Aircraft Approach Category	A grouping of aircraft based on 1.3 times their stall speed in their landing configuration, at the certificated maximum flap setting and maximum landing weight at standard atmospheric conditions.

TERM	DEFINITION
	The categories are as follows: Category A: Speed less than 91 knots. Category B: Speed 91 knots or more but less than 121 knots. Category C: Speed 121 knots or more but less than 141 knots. Category D: Speed 141 knots or more but less than 166 knots. Category E: Speed 166 knots or more.
Aircraft Design Group (ADG)	A Roman numerical classification of aircraft based on wingspan or tail height.
Aircraft Mix	See Fleet Mix
Aircraft Movement	An aircraft takeoff or landing at an airport. For airport traffic purposes, one arrival and one departure is counted as two movements.
Aircraft Operations	The landing, takeoff, or touch-and-go procedure by an aircraft on a runway at an airport.
Aircraft Operations Area	A portion of an airport, specified in the airport security program, in which security measures specified in 49 Code of Federal Regulations (CFR) 1542 are implemented. This area includes aircraft movement areas, aircraft parking areas, loading ramps, secure areas for use by aircraft regulated under 49 CFR 1544 or 49 CFR 1546, and any adjacent areas (such as general aviation areas) that are not protected by adequate security systems, measures, or procedures.
Aircraft Rescue and Fire Fighting (ARFF) Facility	A facility located at an airport that provides emergency vehicles, extinguishing agents, and personnel responsible for minimizing damage and casualties in the event of an aircraft fire, accident, or incident.
Aircraft Stand	A designated area on an apron intended to be used for parking an aircraft.
Aircraft Type	Aircraft of the same family or similar operational characteristics, for example, the Boeing 747 is a type of aircraft made up of the following sub-types: 747-100, 747-200, 747-300, and 747-400.
Airfield	The portion of an airport that contains the facilities necessary for the landing, takeoff, and maneuvering of aircraft.
Airline	A commercial air carrier including its equipment, routes, operating personnel, and management.
Airline Club	An airport amenity sponsored by an airline. Benefits for club members may include a private waiting area, business center, complimentary refreshments, and the service of an airline representative.
Airline Ticket Counter	A place for airlines to provide staff to assist with ticket sales and seating assignments, confirms passenger identification, and undertakes baggage check-in prior to delivery to the Transportation Security Administration (TSA) baggage screening process.
Airline (or Airport) Ticket Office (ATO)	An airline office location for supporting operations including ticket sales, passenger and baggage check-in typically located in or near the check-in lobby.

TERM	DEFINITION
Airport Authority	A quasi-governmental public organization responsible for setting the policies that govern the management and operation of an airport, or system of airports, under its jurisdiction.
Airport Configuration	The relative layout of component parts of an airport such as the runways, taxiways, and terminal building.
Airport Elevation	The highest point on an airport's usable runway expressed in feet above mean sea level (MSL).
Airport Emergency Command Post	A room or combination of rooms/facilities from which a Crisis Management Team commands and directs the response to abnormal situations and threats to airport operations, such as extreme weather or other natural disaster, terrorist event, hostage situation, or aircraft disaster.
Airport Improvement Program (AIP)	Provides grants to public agencies, and in some cases, to private owners and entities for the planning and development of public-use airports that are included in the National Plan of Integrated Airport Systems (NPIAS). The program's broad objective is to assist in the development of a nationwide system of public-use airports adequate to meet the current projected growth of civil aviation.
Airport Layout Plan (ALP)	The plan of an airport showing the layout of existing and proposed airport facilities.
Airport Master Plan	A comprehensive study of an airport that describes the airport's short-, medium-, and long-term development plans to meet future aviation demand.
Airport Operator	The holder of an airport certificate, or the person designated to be in charge of a certificated airport, whether an employee, agent, or representative.
Airport Reference Code (ARC)	A coding system developed by the FAA to relate airport design criteria to the operational and physical characteristics of the aircraft types that will operate at a particular airport.
Airport Security Program	A program sponsored by the airport. There is no standardized program for airport operators regulated in accordance with 49 Code of Federal Regulations Part 1542. The regulatory requirements are specified in Part 1542.103 and adapted to each airport's local conditions.
Airport Sponsor	The recipient of a grant that has eligibility to receive funds under the Airport Improvement Plan (AIP).
Airport Surface Detection Equipment (ASDE)	Radar equipment specifically designed to detect all principal features and traffic on the surface of an airport, and display this information in the Air Traffic Control Tower (ATCT).
Airside	That part of an airport that contains the facilities necessary for the operation of aircraft. Also used to refer to the portion of the terminal that contains the gates, holdrooms, etc.

TERM	DEFINITION
Airspace	The area above the ground through which aircraft travel between their points of origin and destination. It is divided into corridors, routes, and restricted zones for the safe and efficient management and control of air traffic.
Albedo	See Solar Reflectance.
Algorithm	A formula in which a series of clearly defined steps is followed systematically to solve a particular problem.
Americans with Disabilities Act (ADA)	A landmark law that protects the civil rights of persons with disabilities. It prohibits discrimination on the basis of disability in employment, state and local government services, transportation, public accommodations, commercial facilities, and telecommunications.
Approach Surface	An imaginary obstruction-limiting surface defined in Federal Aviation Regulations (FAR) Part 77, which is longitudinally centered on an extended runway centerline and extends outward and upward from the primary surface at each end of a runway, at a designated slope and distance based upon the type of available or planned approach by aircraft to a runway.
Apron	A specified portion of the airfield used for passenger, cargo, or freight loading and unloading; aircraft parking; and the refueling, maintenance, and servicing of aircraft.
Arterial	A class of road providing the principal highway connection between major points of destination.
American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)	An international organization of professionals employed in these fields, founded in 1894. ASHRAE fulfills its mission of advancing heating, ventilation, air conditioning, and refrigeration to serve humanity and promote a sustainable world through research, standards writing, publishing, and continuing education.
Attainment/ Non-Attainment Area	A non-attainment area is any geographic area of the United States that is in violation of one or more National Ambient Air Quality Standards (NAAQS).
Automated People Mover (APM)	A transportation system that is used to transport, horizontally, large numbers of people between various points on the landside and/or airside of an airport.
Automated Tag Reader (ATR)	Equipment utilized to automatically scan bag tags and sort baggage to the proper designated make-up destination. (Also called Laser Barcode Reader Arrays.)
Automatic (Fixture) Sensors	Motion sensors that automatically activate the water supply to sinks and toilets by sensing physical movement in the proximity.
Auxiliary Power Unit (APU)	Equipment, either on-board an aircraft or on the ground, that is used to generate electric power for operating on-board equipment or for aircraft engine startup.

TERM	DEFINITION
Average Day of the Peak Month (ADPM)	Activity (passengers or aircraft operations) in the average day of the peak month of the year. Average day activity is obtained by dividing the peak month activity by the number of days in the month.
Badge	See ID Badge.
Baggage Claim Area	Area located in the passenger terminal building for checked baggage that has arrived at the final destination for passengers to reclaim.
Baggage Handling System (BHS)	The system(s) by which all checked baggage is tagged, sorted, and assigned to the correct location for loading onto a departing aircraft or collection by passengers on arrival at their final destination.
Baggage Information Display Systems (BIDS)	Information systems designed to inform passengers which baggage claim unit will be used to deliver their luggage. Also includes multiuser systems (MUBIDS).
Baggage Make-up Area	Area of the baggage handling system in which departing baggage is sorted and placed in carts or containers for loading onto aircraft.
Baggage Reconciliation System	Method of baggage management that creates a bag tag and tracks the baggage throughout the sortation process until it is delivered to the aircraft or the baggage belt.
Baggage Screening Area	That part of the baggage handling system to or through which all originating and international re-check baggage will be delivered for explosives detection screening by the TSA.
Bandwidth	In information technology, the term describes data-carrying capacity—how much (and how fast) data flows on a given transmission path. Bandwidth is commonly measured in bits or bytes per second.
Baseline Building Performance	The annual energy cost for a building design intended for use as a baseline for rating above standard design, as defined in ASHRAE 90.1-2004 Informative Appendix G.
Best Management Practices (BMPs)	Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources, such as pollutants carried by urban runoff.
Biomass	Plant material such as trees, grasses, and crops that can be converted to heat energy to produce electricity.
Biometrics	A general term used alternatively to describe a characteristic or a process. As a characteristic: A measurable biological (anatomical and physiological) and behavioral characteristic that can be used for automated recognition. As a process: Automated methods of recognizing an individual based on measurable biological (anatomical and physiological) and behavioral characteristics. At an airport, biometric identifiers may include fingerprint, hand geometry, iris scan, facial recognition, and/or several other methods currently in development.
Bioretention	A system (also referred to as a “rain garden” or a “biofilter”) for stormwater management practice, to manage and treat stormwater runoff, using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression.

TERM	DEFINITION
Bioswale	A shallow depression used to capture stormwater runoff and filter out pollutants. They are very similar to rain gardens, but are generally used in commercial and municipal settings.
Blast Fence	A barrier used to divert or dissipate jet blast or propeller wash.
Blast Resistant Façade	A laminated form of glazing installation commonly specified to mitigate injuries from flying glass.
Bomb Incident Prevention Plan	Detailed procedures to be implemented during an actual bombing or when a facility has received a bomb threat.
Brownfield	Abandoned or underused industrial and commercial facilities/sites, where expansion or redevelopment is complicated by real or perceived environmental contamination. Additionally in an airport planning context the term "brownfield" also refers to any site that has previous development as compared to a "greenfield" site; not necessarily contaminated or abandoned.
Building Codes	Codes, either local or state, that regulate the functional and structural aspects of buildings and/or structures.
Building Envelope	The exterior surface of a building's construction—the walls, windows, roof, and floor. (Also referred to as the "building shell.")
Building Footprint	The area on the project site that is taken up by the building structure and is defined by the perimeter of the building plan. Parking lots, landscapes, and other non-building facilities are not included in the building footprint.
Building Information Modeling (BIM)	A model-based technology, linked with a database of project information, used to create a digital representation of the building process to facilitate exchange and interoperability of information in digital format. BIM addresses geometry, spatial relationships, geographic information, quantities, and properties of building components.
Building Officials and Code Administrators International (BOCA) Inc.	A group that publishes codes that establish minimum performance requirements for all aspects of the construction industry. (Now known as the International Code Council.)
Bypass Lane	A road lane that allows vehicles to go around other stopped vehicles picking up or dropping off passengers on a curbside lane or maneuvering in and out of the curbside lane.
Capacity	The variable measurement of a specific airport system or subsystem's throughput, or the system's capability to accommodate a designated level of demand.
Carpool	An arrangement in which two or more independent individuals share a vehicle for transportation.
Carry-on Baggage	An individual's personal property that is carried into a designated sterile area or into an aircraft cabin and is accessible to an individual during flight.

TERM	DEFINITION
Catchment Basin	A storage site (such as a small reservoir) that delays the flow of water downstream.
Categorical Exclusion	Categories of actions that do not individually or cumulatively have a significant effect on the environment and that have been found to have no such effect by procedures adopted by a federal agency in implementation of these regulations (1507.3) and for which, therefore, neither an Environmental Assessment nor an Environmental Impact Statement is required.
Customs and Border Protection (CBP)	See U.S. Customs and Border Protection
Cell Phone Lots	Designated parking areas that allow drivers, free-of-charge, to sit and wait for passengers without having to enter a formal parking lot, dwell on a curb, or continuously recirculate.
Charter Flights	Flights performed for remuneration on an unscheduled basis, including related empty flight stages and inclusive tours other than those reported under scheduled services.
Checked Baggage	Property tendered by, or on behalf of, a passenger and accepted by an aircraft operator for transport, which is inaccessible to passengers during flight. Accompanied commercial courier consignments are not classified as checked baggage.
Clean Air Act (CAA)	The federal law regulating air quality, first passed in 1967, required that air quality criteria necessary to protect the public health and welfare be developed. Since 1967, there have been several revisions to the CAA. The Clean Air Act Amendments (CAAA) of 1990 represent the fifth major upgrade of clean air legislation. Among other things, the CAA has added requirements for federal actions to conform to State Implementation Plans (SIPs), expanded the list of hazardous air pollutants from eight to 189, and strengthened the operation permit program.
Clean Water Act (CWA)	Act that establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but was significantly reorganized and expanded in 1972. "CWA" became the Act's common name following amendments in 1977.
Closed Circuit Television (CCT)	A non-public television system with typically very limited circulation, intended to be viewed by restricted personnel and with a dedicated purpose of surveillance.
Coastal Zone Management Act	Administered by the National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management, and provides for management of the nation's coastal resources, including the Great Lakes, and balances economic development with environmental conservation.

TERM	DEFINITION
Code of Federal Regulations (CFR)	A compilation of the general and permanent rules of the executive departments and agencies of the federal government as published in the *Federal Register.* The code is divided into 50 titles that cover the broad areas subject to federal regulation.
Commercial Aviation	The business of operating aircraft that carry passengers and freight on a commercial basis.
Commercial Service (Airport)	A public airport providing scheduled passenger and/or freight services that enplanes at least 2,500 annual passengers.
Commissioning	The process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the owner's project requirements.
Common Use	The process, systems, and physical changes needed at an airport to make various airport facilities such as gates, ticket counters, bag claim devices, etc. useable by multiple airlines.
Common Use Passenger Processing System (CUPPS)	A system that describes the range of services, specifications, and standards enacted to enable multiple airlines to share physical check-in and/or gate podium positions (whether simultaneously or consecutively).
Common Use Self-Service (CUSS)	A means for multiple airlines to share a self-service electronic check-in application for use by their passengers at a single point of service usually known as a kiosk.
Common Use Sortation System	A system that incorporates all of the carriers' bags into one common shared sortation and delivery system to process and sort the bags by carrier destination.
Common Use Terminal Equipment (CUTE)	Computer system provided to airlines by the airport (or other party) that allows airline staff to access their own computer systems without having their own dedicated equipment, thus promoting more flexible and efficient use of airport facilities.
Commuter Carrier	Different definitions are used for safety purposes and for economic regulations and reporting. For the purposes of economic regulation and other reporting requirements, commuter air carriers are those carriers that operate aircraft of 60 or fewer seats or a maximum payload capacity of 18,000 pounds or less.
Commuter Rail	Urban passenger train service for short-distance travel between a central city and adjacent suburb.
Computer-Aided Design	Software that is commonly used for drafting architectural and engineering drawings.
Concourse	The portion of a terminal that contains the aircraft gate holdrooms, related concessions, restrooms and services, and the circulation corridors needed for access.
Conical Surface	An imaginary obstruction-limiting surface defined in Federal Aviation Regulations Part 77 that extends from the edge of the horizontal surface outward and upward at a slope of 20 to 1 for a horizontal distance of 4,000 feet.

TERM	DEFINITION
Connecting Passengers	See Transfer Passenger.
Constructed Wetland	Engineered wetlands that simulate natural wetlands and utilize natural and biological processes for wastewater treatment.
Construction Indoor Air Quality Management Plan	A document specific to a building project that outlines measures to minimize contamination in the building during construction and to flush the building of contaminants prior to occupancy.
Construction Waste Management Plan	A plan that diverts construction debris from landfills through conscientious plans to recycle, salvage, and reuse.
Cost–Benefit Analysis	An analysis of the benefit, cost, and uncertainty associated with a project or action. A formal cost–benefit analysis is required for capacity projects of $5 million or more in Airport Improvement Plan (AIP) discretionary funds.
Cost per Enplanement	An airline's airport-related costs, landing fees, and rents divided by the total number of passengers enplaned at the airport.
Crisis Management Team	A group of individuals managing a crisis to prevent, or at least contain, a crisis situation from escalating, jeopardizing safety and facilities, attracting unfavorable attention, inhibiting normal operations, creating a negative public image, and adversely affecting the organization's viability.
Critical (Design) Aircraft	The most demanding aircraft with at least 500 annual operations that operates, or is expected to operate, at the airport.
Crosswind	A wind that is not parallel or roughly parallel to a runway centerline or to the intended flight path of an aircraft.
Crosswind Component	The component of wind blowing across the direction to the runway centerline or the intended flight path of an aircraft.
Curb Island	A pedestrian area between traffic lanes of a highway or street. In the airport context, a curb island is used to increase curb frontage and separate different vehicle types.
Curbside/Terminal Curb/Curb Frontage	The portion of the airport terminal dedicated to the safe and efficient transfer of people between the terminal and cars, buses, taxis, and other vehicles.
Curbside Check-in	An area located along the terminal's vehicle curb frontage where designated employees accept and check in baggage from departing passengers.
Daylighting	The controlled admission of natural light into a space through glazing with the intent of reducing or eliminating electric lighting.
Deicing	The process that removes ice, snow, slush, or frost from airplane surfaces for flight safety purposes.
Delay	The difference, in minutes, between the scheduled time and actual time of an aircraft arrival or departure. For airport planning purposes, it is often expressed as an annual average delay per aircraft operation (in minutes).

TERM	DEFINITION
Demand	The number of persons, aircraft, or vehicles who want to use a facility.
Deplanement	Any passenger getting off an arriving aircraft at an airport. Can be a terminating or connecting passenger. Also applies to freight shipments.
Design Day	A typical day's activity used to estimate demand for terminal facilities. Most typically this is the average day of the peak month, but can also be an average weekday or a specific day in the case of some airports with highly peaked service.
Design Hour	The numbers of enplaned and deplaned passengers, in rolling hour of a typically busy (design) day.
Destination Coded Vehicle	A type of high-speed automated baggage handling system that uses individual carts running on guideways for each bag.
Discretionary Grants	The funds remaining in the Airport Improvement Plan after apportioned grants are approved and dispersed as discretionary grants. Discretionary grants may be appropriated to an airport by the Secretary of Transportation or Congress, on the basis of the agency's goals and congressional direction. Of these remaining funds, 75%, known as capacity, safety, security, and noise, is to be used for preserving and enhancing capacity, safety or security, and carrying out noise compatibility and mitigation programs. The remaining 25%, known as remaining or pure discretionary funds, may be used for any project deemed eligible at any airport.
Door Sill Height	Height from ground to aircraft door sill.
Drug Enforcement Administration	A federal agency and the part of the U.S. Department of Justice responsible for enforcing laws and regulations governing narcotics and controlled substances.
Dwell Time	The length of time a vehicle remains stopped at the curbside area to load and unload passengers.
e-freight	Designed to eliminate the need to produce and transport paper documentation for air cargo shipments by moving to a harmonized, industry-wide system of on-line electronic processing.
Electronic Check-in	The process by which passengers check-in using self-service kiosks at the airport (on airport) or via the airlines' Internet sites (off airport).
Emergency Operations Center	See Airport Emergency Command Post.
Energy Conservation Measures	The installation of equipment or systems, or modifications to equipment or systems, for the purpose of reducing energy use and/or costs.
Energy Modeling	The use of computer-based tools to simulate the energy use of a building, throughout an entire year of operation, in order to assess the energy use of a building and to quantify the savings attributable to the proposed design.

TERM	DEFINITION
Enplanement	The boarding of a passenger, or item of cargo, freight, or mail onto an aircraft at an airport.
Entitlement Grants	Statutory provisions require that Airport Improvement Program funds be apportioned by formula each year to specific airports, in the form of entitlement grants. Among the recipients of apportioned funds are primary airports, cargo service airports, and states, among others. For each primary airport, apportionment is based upon the number of passenger boardings at the airport.
Environmental Assessment (EA)	A "concise document" that takes a "hard look" at expected environmental effects of a proposed action. Depending on project scope and complexity, the EA should be no more than 15 pages.
Environmental Impact Statement (EIS)	A document with the primary purpose of being an "action-forcing tool" to ensure federal government programs and actions meet the National Environmental Policy Act's goals and policies. The EIS requires the sponsor of a project to critically assess the relative environmental impacts of no actions, the proposed action, and any feasible and reasonable alternatives.
Environmentally Sensitive Area	An area of environmental importance having natural resources that if degraded, may lead to significant adverse, social, economic, or ecological consequences. These could be areas in or adjacent to aquatic ecosystems, drinking water sources, unique or declining species habitat, and other similar sites.
Equivalent Aircraft (EQA)	This metric is used to normalize the capacity of each gate, based on the seating capacity of the aircraft that can be accommodated. 1 EQA is equal to a typical narrowbody aircraft of 145 seats.
Erosion and Sedimentation Control Plan (ESC)	A plan to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust generation.
Ethernet	A standard information technology for network area communications in local area networks when all devices in the network are connected to a central cable or hub.
Explosive Ordnance Disposal	To render safe either improvised or manufactured explosive devices with the assistance of appropriately technically trained and equipped personnel.
Explosives Detection System (EDS)	Equipment designed to automatically detect the chemical signature of explosive materials. The Transportation Security Administration has tested the system against pre-established standards and has certified that the system meets the criteria in terms of detection capabilities and throughput.
Explosives Trace Detection (ETD)	A device that has been certified by the Transportation Security Administration for detecting explosive particles on objects intended to be carried into the sterile area or transported on board an aircraft.
FAR Part 77, Objects Affecting Navigable Airspace	(a) establishes standards for determining obstructions in navigable airspace; (b) defines the requirements for providing notice to the FAA Administrator of certain types of proposed construction or

TERM	DEFINITION
	alteration; (c) provides for aeronautical studies of obstructions to air navigation to determine their effect on the safe and efficient use of airspace; (d) provides for public hearings on the hazardous effect of proposed construction or alteration on air navigation; and (e) provides for establishing antenna farm areas.
Federal Aviation Regulations (FAR)	The general and permanent rules established by the executive departments and agencies of the federal government regarding aviation, which are published in the *Federal Register.* These are the aviation subset of the *Code of Federal Regulations.*
Federal Inspection Services (FIS)	U.S. agencies responsible for inspecting arriving international passengers, baggage, and cargo. Consists of U.S. Customs and Border Protection (CBP), U.S. Fish and Wildlife Service (USFWS), and Public Health Service.
Federal Security Director (FSD)	The director of the Transportation Security Administration is responsible for providing day-to-day operational direction for federal security screening and inspection personnel at airports, as well as regulatory compliance of airports and aircraft operators. FSDs are not law enforcement officers; that responsibility falls to local jurisdictions.
Fiber Optics	Fibers used to transmit digital information over long distances at a high speed.
Finding of No Significant Impact (FONSI)	A finding issued when environmental analysis and inter-agency review during the Environmental Assessment (EA) process finds a project to have no significant impacts on the quality of the environment. The FONSI document is the EA modified to reflect all applicable comments and responses. If it was not covered by the EA, the FONSI must include the project sponsor's recommendation or selected alternative.
Firewall	Software that prevents unauthorized users from logging in to a private network (usually one that's connected to the public Internet).
Fixed-Base Operator (FBO)	An airport-based business enterprise that provides services to the operators of general and business aviation aircraft, including aircraft parking and rental, training, fueling, maintenance, parking, and the sale of pilot supplies.
Flat Plate Claim Device	A flat level rotating baggage reclaim belt for the delivery of relatively low volumes of baggage. These devices are typically configured in an oval shaped, "L" shaped, "T" shaped, or a "U" shaped configuration located in the baggage claim area.
Fleet Mix	A collective term generally used to describe the categorization and breakdown of aircraft within a specific airline fleet by reference to aircraft type.
Flight Information Display System (FIDS)	A computerized system for conveying and displaying airport and airline operational information to the general public and relevant airport service providers including gate, arrival/departure times, and on-time status. Also includes multi-user systems (MUFIDS).

TERM	DEFINITION
Foot-Candle	A unit of luminance equal to 1 lumen of light falling on 1-square-foot area, from a 1-candela light source at a distance of 1 foot.
Foreign Object Debris or Foreign Object Damage (FBO)	Any object that does not belong in or near aircraft and that can potentially injure airport or airline personnel and/or damage airplanes, such as loose hardware, pavement fragments, catering supplies and other garbage, building materials, rocks, sand, pieces of luggage, and even wildlife.
Fuselage	The main body of an airplane to which the wings and tail are fastened.
Gantt Chart	A graphical representation of the duration of specified tasks against a specific timeline.
Gate	An aircraft parking position that is used for actively loading and unloading passengers.
Gate Management System	A software-based system designed to optimize the assignment of aircraft gates consistent with specified airport/airline business goals and physical constraints.
General Aviation	Civil aviation carried out by, or on behalf of, private individuals and corporate entities, including on a commercial basis, but not marketed to the general public.
General Aviation Airport	An airport that provides air service only to general aviation.
Geo-Thermal	Also known as geo-exchange or ground source heating and cooling. Geo-thermal systems exploit the ability to exchange heat between the relatively constant temperature of the ground and a building.
Glide Slope	Equipment that provides vertical guidance for aircraft during approach and landing.
Gradient	A slope expressed as a ratio of the horizontal to the vertical distance. For example, 40:1 means that for every 40 feet traveled horizontally the surface rises by 1 foot vertically.
Green Roof or Vegetated Roof	Also known as rooftop gardens, green roofs are planted over existing roof structures and consist of a waterproof, root-safe membrane that is covered by a drainage system; lightweight growing medium; and plants. Green roofs reduce rooftop and building temperatures, filter pollution, lessen pressure on sewer systems, and reduce the heat island effect.
Greenfield Airport or Terminal	The development of a new airport or terminal on a new site, as opposed to expansion or reconfiguration of an existing facility.
Ground Access	The transportation system on and around the airport that provides access to and from the airport by ground transportation for passengers, employees, cargo, freight, and airport services.
Ground Power Unit (GPU)	Equipment used to provide power to an aircraft while parked on the ground.
Ground Service Equipment (GSE)	Equipment used to service aircraft while parked at the gate including maintenance, fueling, baggage transport, cargo, and airline personnel.

TERM	DEFINITION
Ground Transportation Center	Provides a centralized location where commercial vehicles can pick up and drop off passengers.
Hazard to Air Navigation	An object that, following an aeronautical study, the FAA determines will have a substantial adverse effect upon the safe and efficient use of navigable airspace by aircraft, the operation of air navigation facilities, or existing or potential airport capacity.
Hazardous Materials	Any substances or materials that, if commercially transported, pose unreasonable risk to public health, safety, and property. Includes hazardous wastes and hazardous substances, as well as petroleum and natural gas substances and materials.
Heat Island Effect	This occurs when warmer temperatures are experienced in urban landscapes compared to adjacent rural areas as a result of solar energy retention on constructed surfaces. Principal surfaces that contribute to the heat island effect include streets, sidewalks, parking lots, and buildings.
Heating, Ventilation and Air Conditioning (HVAC)	Systems used to provide thermal comfort and ventilation for building interiors.
Heavy Rail	A high-capacity railway characterized by exclusive rights-of-way, multicar trains, high speed, and high-platform loading.
Highway Capacity Manual	A manual produced by TRB that details methodologies for analyzing roadways and intersections and is the standard for roadway analysis both in the United States and in many other nations.
Highway Capacity Software	Designed to replicate procedures, manual worksheets, and examples in the Highway Capacity Manual that is issued by TRB.
Holding Station	A location created specifically to hold passengers temporarily at a security screening checkpoint until screeners are available to escort them to the proper area to conduct secondary screening. (A holding station differs from a wanding station.)
Horizontal Surface	An imaginary obstruction-limiting surface defined in Federal Aviation Regulations (FAR) Part 77 that is specified as a portion of a horizontal plane surrounding a runway located 150 feet above the established airport elevation. The specific horizontal dimensions of this surface are a function of the types of approaches existing or planned for the runway.
Hub	An airport having a high percentage of connecting flights.
Hub and Spoke	A system for deploying aircraft that enables a carrier to increase service options at all airports encompassed by the system. It entails the use of a strategically located airport (the hub) as a passenger exchange point for flights to and from outlying cities (the spokes).
Hubbing	A method of airline scheduling that schedules the arrival and departure of banks of aircraft in a close period of time, in order to promote the expeditious transfer of passengers between different flights of the same airline.

TERM	DEFINITION
Hybrid Vehicles	Vehicles that use a gasoline engine to drive an electric generator and use the electric generator and/or storage batteries to power electric motors that drive the vehicle's wheels.
Identification (ID) Badge	A personal identification medium compliant with 49 *Code of Federal Regulations* Part 1542.211, typically used in conjunction with a separate access control medium. May also apply to the use of methods employing decals, signs, or markers to identify authorized persons, vehicles, and/or property.
Imaginary Surfaces	Surfaces established in relation to the end of each runway or designated takeoff and landing areas for heliports, as defined in paragraphs 77.25, 77.28, and 77.29 of Federal Aviation Regulations Part 77, *Objects Affecting the Navigable Airspace.* Such surfaces include the approach, horizontal, conical, transitional, primary, and other surfaces.
Improvised Explosive Device (IED)	A device that has been fabricated in an improvised manner and incorporates explosives or destructive, lethal, noxious, pyrotechnic, or incendiary chemicals in its design.
In-Line Screening System	A form of checked baggage screening where EDS equipment is located along the baggage conveyors to allow bags to be screened at a high rate.
Inbound Conveyor	Conveyor that carries baggage from the aircraft or baggage carts to the baggage reclaim units.
Indoor Air Quality	The quality of air inside a building that may affect the health and well-being of building occupants.
Interline Baggage	Baggage of passengers subject to transfer from the aircraft of one airline to the aircraft of another airline.
Intermodal	The ability to make connections between different modes of transportation.
International Airport	Any airport designated as an airport of entry and departure for international air traffic, and carries out the formalities relating to customs, immigration, public health, animal and plant quarantine, and similar procedures.
International Operations	Aircraft operations performed by air carriers engaged in scheduled international air service.
Isolated Parking Position	An area designated for the parking of aircraft suspected of carrying explosives or incendiaries to accommodate responding law enforcement and/or Explosive Ordnance Disposal (EOD) personnel in search efforts.
Jet Blast	The force or wind generated behind a jet engine, particularly on or before takeoff when the engine is operated at high/full thrust, but also a planning consideration in respect of aircraft taxiing areas.
K-9 (Canine Team)	Dog teams used for the detection of explosives, narcotics, or other contraband materials.

TERM	DEFINITION
Landside	Areas of an airport to which passengers and members of the non-traveling public have free access. Also used to refer to ground access facilities, and portions of the terminal related to check-in, baggage claim and other functions outside of the secured portion of the terminal.
Law Enforcement Officer (LEO)	An individual authorized to carry and use firearms, vested with such police power of arrest as determined by federal law and state statutes and identifiable by appropriate indicia of authority.
Leadership in Energy and Environmental Design (LEED)	A third-party certification program and the nationally accepted benchmark for the design, construction, and operation of high-performance green buildings.
Legacy Carrier	In the U.S. market, the term specifically refers to those airlines that flew interstate routes prior to the Airline Deregulation Act of 1978.
Level of Service (LOS)	A defined set of qualitative and quantitative standards against which to measure the quality of the passenger experience in a particular airport. Planning of an airport terminal typically identifies a particular LOS as the starting point for establishing facilities requirements.
Life-Cycle Cost Method	A technique of economic evaluation that analyzes, over a given study period, the cost of initial investment (less resale value), replacements, operations (including energy use), and maintenance and repair of an investment decision (expressed in net present or annual value terms).
Light Rail	A streetcar-type vehicle operated on city streets, semi-exclusive rights-of-way, or exclusive rights-of-way. Service may be provided by step-entry vehicles or by level boarding.
(Passenger) Load Factor	The number of passenger seats occupied expressed as a percentage of the total seat capacity of an aircraft.
Local Area Network	A short-distance electronic network used to link a group of computers together within a building
Long Haul	Operating sectors of 5,000 kilometers or more, operated non-stop and presuming an aircraft with a full payload at normal cruising conditions and with an adequate fuel reserve to reach an alternate airport.
Long-Range Transportation Plan or Regional Transportation Plan	A document resulting from regional or statewide collaboration and consensus on a region or state's transportation system and serving as the defining vision for the region's or state's transportation systems and services. In metropolitan areas, the plan indicates all of the transportation improvements scheduled for funding over the next 20 years.
Low-Flow	Plumbing product fixtures and fittings that meet the water efficiency standard of the Energy Policy Act of 1992. The term is used interchangeably with the term "low consumption."
Magnetometer or Walk Through Metal Detector	A walk-through archway device, approved by the FAA, to detect metal on persons desiring access beyond the screening checkpoint. Metal detection can also be accomplished using hand-held "wand" devices.

TERM	DEFINITION
Mainline Aircraft (Jet)	Generally a medium- to long-haul airliner such as the B737, A320, and larger widebody aircraft.
Mass Transit	Any form of high-density, low-fare mode of public ground transportation.
Metropolitan Planning Organization	Regional body, required in urbanized areas with populations over 50,000. Amongst other things, it is responsible for cooperating with the state and other transportation providers in carrying out the metropolitan transportation planning requirements mandated by federal highway and transit legislation.
Mobile Lounges (Transporters)	Used to transport passengers between the terminal and remotely parked aircraft. This special type of airport equipment is designed to elevate vertically, connect with a terminal dock and/or aircraft, and drive between each location. Passengers typically walk directly into the transporter on the same level as the terminal or aircraft.
Mode Split (or Modal Split)	The relative proportion of all trips to and from the airport that are made on the various modes of transportation, whether private car, taxi, public bus, or rail and so forth.
Movement Areas	The runways, taxiways, and other areas of an airport that are used for taxiing, takeoff, and landing of aircraft, exclusive of loading ramps and aircraft parking areas.
Moving Walkway	A fixed conveyor device on which pedestrians may stand or walk while they are being transported.
Multi-Modal	The availability of transportation options using different modes within a system or corridor.
Narrowbody Equivalent Gate (NBEG)	This metric is used to normalize the capacity of each gate, based on the wingspan of the aircraft that can be accommodated. 1 NBEG is equal to a typical ADG III narrowbody aircraft with a 118-foot wingspan.
National Airspace System	The network of air traffic control facilities, air traffic control areas, and navigational facilities throughout the United States.
National Environmental Policy Act	An act that requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions.
National Register of Historic Places (NRHP)	The official list of the nation's historic places worthy of preservation. Authorized under the National Historic Preservation Act of 1966, it is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources.
Native (Indigenous) Plants	Plants that have adapted to a given area during a defined time period and are not invasive.
Navigational Aid	Any visual or electronic device, airborne or on the ground surface, that provides point-to-point guidance information or position data to aircraft in flight.

TERM	DEFINITION
Net Present Value	The present value of the expected future cash flows taking into account initial capital and ongoing recurrent costs.
Noise Compatibility Programs	List of actions the airport sponsor proposes to undertake to minimize noise/land use incompatibilities.
Object Free Area (OFA)	An area on the ground centered on a runway, taxiway, or taxilane centerline provided to enhance the safety of aircraft operations by having the area free of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.
Obstacle	An existing object, object of natural growth, or terrain at a fixed geographical location, in respect of which vertical clearance is, or must be, provided during flight operations.
Obstacle Free Zone (OFZ)	The OFZ is the airspace below 150 feet (45 meters) above the established airport elevation and along the runway and extended runway centerline that is required to be clear of all objects, except for frangible visual navigational aids that need to be located in the OFZ because of their function, in order to provide clearance protection for aircraft landing or taking off from the runway, and for missed approaches.
Official Airline Guide (OAG)	A listing of airline flight schedules including flight times, connections, and aircraft types.
On-Screen Resolution (OSR)	A visual system that allows a TSA screener to visually review an image of an alarmed bag on a monitor and clear it prior to reaching the Explosives Trace Detection room, also called Level 2 screening.
Operations	The landing, takeoff, or touch-and-go procedure by an aircraft on a runway at an airport.
Origin and Destination Passengers	Passengers who begin or end their trip at a particular airport.
Outbound Conveyor	Conveyor that takes baggage from the ticket counters and curbside to sort piers or make-up units.
Part 139 Certification	The FAA is required by 14 *Code of Federal Regulations* Part 139 to issue airport operating certificates to airports that serve scheduled and unscheduled air carrier aircraft with more than 30 seats, and scheduled air carrier operations in aircraft with more than 9 seats but less than 31 seats.
Part 77	See Federal Aviation Regulations Part 77, *Objects Affecting Navigable Airspace.*
Passenger Facility Charge (PFC)	A fee collected by airlines on behalf of the FAA for every enplaned passenger at commercial airports controlled by public agencies. Revenues from this source are used to fund FAA-approved projects that enhance safety, security, or capacity; reduce noise; or increase air carrier competition.
Passenger Load Factor	See Load Factor

TERM	DEFINITION
Passenger Loading Bridge	A mechanically operated, adjustable enclosed ramp used to provide direct passenger access between aircraft and terminal buildings. Synonymous with aerobridge, air bridge, passenger bridge, passenger boarding bridge, jet bridge, and Jetway®.
Passive Solar Technology (Cooling/Heating)	Used for harnessing the sun's renewable source of heat during winter months, ventilation during the cooling season, and natural daylighting which displaces the need for electrical systems during normal daylight operating hours.
Payback Analysis	Evaluation of the period of time in which initial expenditures are recovered through subsequent savings.
Peak Hour	An estimate of the busiest hour in a day.
Peak Period	See Design Hour.
Perimeter	The outer boundary of an airport, typically but not necessarily delineated by fences. Also a boundary that can separate areas controlled for security purposes from those that are not, which may or may not include physical barriers.
Planning Activity Level	Selected activity levels that may trigger the need for additional facilities or improvements.
Post-Check-in Screening	Checked baggage screening that occurs after the passenger checks in at the aircraft operator's ticket counter, including curbside.
Potable Water	Water suitable for drinking.
Pre-Check-in Screening	Checked baggage screening that occurs before the passenger checks in at the aircraft operator's ticket counter, including curbside.
Precision and Non-Precision	These terms are used to differentiate between navigational facilities that provide a combined azimuth and glide slope guidance to a runway (Precision) and those that do not. The term non-precision refers to facilities without a glide slope and does not imply an unacceptable quality of course guidance.
Preferred Parking	Parking places that are closer to the main entrance of the building, exclusive of spaces designated for disabled persons.
Premises Distribution System	A building communications network or a network between groups of buildings. It is used to connect desktop equipment with a host and to outside networks.
Primary Airport	A commercial service airport that enplanes at least 10,000 annual passengers.
Primary Surface	An imaginary obstruction-limiting surface defined in Federal Aviation Regulations Part 77 that is specified as a rectangular surface longitudinally centered about a runway. The specific dimensions of this surface are a function of the types of approaches that exist or are planned for the runway.
Programmable Logic Controller	A small industrial computer with special software and circuits for monitoring and controlling conveyor equipment.

TERM	DEFINITION
Prop Wash	A wind caused by the spinning propeller of a plane, sometimes strong enough to be hazardous to aircraft taxiing or landing behind.
Public Areas	The portion of the airport that includes all publicly accessible real estate and facilities other than the airside operations area and those sterile areas downstream of security screening stations or beyond access-controlled portals.
Public Meeting	A public gathering for the express purpose of informing and soliciting input from interested individuals regarding planning issues.
Public Transportation	Transportation by bus, rail, or other conveyance, either publicly or privately owned, that provides to the public a general or special transport service on a regular and continuing basis. Also known as "mass transportation," "mass transit," and "transit."
Queue	A line of passengers, pedestrians, or vehicles waiting to move into, out of, or through a processing facility.
Queuing Theory	The theoretical study of waiting lines expressed in mathematical terms, including components such as number of waiting lines, number of servers, average wait time, number of queues or lines, and probabilities of queue times' either increasing or decreasing.
Radio Frequency Identification (RFID)	A method of identifying items using radio waves, it provides a unique signal that identifies that object. The RFID device serves the same purpose as a bar code on a bag tag or a magnetic strip on the back of a credit card.
Ramp Areas	Areas used by airport tenants for servicing and loading aircraft, located on the Airport Operations Area directly adjacent to the terminal area. These areas are part of the Security Identification Display Area. Also sometimes called "apron" or "tarmac."
Recycling	The collection, reprocessing, marketing, and use of materials that have been diverted or recovered from the solid waste stream.
Regional Aircraft	A small aircraft designed to fly between 19 and 90 passengers. This class of airliners is typically flown by the regional airline divisions of the larger national carriers.
Regional Airport System Plan (RASP)	The plan for the region's public airports. The RASP addresses the existing and future need for airport and related improvements from a regional, system-wide perspective.
Regional Carriers	An airline with annual revenues of less than $100 million whose service generally is limited to a particular geographic region.
Regional Transportation Plan	See Long-Range Transportation Plan
Regression Analysis	A statistical technique that seeks to identify and quantify the relationships between a range of independent factors associated with a forecast.

TERM	DEFINITION
Remain Overnight (RON)	Aircraft remaining overnight at the airport, either at the gate, remote parking stand, or hangar. Airlines take advantage of remain overnights to perform maintenance, cleaning, and so forth of the aircraft.
Renewable Energy Certificates (RECs)	A representation of the environmental attributes of green power and sold separately from the electrons that make up the electricity. RECs allow the purchase of green power even when the electrons are not purchased.
Reuse	A strategy to return materials to active use in the same or related capacity.
Rough Order of Magnitude	An estimate done without detailed costing, or based on initial or incomplete data. A rough order of magnitude estimate establishes an approximate cost for a scenario or quality of service requirement.
Runway	A defined length of pavement area at an airport designated for the landing and takeoff of an aircraft.
Runway Incursion	Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft.
Runway Threshold	Marks the beginning of that part of the runway usable for landing. It extends the full width of the runway.
Sally Port	A secure entryway that consists of a series of doors or gates.
Scope	The document that identifies and defines the tasks, emphasis, and level of effort associated with a project or study.
Screening Function	The inspection of individuals and property for weapons, explosives, incendiaries, and other prohibited items using technical or other means.
Secured Area	A portion(s) of an airport, specified in the Airport Security Program, in which certain security measures specified in 49 *Code of Federal Regulations* (CFR) Part 1542.201 are carried out and where aircraft operators that have a security program under 49 CFR 1544 or 49 CFR 1546 enplane and deplane passengers.
Security Areas	Areas defined by and subject to security requirements and regulation (e.g., Airport Operations Area, Air Traffic Service Provider Area, Exclusive Area, Secured Area, Security Identification Display Area, and Sterile Area). "Restricted area" is not a Transportation Security Administration–defined term.
Security Identification Display Area (SIDA)	Area established pursuant to 49 CFR Part 1542.205 includes any area identified in the Airport Security Program as requiring each person to continuously display airport-approved identification, unless the person is under airport-approved escort. SIDA boundaries can differ greatly between airports.
Security Operations Center (SOC)	Typically the central point for all airport security-related monitoring and communication. It may or may not be co-located with the Airport Operations Center.

TERM	DEFINITION
Security Screening Checkpoint (SSCP)	A checkpoint area established to conduct security screening of persons and their possessions prior to their entering a sterile or secured area.
Selectee	A person selected for additional screening by a passenger pre-screening system or another process as approved by the TSA.
Self-Service Kiosk	Equipment installed in airport check-in halls and other locations, allowing passengers to check in independently and print out their boarding passes and baggage tags, eliminating the need to go to the check-in desk.
Service Road	Roadways, access lanes, and passageways, or other designated areas set aside for the movement of vehicles on the Airport Operations Area.
Short Haul	Operating distances of less than or equal to 1,000 kilometers non-stop, presuming an aircraft with a full payload at normal cruising conditions and with an adequate fuel reserve to reach an alternate airport.
Slope Bed Claim Device	One method for passengers to reclaim their checked baggage. These devices are typically configured in an oval or rectangular configuration located in the baggage claim area and fed by conveyors.
Solar Reflectance (Albedo)	The ratio of the reflected solar energy to the incoming solar energy over wavelengths of approximately 0.3 to 2.5 micrometers. A reflectance of 100% means that all of the energy striking a reflecting surface is reflected back into the atmosphere and none of the energy is absorbed by the surface.
Solar Reflectance Index	A measure of a material's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. Materials with the highest Solar Reflectance Index values are the coolest choices for paving.
Suspect Bag/Item	A bag or item that registers an alarm in an Explosives Detection System/Explosives Trace Detection (EDS/ETD) for which the cause of the alarm cannot be cleared with normal alarm resolution procedures.
Sustainability	Meeting the needs of the present without compromising the ability of future generations to meet their own needs.
Swing Gates	Gates with a vestibule that can be configured both to deplane international arrival passengers and to accommodate domestic and outbound international traffic at other times.
Strengths, Weaknesses, Opportunities, and Threats Analysis	A strategic planning tool used to evaluate the strengths, weaknesses, opportunities, and threats associated with a project, in a business venture, or any other situation faced by an organization or individual that requires a decision in pursuit of an objective.
Taxi	To operate an airplane under its own power; other than during takeoff or landing.

TERM	DEFINITION
Taxilane	An aircraft path bounded on either one or both sides by aircraft parking positions, and by which aircraft can only gain access to these parking positions.
Taxiway	A defined path on an airfield established for the taxiing of aircraft and intended to provide a link between one part of the airport and another.
Terminal Area Forecast (TAF)	The official forecast of aviation activity, both aircraft and enplanements, at FAA facilities. Such facilities include FAA-towered airports, federally contracted towered airports, non-federal towered airports, and many non-towered airports.
Terminal Building	A building or buildings designed to provide the interface between the aircraft and ground transportation facilities. The building accommodates the processes and services necessary for the enplaning and deplaning of airline passengers.
Terminating Passenger	A passenger whose final section of carriage, including aircraft disembarkation, baggage claim, etc., takes place at the airport in question. Synonymous with destination arriving or arrivals passenger.
Threat	Any indication, circumstance, or event with the potential to cause loss of or damage to an asset. It can also be defined as the intention and capability of an adversary to undertake actions that would be detrimental to U.S. interest.
Threat Containment Units (TCU)	Any of a wide variety of devices intended to be used to contain wholly, or in part, the blast effects of an explosive device. TCUs may be stationery or may be part of a vehicle or piece of apparatus by which an explosive device may be transported.
Threatened Species	An animal or plant species that is likely to become endangered within the foreseeable future.
Threshold Crossing Height	The height of the straight line extension of the glide slope above the runway at the threshold.
Trace Portals or Explosives Trace Portals or Puffers	Passenger screening machines that blow puffs of air on a passenger's person and then analyze for trace amounts of explosives.
Transfer Passenger	A passenger making a direct connection between two flights using different aircraft and flight numbers operated by the same or another airline.
Transit Passenger	A passenger who arrives and departs on the same aircraft.
Transit Staging Areas	The location where taxis, limousines, buses, and/or other ground transportation vehicles are staged prior to being allowed access to the terminal to pick up passengers.
Transitional Surface	An imaginary obstruction-limiting surface defined in Federal Aviation Regulations (FAR) Part 77 that extends outward and upward at right angles to the runway centerline and the runway centerline extended at a slope of 7 to 1 from the sides of the primary and approach surface.

TERM	DEFINITION
Transporters	See Mobile Lounges.
Transportation Security Regulations (TSR) §1542 *Code of Federal Regulations* (CFR), Title 49, Sub-Chapter C—Civil Aviation Security, §1542—Airport Security	§1542 requires airport operators to adopt and carry out a security program approved by the TSA and requires that an airport operator must, in its security program: • Establish a secured area—Air Operations Area and/or Security Identification Display Area; • Control entry into the secure area via access control systems; and • Perform the access control functions required and procedures to control movement within the secured area, including identification media.
Tug and cart	The traditional type of baggage handling system, which includes gasoline-, diesel- or electric-powered tug vehicles that pull luggage-carrying carts.
Turnstiles (Baffle Gate)	A form of gate that allows one person to pass at a time. It can also be made so as to enforce one-way traffic of people, and, in addition, it can restrict passage to people who insert a coin, a ticket, a pass, or similar token.
U.S. Customs and Border Protection	An agency of the U.S. Department of Homeland Security responsible for regulating and facilitating the flow of legitimate travel and trade across the borders of the United States.
Uniform Building Code (UBC)	One of the family of codes and related publications published by the International Conference of Building Officials (ICBO) and other organizations. Others include those published by the International Association of Plumbing and Mechanical Officials (IAPMO) and the National Fire Protection Association (NFPA), which have similar goals as far as code publications are concerned. The UBC is designed to be compatible with these other codes which, in combination, they make up the regulatory and enforcement tools of a particular jurisdiction.
Unit Load Device	A standard-sized aircraft container unit for baggage or cargo used to facilitate rapid loading and unloading of aircraft having compatible handling and restraint systems.
United States Green Building Council	A non-profit organization dedicated to sustainable building design and construction.
United States Standard for Terminal Instrument Procedures [TERPS]	Published flight procedures for conducting instrument approaches to runways under instrument meteorological conditions.
Universal Encoding Console or Manual Encode Stations	Hand-held laser scanner and keypad used to enter bag tag data and sort baggage manually to the proper designated make-up destination, when the automated tag reader fails to sort baggage automatically.
Vehicle Classification	The process of identifying vehicles by type and/or size. Vehicle classifications at curbfronts may include private auto, taxi, limousine, bus, hotel/motel shuttle, rental car shuttle, off-airport parking shuttle, and off-airport rental car shuttle.

TERM	DEFINITION
Vehicle Occupancy	The number of persons, including driver and passenger(s), in a vehicle.
Virtual Local Area Network	A logical grouping of hosts on one or more local area networks (LAN) that allows communication to occur between hosts as if they were on the same physical LAN.
Virtual Private Network (VPN)	A network that emulates a private network, although it runs over public network lines and infrastructure. Using specialist hardware and software, a VPN may be established running over the Internet.
Visual Approach	A visual approach is an Air Traffic Control (ATC) authorization for an aircraft on an Instrument Flight Rules (TFR) flight plan to proceed visually to the airport of intended landing; it is not an Instrument Approach Procedure. Also, there is no missed approach segment.
Voice over Internet Protocol (VoIP)	Internet telephony (also called Voice over IP, IP Telephony, and Digital Phone) enables the user to make telephone calls over a broadband Internet connection instead of a regular (or analog) phone line.
Volatile Organic Compounds (VOCs)	Carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize (become a gas) at normal room temperatures.
Vulnerability Assessment	Any review, audit, or other examination of the security of an airport to determine its vulnerability to various threats or unlawful interference, whether during the conception, planning, design, construction, operation, or decommissioning phase. A *vulnerability assessment* may include proposed, recommended, or directed actions or countermeasures to address security concerns.
Walk Through Metal Detector	See Magnetometer.
Wanding Station	Used to separate passengers who have registered an alarm from the walk through metal detector and/or require additional screening via a hand-held metal detector (HHMD or "wand").
Wide Area Network (WAN)	A system for interconnecting many computers and groups of computers over a large geographic area, via telephone lines, satellite links, and other long-range communications technologies. While a local area network typically services a single building or location, a WAN covers a much larger area, such as a city, region, or country.
Wireless-Fidelity (Wi-Fi)	The term refers to wireless local networks that can enable users to access the Internet without the need for cables.
Worldwide Interoperability for Microwave Access (WiMAX)	Also known as the IEEE 802.16 group of standards. WiMax is a packet-based wireless technology that provides high-throughput broadband connections over longer distances than Wi-Fi.

TERM	DEFINITION
Wingspan	On a fixed-wing aircraft, the span or straight-line distance between one wingtip and the other, including projecting ailerons.
Wireless	Telecommunications using electromagnetic waves rather than wires or cable to transmit information.
Wireless Access Point	A wireless access point or hotspot—an area for connecting to the Internet.
Xeriscaping	Landscaping with the use of drought-tolerant plants, to eliminate the need for supplemental watering.

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation