NextGen for Airports, Volume 4: Leveraging NextGen Spatial Data to Benefit Airports: Guidebook

DETAILS

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ACRP REPORT 150

NextGEN for Airports

AIRPORT COOPERATIVE RESEARCH PROGRAM

Volume 4

Leveraging NextGen Spatial Data for Airports
Guidebook

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AIRPORT COOPERATIVE RESEARCH PROGRAM

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NextGEN for Airports Volume 4

Leveraging NextGen Spatial Data to Benefit Airports 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). ACRP carries out applied research on problems that are shared by airport operating agencies and not being adequately addressed by existing federal research programs. ACRP is modeled after the successful National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP). ACRP undertakes research and other technical activities in various airport subject areas, including design, construction, legal, maintenance, operations, safety, policy, planning, human resources, and administration. ACRP provides a forum where airport operators can cooperatively address common operational problems.

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), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) 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 Academy of Sciences formally initiating the program.

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.

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Randy Murphy, president at Grafton Technologies, Inc.; Thomas Wade, principal at McWade Airport and Airspace Planning, LLC; Suzette Matthews, principal at Washington Progress Group, LLC; Rick Day, vice president, transportation solutions, at CSRA, LLC; Eric Risner, aeronautical survey specialist at Woolpert, Inc.; and David Barron, geospatial specialist and airport services director at Woolpert, Inc.

Foreword

By **Marci A. Greenberger**
Staff Officer
Transportation Research Board

The Next Generation Air Transportation System (NextGen) refers to the federal programs (predominately airspace, air traffic, or avionics related) that are designed to modernize the National Airspace System (NAS). ACRP's NextGen initiative aims to inform airport operators about some of these programs and how the enabling practices, data, and technologies resulting from them will affect airports and change how they operate.

ACRP Report 150: *NextGen for Airports, Volume 4: Leveraging NextGen Spatial Data to Benefit Airports: Guidebook* is the fourth report in this series. This report provides information for airport operators on the creation, maintenance, and use of spatial data that is generated as a result of NextGen initiatives. The data that airports have or will have to produce is used in a variety of different ways to advance some of the NextGen programs. This guidebook identifies benefits to airports from the spatial data that is required or produced from NextGen programs, not all of which are obvious. The guidebook also describes costs, and financial and legal considerations. In addition, a customizable presentation template can be downloaded from the report webpage at www.trb.org/acrp. The presentation can be tailored to educate various communities about NextGen and spatial data.

In support of NextGen technologies and programs, the FAA requires that airports participate in a number of initiatives that call for airports to collect, organize, maintain, and provide spatial data. However, confusion exists about what exactly will be required of airports and the corresponding benefits.

For ACRP Project 09-12, Woolpert, Inc., conducted research on the spatial data requirements of NextGen initiatives, and corresponding opportunities for airports. Their research included conducting several interviews, which led to the development of case studies and culminated in a webinar with industry experts.

A PowerPoint presentation also was developed that can be customized by airport staff to help educate their governing board and community about NextGen and spatial data. This guidebook and presentation summarizes many of the ways in which airports, through leveraging this data along with certain NextGen programs, can potentially gain new capacity, reduce landing minimums, and increase safety.

Airport managers, planners, and operations staff will find this guidebook useful in better understanding spatial data.

Contents

Summary

Leveraging NextGen Spatial Data to Benefit Airports

NextGen began in December 2003 with the Vision 100 Century of Aviation Reauthorization Act. Its goals were "to take advantage of data from emerging ground-based and space-based communications, navigation, and surveillance technologies; and to integrate data streams from multiple agencies and sources to enable situational awareness and seamless global operations for all appropriate users of the system." Airports play a critical role in achieving these goals. This guidebook, along with the accompanying four volumes, is intended to help airports fulfill this important role and maximize the benefits they receive in return. This volume focuses on one key aspect of airports' role in NextGen: the creation, maintenance, and use of spatial data that is critical to many NextGen programs.

Spatial data can come in a variety of formats, and at various levels of accuracy, completeness, and currency. Over the past few decades, many airports have implemented one such format, geographic information systems (GIS), to meet a spectrum of needs. In recent years, the FAA has developed additional requirements for airports to collect geospatial data sufficient for meeting myriad needs such as instrument approach procedure design, construction as-built surveys, navigational aids (NAVAIDs) installation/relocation, master plans and airport layout plans (ALPs), and airfield configuration changes.

As the FAA moves toward employing more advanced solutions for airspace and airfield safety, operational efficiency, and situational awareness under NextGen, the need is increasing for high quality, current, and accurate spatial data depicting airports, as well as the airspace around airports. The nexus of these spatial data requirements is the focus of this guidebook.

Research Goals and Objectives

This guidebook is part of a larger NextGen ACRP research project series that provides general information about NextGen while also detailing specific subject areas under NextGen.

Other projects in this series include:

- ACRP Project 01-27, NextGen—A Primer;
- ACRP Project 01-28, NextGen—Guidance for Engaging Airport Stakeholders;
- ACRP Project 03-33, NextGen—Airport Planning and Development; and
- ACRP Project 03-34, NextGen—Understanding the Airport's Role in Performance-Based Navigation.

The main project objectives for ACRP Project 09-12 are to document the benefits that can be derived from spatial data collected in support of the FAA's NextGen effort, how NextGen programs use this data, and how airports can maximize the use of this data.

Although NextGen affects the entire national airspace system (NAS), not all programs within NextGen have a need for spatial data, produce spatial data, or have a direct benefit to airports. The focus of this research examined and elaborated on how spatial data produced by an airport is utilized within certain NextGen programs and, conversely, how spatial data that a NextGen program might produce could benefit an airport.

Summary of Research Conclusions

- Some NextGen initiatives clearly benefit from spatial data or produce spatial data. Four priority areas are multiple runway operations (MRO), performance-based navigation (PBN), surface operations, and data communications.
- MRO, PBN, and surface operations all have a need for and/or produce spatial data.
- Many airports have found it difficult to understand what is required of them to support the implementation of NextGen, and there is a need to expand public outreach and education about these programs and data requirements.
- A challenge encountered by many users of spatial data is that there have been many sources that are sometimes redundant, not broadly accessible, and of varying degrees of quality. A duplication of data resides in the FAA databases, and additional duplication occurs as data is separately developed by airports, by other public-sector agencies, and through third-party sources.
- The FAA's Airports GIS (AGIS) program has long been called an "enabler" of NextGen. AGIS has provided high-quality data required for the development of PBN and other flight procedures, but many programs within NextGen do not currently utilize AGIS data to its full extent. Although flight procedures and airspace analysis clearly take advantage of AGIS-compliant data where it exists, many NextGen capabilities rely on spatial data produced by third-party vendors.
- One goal of AGIS is for all airports listed in the National Plan of Integrated Airport Systems (NPIAS) to have spatial data populated in the AGIS databases. As the inclusion of additional airports continues, and as more airports populate AGIS, additional NextGen initiatives will be able to take advantage of this data.
- Some reasons airports have not submitted data to AGIS include: (1) they do not perceive that the benefits exceed the cost of doing so; (2) the local FAA Airports District Office (ADO) is not enforcing or, in some cases, strongly encouraging it; and (3) many airports lack the resources needed to maintain this data over time.
- Many airports perceive that they bear new costs for the collection of spatial data but do not reap new rewards. Airports are, in fact, gaining new capacity, reducing minimums, and increasing safety because they have collected this data. Unfortunately, the benefits have not been as apparent as the costs, an issue which the FAA, RTCA, the ACRP Project 01-28 research team, and others are trying to address.

Recommendations and Suggested Research

- An in-depth study of the spatial data needs for unmanned aerial systems (UAS) planning and operations, as well as ways in which GIS can support UAS, is suggested.
- An independent review of RTCA DO-272, User Requirements for Aerodrome Mapping Information and FAA Advisory Circular (AC) 150/5300-18, General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards, as well as an assessment of the potential for merging these two standards into one industry standard, also is suggested.
- The benefits and requirements of NextGen and AGIS are not fully understood by the aviation community. A clear need exists for additional education of the aviation community about these benefits and requirements. Methods for further educating the aviation community and development of additional content to support these efforts are both needed.

1 Introduction

NextGen consists of many different programs with multiple priorities and requirements. A multitude of inputs and outputs within these programs allow them to operate efficiently. The focus of ACRP Project 09-12 is on spatial data as an input and/or output of specific elements within NextGen. Spatial data comes in a variety of formats, and at various levels of accuracy, completeness, and currency. Over the past few decades, many airports have implemented one such format, GIS, to meet a spectrum of needs. In recent years, the FAA has developed additional requirements for airports to collect geospatial data sufficient for meeting myriad needs such as instrument approach procedure design, construction as-built surveys, NAVAIDs installation/relocation, master plans and airport layout plans (ALPs), and airfield configuration changes.

As the FAA moves toward employing more advanced solutions for airspace and airfield safety, operational efficiency, and situational awareness under NextGen, there is an increasing need for high quality, current, and accurate spatial data depicting both airports and the airspace around airports. The nexus of these spatial data requirements is the focus of this research. It is important for airport managers and staff to know how the data they are developing and/or are required to develop benefits NextGen, as well as how the spatial data required by NextGen can both directly or indirectly benefit the airport.

This guidebook and its supporting materials describe the spatial data requirements of certain NextGen programs and identify which data the FAA requires airports to collect, maintain, organize, and provide in support of NextGen. Some NextGen programs use additional spatial data sets that are not directly needed by airports. Although airports may not benefit directly from these data sets, they reap considerable indirect benefits through the application of such spatial data within NextGen programs.

Research Goals and Objectives

This guidebook is part of a larger NextGen ACRP research project series that provides general information while also detailing additional information about specific subject areas under NextGen.

Other projects in this series include:

- ACRP Project 01-27, NextGen—A Primer;
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- ACRP Project 03-33, NextGen—Airport Planning and Development; and
- ACRP Project 03-34, NextGen—Understanding the Airport's Role in Performance-Based Navigation.

A presentation file accompanies this guidebook. Created to assist interested parties in presenting the information contained in the guidebook at conferences, workshops, and other educational or industry-related events, the presentation file can be downloaded from the *ACRP Report 150, Volume 4,* webpage at www.trb.org. The presentation follows the outline of the guidebook's content and provides both text and graphics. A sample abstract (provided in Appendix D) can be adapted and used to aid in requests for presenting the materials at these forums.

The research conducted under ACRP Project 09-12 revealed that airports and airport sponsors have a need for additional information about the requirements of NextGen, how these requirements impact them, and how spatial data either obtained from or provided to the FAA in support of NextGen programs can benefit them. The educational presentation can help stakeholders who are unfamiliar with NextGen requirements better understand how the creation and application of this spatial data also benefits them.

Focus of This Guidebook

Although NextGen affects the entire national airspace system (NAS), not all programs within NextGen need spatial data, produce spatial data, or directly benefit airports. For example, some priorities and programs benefit the operation of aircraft flying between airports, provide for enhanced navigational capabilities en route, or otherwise involve technologies or programs only indirectly connected with airports. This guidebook examines and elaborates on how spatial data produced by an airport is used in certain NextGen programs and, conversely, how spatial data that a NextGen program might produce can benefit an airport.

This research focuses on airport property and those areas directly surrounding an airport to the extent of the airspace protection surfaces (Figure 1-1). These are the areas where, most notably, airports develop spatial data or need spatial data to support their everyday operational requirements. For example, airports are responsible for ensuring that objects affecting navigable airspace are identified, removed, and/or mitigated according to certain standard requirements. The identification of these

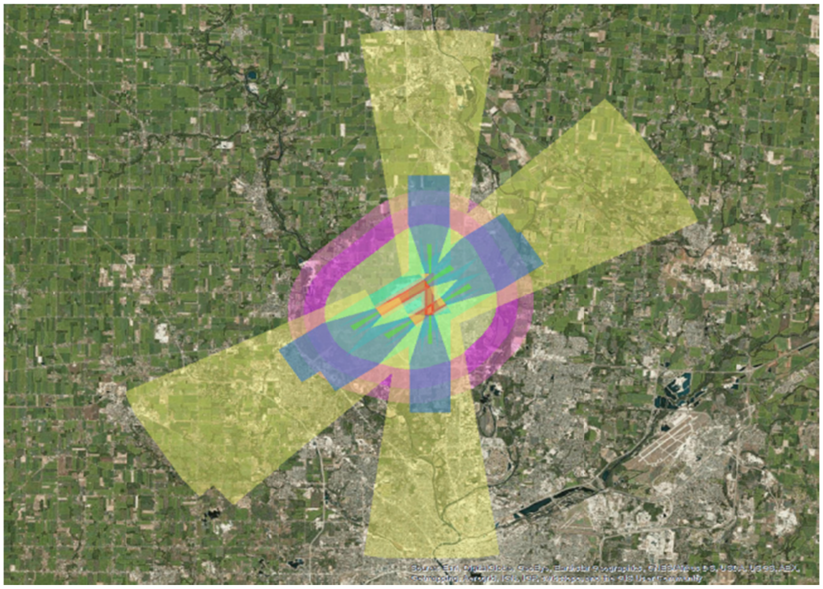


Figure 1-1. *Project geographic focus as shown on an Obstruction Identification Surface Map (Woolpert, Inc.).*

objects is a spatial data exercise, and the data produced is submitted to the FAA. Ultimately the data may be used in the development of new flight procedures or in the review of existing procedures for that airport.

Spatial data also supports certain NextGen initiatives that result in direct benefits to the airport. For example, performance-based navigation (PBN) provides airports tremendous benefits in terms of lowered costs and greater efficiencies in relation to the airport's approach and departure procedures. In addition to the direct benefits to the airport, everyone from air carriers to passengers benefits from these efficiencies—which all start with having high quality, accurate spatial data. Lacking accurate spatial data developed by the airport, however, the creation of a PBN procedure would not be possible.

Although most of the areas where objects have an impact on navigable airspace are off airport property, it is still the airport's responsibility to ensure that those areas are protected or mitigated.

NextGen Progress and Plans Discussed in This Guidebook

Overall, NextGen is a very complex and multi-tiered program. Aligning specific initiatives to correlating programs can prove challenging. Overlap occurs across programs, and, more importantly, key elements of an initiative can be worked on under multiple programs. To better organize the spatial data requirements and benefits directly related to NextGen programs, this guidebook aligns with the four focus areas of the RTCA NextGen Implementation Working Group (NIWG); these focus areas represent the consensus programmatic focus of the FAA deputy administrator, chief operating officer (COO), and the director of the FAA's NextGen office.

The four focus areas shown in Figure 1-2 are being implemented in segments at targeted locations throughout the NAS. According to the FAA, these programs are producing useful and measurable benefits to the industry. MRO, PBN, and surface operations and data sharing all need—or produce—spatial data. Data communications does not need or produce spatial data in any direct or indirect way, so it is the only NextGen program of the four that is not considered in this guidebook. To keep information clear throughout the guidebook, MRO, PBN, surface operations, and data sharing will be addressed consistently in the same order across chapters and sections. For additional details on specific NextGen programs, refer to *ACRP Report 150: NextGen for Airports, Volume 3: Resources for Airports.*

One finding of the research conducted in ACRP Project 09-12 is that some NextGen initiatives, such as PBN and terminal automation modernization and replacement (TAMR), clearly benefit from or produce spatial data. Other initiatives, such as en route automation modernization (ERAM) and NAS voice, have very little need for spatial data and do not generate spatial data of the types examined in this study. Still other programs, such as automatic dependent surveillance-broadcast (ADS-B) and data communications, have a limited need for spatial data that is mostly utilized for en route applications. Significantly, although some issues have arisen with the establishment of PBN, the overall benefits of PBN to airports and air carriers are unquestioned.

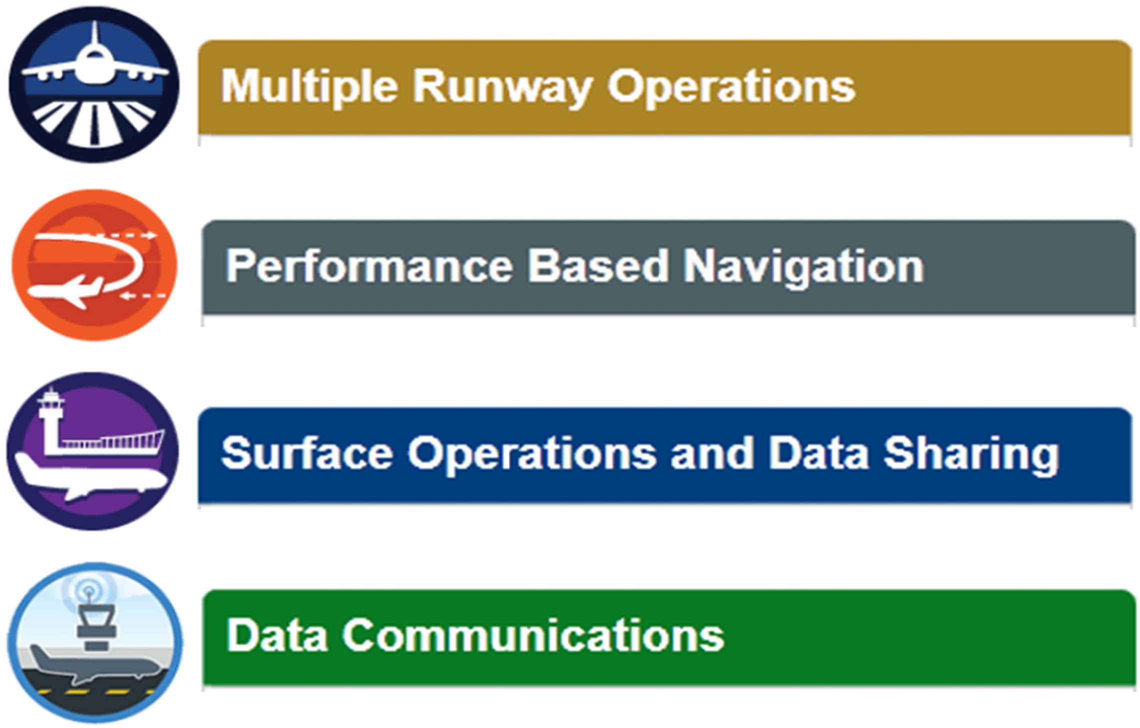


Figure 1-2. *NextGen programs (FAA).*

Guidebook Structure and Content Overview

Airports and certain NextGen programs can benefit from spatial data that is readily available, current, and accurate. Airport staff and NextGen stakeholders who (1) are involved in the business operations of an airport are involved in the planning and delivery of spatial data, or (2) have the ability to support NextGen in some capacity, are encouraged to familiarize themselves with all chapters of this guidebook.

These chapters include:

- Summary—Provides an overview of the ACRP NextGen series as well as this project and the findings of the research.
- Chapter 1—Introduces ACRP Project 09-12, its goals and areas of focus, and describes the structure of the remainder of the guidebook.
- Chapter 2—Describes and documents the different types of spatial data that NextGen programs utilize or produce, including Airports GIS (AGIS), and the ways NextGen programs use spatial data. This chapter also discusses those NextGen programs that in some way enhance existing spatial data.
- Chapter 3—Explains how spatial data benefits airports and how airports can further benefit from the application of spatial data within NextGen initiatives. The chapter describes specific NextGen initiatives and means of applying spatial data. It also elaborates on NextGen initiatives that are not currently benefitting from data created by the airport but have the potential to do so.

- Chapter 4—Provides information about financial and legal considerations associated with developing and communicating spatial data for airports. This chapter reviews the potential for airports to recoup some of the costs of creating spatial data through the monetization of that data. It documents regulatory requirements and potential liability issues related to the use of spatial data in certain circumstances.
- Chapter 5—Presents the researchers' conclusions and suggestions for additional research and followup through educational forums. Areas with potential for improvement in programs having direct impacts on NextGen and programs that benefit airports are addressed.
- Chapter 6—Offers guidance to help airports submit and use spatial data required by the FAA specifically for NextGen.
- References and Bibliography—Combines source material referenced in chapter copy with material consulted during the literature review for ACRP Project 09-12. Note: Because of the nature of the content in Chapter 4, endnotes have been used in that chapter.
- Appendices—Provide a list of acronyms and initialisms; a glossary of terms; information about the interviews conducted and case studies developed as part of the research; an abstract for use when proposing an educational session about NextGen, spatial data, and airports; and the contents of the companion sample presentation that is available for download from the guidebook website.

2 NextGen and Spatial Data Requirements

This chapter describes the different types of spatial data that NextGen programs utilize, produce, or enhance, and how this data is used.

The NextGen concept of operations (CONOPS) and the FAA's NextGen Implementation Plan emphasize the important role airports play in airspace redesign and procedure development activities, which are cornerstones of NextGen implementation. With the introduction of NextGen, service improvements such as trajectory-based operations, surface traffic management, MRO, and other net-centric concepts require enhanced and open data sharing. The benefits of achieving enhanced and open data sharing include:

- Greater airport, airline, and airspace efficiencies;
- Support for risk-based decision making;
- Enablement of safety management systems (SMS);
- Greater insights into the environmental effects of noise, emissions, and water quality; and
- Improvements to customer and citizen experiences.

Enhanced spatial data also allows for greater insight, planning, monitoring, and control of assets (i.e., land, utilities, NAVAIDs, and facilities); enables better understanding of the topographical elements of the extensive airport property; and supports both security and event management. It also supports future improvements associated with ideas such as aerotropolis concepts, multi-modal integrated solutions, and overall community planning and zoning.

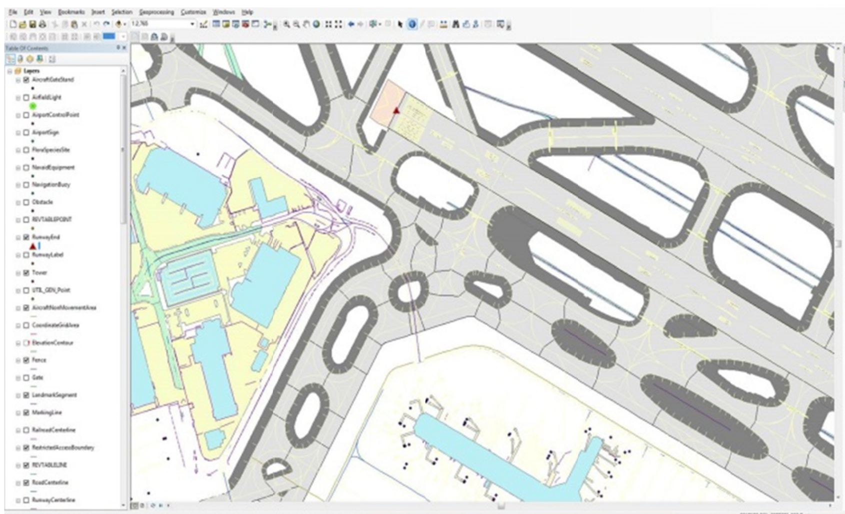
Spatial data originates from a variety of sources, including federal, state, and local agencies; airports; airport consultants; and private vendors. Spatial data built upon common data standards, categorized by data quality and accuracy, and organized as a single authoritative source for each data element in an accessible database, enables NextGen operational improvements and other airside and landside improvements. Such improvements in spatial data benefit many operational, economic, environmental, political, and customer-experience drivers of growth, as well as regional and community leadership in air transportation.

Overview of Spatial Data Sources and Requirements

The FAA's AGIS program has been described as an "enabler" of NextGen. Although this is true, NextGen programs also take advantage of other spatial data sets from third parties, as well as existing state and local data and legacy data sets not currently found in AGIS. NextGen initiatives also produce spatial data that other users, such as airports, the local community, or airlines may find beneficial. Some

NextGen programs do not use or produce spatial data but may enhance existing spatial data sets or have applications for airport operations.

In considering spatial data requirements and sources, how the data will be used in certain NextGen programs is an important factor. NextGen programs such as PBN or MRO, which rely on GPS navigation during certain phases of an arriving or departing procedure, require a high level of spatial accuracy and currency for features such as obstacles, runway ends, runway centerlines, and a list of other spatial data features (see Figure 2-1). These programs have accuracy requirements for spatial data features as stringent as 1 ft. horizontally and 0.25 ft. vertically. A majority of the near-airport and on-airport spatial data features used in the development of flight procedures come from AGIS data sets, and are often referred to as "safety critical" features. (Chapter 5 of FAA's Advisory Circular AC 150/5300-18 lists all of the AGIS features and their associated horizontal and vertical accuracies).



Note: GIS map created from San Francisco International Airport's AGIS data.

Figure 2-1. *AGIS spatial data for a large hub airport.*

The use and accuracy requirements of spatial data sets used in certain surface operations portfolios may be quite different and may have a lower spatial quality constraint. For example, surface visualization and situational awareness tools employ spatial data and mapping but do not necessarily need survey-grade accuracy. These tools can use a base map that depicts the airfield features and layout, showing where an incoming or departing airplane is on the airfield and where other moving elements (i.e., other planes and vehicles) are in relation to their current position.

Another factor in the consideration of what spatial data source to use in certain NextGen programs is the end user. For users who are developing flight procedures, current and accurate source data is critical. In addition to other supporting data sets, procedure designers use AGIS data extracted from a server at FAA. In certain cases, a new aeronautical survey must be conducted in order to develop a requested new procedure because the high-accuracy AGIS data either is not currently in the system or is out of date. This user community requires high accuracy and current information for analysis and modeling to develop the safest and most efficient procedures possible.

Other users of spatial data are primarily viewers who are not using the data for analysis. For example, viewers may consult a map for information such as location or descriptive information (see Figure 2-2).

Figure 2-2. *Tablet-based moving map (Jeppesen).*

A pilot may consult a map to determine where the next taxiway is and where other aircraft are positioned on the airfield relative to the pilot's own position. From a pilot's perspective, whether the map information is viewed on a head-up display or via a digital flight bag, the map display should have a consistent look and feel to it. Pilots view airfield map information at up to 15 different airports on any given day. Although the positional accuracy may be off by 10 to 20 ft., being able to quickly read the information on the map display and easily understand the output is equally important, if not more important, than the spatial accuracy. Airlines and Air Traffic Control (ATC) in terminal radar approach control facilities (TRACONs) staff use third-party spatial data for some NextGen programs and applications. Third-party data currently is more readily available and has been configured so that it has the consistent look and feel required for these types of applications. As AGIS continues to expand, the potential exists that the more accurate data developed under AGIS will be incorporated into these programs. However, more airports will need to obtain a completed AGIS data set in order for surface operations program applications to take advantage of this data.

Types of Data Sources

Spatial Data Comes from Multiple Data Sources

NextGen largely focuses on the safe and efficient operation of aircraft during all phases of flight. Much of the spatial data required for or produced by NextGen programs is operational by nature. For example, aircraft positional data, approach procedures, obstructions, and NAVAID locations all have a spatial component that supports the safe and efficient operation of aircraft. Data that is not directly related to the operation of aircraft, such as land parcels or land use, also is relevant to airports and

Figure 2-3. *Overlapping needs for spatial data.*

to NextGen. These varying, and sometimes overlapping, spatial data sets can be broken into various source group types (see Figure 2-3). This section provides an overview of how these data sets currently are applied to NextGen programs and where the data comes from. It also provides some historical context for AGIS data in particular.

Airport Data

Airports develop spatial data for many different reasons, primarily to fulfill their own needs and support their own operations, but also as required by the FAA for federally funded projects (see Figure 2-4). These projects may include the development of new flight procedures, new master plans

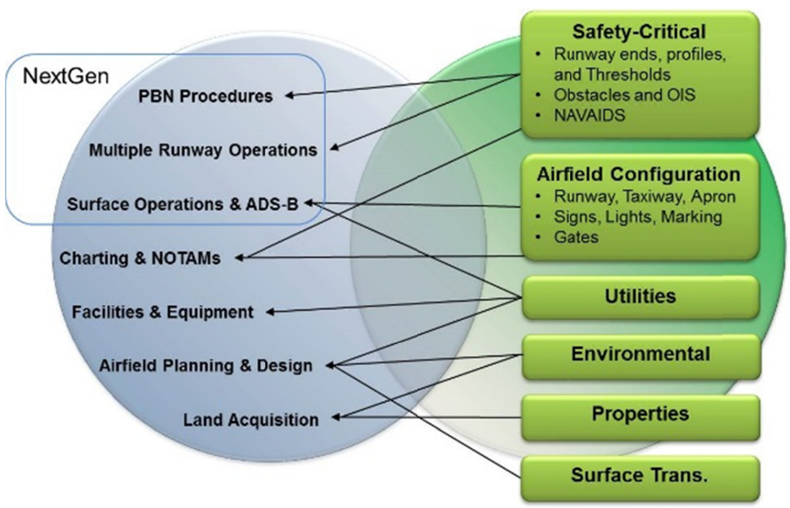


Figure 2-4. *FAA's use of spatial data from airports.*

and ALPs, various airfield projects such as runway extensions, and other large capital improvements to the airfield. The data developed in support of and as a result of these many different federally funded airfield projects typically must comply with FAA ACs 150/5300-16, 17, and 18. This data is often referred to throughout these documents as AGIS data. (For additional information, see the FAA's Airport Geographic Information System Transition Policy memorandum dated August 23, 2012.) An overview of these two core sets of airport-produced spatial data is provided in the next two sections.

FAA's AGIS Program—Its Origin and Current Use for NextGen Programs

Historically, airport spatial data has been collected by at least three separate organizations.

1. Airport sponsors have surveyed airports in order to support development and planning initiatives, including updating ALPs.
2. The FAA has conducted surveys to install NAVAIDs to support instrument landings.
3. In 1941, the **U.S. Coast and Geodetic Survey (CGS)** began conducting aeronautical surveys of airports and obstacles to improve flight safety. Subsequently, the National Geodetic Survey (NGS) conducted aeronautical surveys in order to create obstruction charts (OCs) and to provide data to the FAA for use in developing instrument approach and departure procedures.

Each of these surveys was available only to the specific organization that developed it. The surveys were developed according to varying standards and in different coordinate reference systems:

- NGS surveys were in spatial coordinates (initially following a technical service order and then, beginning in 1968, following FAA No. 405, Standards for Aeronautical Surveys and Related Products).
- Airport surveys often used a local coordinate system.
- FAA surveys that used the state plane coordinate system often were in differing state plane zones, which affected how the coordinates were defined.

Although the data could be transformed between differing coordinate systems, identifying the specific person with access to the data was difficult and time consuming, and the data was of unknown reliability.

Furthermore, the FAA did not provide specific survey standards to airports to develop FAA-mandated ALPs. Each time the ALP was updated, an additional survey was conducted by the airport. The ALPs were approved by the FAA, and then typically maintained in hardcopy format, which meant they were not readily available outside of the local ADO.

With the initiation of area navigation (RNAV) approaches, NGS lacked sufficient human and financial resources to conduct the number of surveys now needed. To meet the aggressive RNAV development schedule, third-party surveyors were contracted directly through the FAA and by airports that received Airport Improvement Program (AIP) funding. NGS transitioned from being the prime originator of aeronautical data for procedure development to focusing on quality control of aeronautical data, ensuring third-party surveyors were collecting and organizing the data accurately in order to meet FAA needs. FAA No. 405 defined these third-party surveying requirements. The data collected in FAA No. 405 was limited to elements critical to flight safety, including runway profiles and end coordinates, instrument landing equipment, and obstacles. The surveys did not include other airport infrastructures such as taxiways, aprons, terminals, or other buildings.

The FAA recognized the inefficiencies and impact on data quality caused by a lack of uniform standards and the use of multiple surveying coordinate systems. In 2006 the FAA canceled FAA No. 405 and published AC 150/5300-18, Survey and Data Standards for Submission of Aeronautical Data Using Airports GIS, thus initiating AGIS. AC 150/5300-18 provided a comprehensive set of standards for collection for all features associated with an airport. A companion circular, AC 150/5300-17, established requirements for imagery collection. The collection of airport features utilizing photogrammetry, including obstacles, greatly enhanced the ability to efficiently and accurately collect aeronautical data. Photogrammetry also materially assisted in validating coordinate data.

AGIS reflected a move toward a data-centric environment in which organizations concentrate on integrating data from multiple sources and provide data management that enables the FAA to deliver airport aeronautical information across the NAS, automating tasks such as survey project oversight, processing airport data changes, and creating aeronautical charting products. A primary motivation for developing AGIS was to create common standards for delivering airport aeronautical data to the system's users through enterprise web services.

AGIS's primary objective is to collect, collate, validate, store, and disseminate airport aeronautical information to the NAS. Besides the collection of survey data and the integration of this data with FAA systems and products, this objective includes the management of airport data to ensure that the most up-to-date information is available. Spatial data—collected according to AC 150/5300-18, submitted to AGIS, validated by NGS, and then distributed throughout the NAS—enables the development of NextGen RNAV approaches and numerous products, including airport diagrams and electronic ALPs.

AGIS improves airport productivity by increasing the throughput of survey data, and provides users with a single portal for accessing airport data. According to the FAA, AGIS also leads to long-term reductions in the overall costs associated with data collection, as well as a reduction in the need to use other systems to identify reliable sources or validate data. AGIS data quality is sufficient for use across the NAS, thereby reducing overall costs associated with data management. The FAA has indicated the following expected benefits to the NAS, the FAA, and airports, from use of AGIS:

- **Productivity**
  - Single Internet portal streamlines the collection and distribution of airport survey data;
  - Consolidated view of the current status and availability of data for a given airport supports the identification of gaps in data and the planning of future survey data collection efforts; and
  - Coordinated workflow is associated with reduction in manual processes and streamlined data validation and verification.
- **Economic efficiency**
  - Reduced costs associated with resurveying and duplicate collection of survey data;
  - Data collected is usable for multiple purposes, including analysis, planning, engineering, procedure development, and charting; and
  - Reduced overhead required to use other systems to research, identify, and manage airport data or airport data sources.
- **Data quality**
  - Data standardization;
  - Increased data accuracy; and
  - Availability of metadata.
- **Process standardization**
  - Common data standards and standardized processes for performing airport and aeronautical surveys;
  - Automation of data collection and verification processes; and
  - Defined business rules ensure that FAA offices are notified of changes and next actions as required.

- **Safety**
  - Increased safety, consistency, and efficiency of operations within the NAS.

Like NextGen overall, AGIS has realized multiple successes; yet NextGen and AGIS continue to evolve as their programs and capabilities are implemented in segments. Not all NextGen programs have been fully implemented for the entire NAS; similarly, not all airports—particularly the largest U.S. airports—are in the AGIS system. Approximately one-third of the top 30 airports in the United States do not have a complete ("all-airfield") AGIS project in the system. Although some of these airports have initiated a program, it will still be a minimum of 2 years (and probably longer) before all of the airports that support the majority of the air traffic in the country are in the AGIS database. While these new projects are being finalized, airports already in the system must maintain their current AGIS data for it to remain relevant to NextGen. The importance of data maintenance is discussed in more detail in Chapter 3 of this guidebook.

Airport-Developed Data Sources

Most airports that have computer-aided design (CAD) and GIS programs develop spatial data for their own needs. These airports may have developed a complete AGIS data set, but much airport-developed data extends beyond that required by the FAA as defined in AC 150/5300-18. Airport-developed data may include spatial data collected at a higher level of detail than that required by AGIS, data found on the landside, and spatial data that is related to the inside space of terminal buildings. Although it is not part of AGIS, some of this data still may be of benefit to the FAA and specifically to NextGen. For example,

- AC 150/5300-18 provides a mechanism to exchange basic information about **utility assets**. This information includes the geographic location of utility assets represented as points, lines, and polygons, as well as an attribute to indicate the type of utility. Name, description, status fields, and user-definable fields provide a basis to exchange additional details as desired. Some airports have been asked to include utility infrastructure data as a part of the electronic ALP submittal to the FAA; other airports volunteer this data, but there is no requirement that all airports do so. Also, the data definitions available in AC 150/5300-18 are rudimentary and do not accommodate all of the details airports typically record about their utilities, such as material, size, and ownership information. This data could be invaluable to the FAA, and specifically to NextGen programs that install NAVAIDs, communications facilities, and other equipment at or near airports. A complete and accurate understanding of an airport's utility infrastructure can help FAA projects avoid costly design changes or utility breaks. The same is true for airports that desire greater information about utility assets that the FAA has installed; by exchanging information about the utilities they install, maintain, or discover, airports and the FAA can help each other to more efficiently install and maintain this critical infrastructure.
- Another important spatial data set describes **airfield pavement**, one of the more expensive assets on an airport that is paid for mostly or in part by federal funds. Both airports and the FAA need information on pavement condition, pavement type, pavement dimensions, and other specifics about pavement features (e.g., taxiway, runway, or a safety area). The basic data can be found in an AGIS deliverable. To qualify for federal grant dollars and, most importantly, to keep the pavement maintained at a level of quality that ensures safety, airports collect additional data through regular pavement condition assessments. These condition assessments identify the condition of the pavement at a project level and sometimes at a panel level of detail. The detailed data collected in these pavement studies is well beyond the standards and specifications defined in AGIS. Even though a lot of this highly detailed pavement condition information may make its way to the FAA

through individual reports, spreadsheets, and documents sent in support of AIP grant requests, it is not currently provided in the consistent way that would be most useful to the FAA.

- Airports are constantly changing because of capacity enhancement needs, changes to the airfield to improve safety, new construction, or temporary situations, such as a need for maintenance to a portion of pavement or changes to lighting systems. An airport's AGIS data is just a snapshot in time; that is, it is accurate as of the date on which the imagery was collected and the data was surveyed and converted to an AGIS format. Although data about projects funded through AIPs are ultimately populated into AGIS, data about many smaller or temporary projects and situations most likely does not make its way to an AGIS database. For example, temporary airfield issues that affect departures and arrivals are conveyed to ATC, the airlines, and ultimately to pilots through the issuance of Notices to Airmen (NOTAMs). A lot of this information has a spatial component to it and could easily be portrayed on a map through a digital flight bag, a map interface as part of the in-cockpit avionics, or a map-based application in the ATC tower or at the TRACON facility. The FAA is currently working on map-based digital NOTAM applications; as new avionics with map displays become more common and digital flight bag applications continue to evolve, this temporary data that is critical to ensuring flight safety will become another spatial data source and application.

Local Public-Sector Spatial Data Sources

Spatial data from local agencies has been documented in *ACRP Synthesis of Airport Practice 59: Integrating Airport Geographic Information System (GIS) Data with Public Agency GIS.* This synthesis report found that airports require spatial data "from surrounding communities to support planning and development, airspace analysis, property acquisition, noise mitigation, environmental protection, customer service, and other procedures." Conversely, the study found that "public agencies require geographic information from airports for transportation planning, compatible land development, emergency response, and zoning" (Murphy and Bannura 2014).

Although some of this data describes features within the property boundaries of an airport, a majority of the data collected from local agencies relates to off-airport features. Features such as terrain and land parcels and data about land use and utilities (often stopping right at the airport property boundary), as well as light detection and ranging (LiDAR) data all are important spatial data sets that can be used to benefit airports and NextGen initiatives, specifically in the development of new PBN flight procedures.

The FAA uses data from local agencies in developing new flight procedures in an application called the airport environmental design tool (AEDT). AEDT is a GIS-based software application "that models aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality consequences" (FAA n.d.a). In its analysis of these environmental impacts, AEDT also draws upon local zoning and land use data, as well as information about other local features on the ground, to evaluate and model the impacts of noise.

Third-Party Sources

Airports and aircraft operators also use spatial data developed and provided by third-party sources (Figure 2-5). Spatial data (e.g., maps) developed and provided by third-party sources is often done through a mass production process, utilizing satellite- or aircraft-based digital cameras that can collect a wide area of data. These third-party providers play an important role in NextGen programs in that they can provide spatial data that is updated on a regular basis, is readily accessible, and has a consistent look and feel. The spatial data developed by third-party sources does not meet the level of accuracy or completeness of AGIS data, but most applications that use third-party data do not require that level of accuracy. Third-party vendors involved in the production, maintenance, and distribution

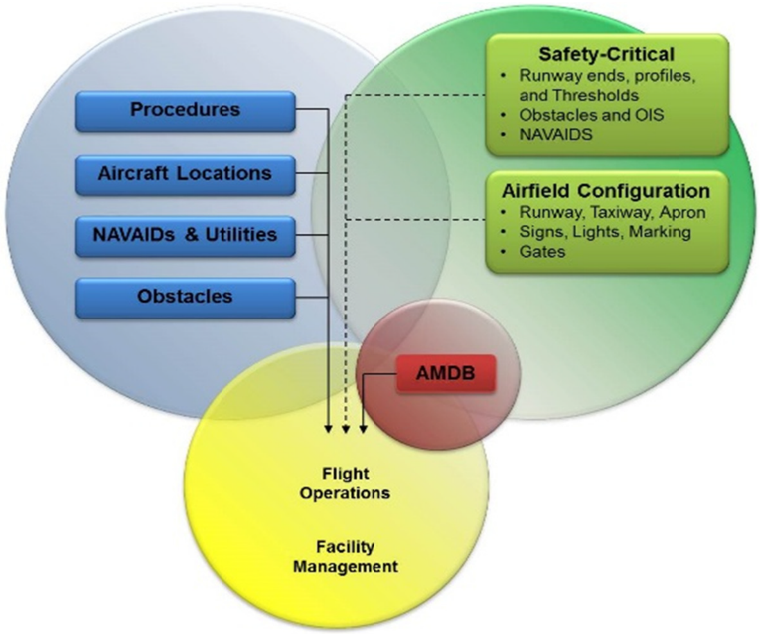


Figure 2-5. *Aircraft operators use data from the FAA, from airports, and from third-party sources.*

of data with applicability to NextGen are encouraged to comply with RTCA DO-272, User Requirements for Aerodrome Mapping Information, a standard developed by that organization's Special Committee 217.

User Requirements for Aerodrome Mapping Information (DO-272/ED-99)

RTCA's Special Committee 217 focuses on the standardization and exchange of aeronautical databases. Aerodrome (or airport) mapping databases (AMDBs) are now sold by a variety of vendors to aircraft operators, air traffic controllers, airports, and other aeronautical users worldwide.

RTCA DO-272 is similar to FAA AC 150/5300-18 in that it defines feature classes, attributes, and domain values that depict airport features. The documents differ slightly in that DO-272 is designed specifically for aeronautical use, whereas AC 150/5300-18 is designed to support aeronautical, planning, and other purposes. Despite these differences, DO-272 and AC 150/5300-18 have aligned many of their definitions at various milestones in their development.

The organized set of user requirements in DO-272 has evolved over the past 15 years, and the document is currently in its fifth revision. The objective of the requirements is for developers to structure the data they provide to aeronautical system designers and other end users in a consistent way. DO-272 complements RTCA DO-276, User Requirements for Terrain and Obstacle Data (eTOD). It also is supported by RTCA DO-342, Guidelines for Verification and Validation of AMDB Aerodrome Surface Routing Networks (ASRN) for Routing Applications, and RTCA DO-291, Minimum Interchange Standards for Terrain, Obstacle, and Aerodrome Mapping Data. These standards are also compatible with Eurocontrol and FAA's aeronautical information exchange model (AIXM), flight information exchange model (FIXM), and the weather information exchange model (WXXM). These data exchange standards are being used to support NextGen system wide information management (SWIM) capabilities such as the SWIM terminal data distribution system (STDSS) (Usmani 2012).

Collectively, these requirements and guidelines define how spatial data relevant to NextGen can be structured and exchanged. With the exception of AC 150/5300-18, U.S. airports are not required to meet the requirements of these documents. Airports may, however, use these documents to understand data provided by vendors, the FAA, or other sources that do follow these requirements. Airports may also consider some of the industry-wide best practices and expert consensus embodied in these documents when developing their own internal spatial databases.

RTCA has developed many of its documents in coordination with the European Organization for Civil Aviation Equipment (EUROCAE). RTCA DO-272 is also published as EUROCAE ED-99. Similarly, RTCA DO-276 is equivalent to ED-98 and RTCA DO-291 is equivalent to ED-119.

NAV Lean

Two common themes can be found in the previous sections' discussion of the use and storage of spatial data: (1) the abundance of spatial data that could—but is not yet—being utilized in support of NextGen programs; and (2) the duplication of efforts to acquire and store data that resides in FAA databases and data that is being developed by airports, by other public sector agencies, and through third-party sources. Although it is not practical for all untapped or duplicate data sets to be brought to the same level of quality or currency, a lot of spatial data is being used for which a more current data set exists elsewhere; moreover, confusion is frequently caused by these duplicate data sets. To address these issues, in 2010 the FAA developed an implementation plan called NAV Lean to improve and streamline the processes used for developing and implementing all instrument flight procedures (IFPs), including PBN, and supporting EAs and NextGen operational improvements to surface operations and MRO.

The FAA's goal for NAV Lean has been to establish a single, authoritative source for each data element in an accessible data repository available to FAA staff that has need of it. NAV Lean objectives included addressing problems in FAA's procedure development, such as a lack of an expedited process for approving minor procedure revisions, inconsistent interpretation of environmental policies and guidance, and data discrepancies across diverse databases. The FAA identified 21 recommendations, which were grouped under nine issues. The recommendations touch on all major aspects of the IFP process, including policy, tools, data, and training. The FAA estimates that the full implementation of the 21 recommendations will reduce the time currently required to implement a new IFP by more than 40%. Full implementation of the NAV Lean program recommendations is intended to establish best implementation practices and operational standards and to produce safe and efficient procedures.

NextGen Programs and Spatial Data

Flight Procedures/PBN

Flight procedures are a fundamental contributor to the safety and capacity of our NAS. Analogous to driving directions used by automobile drivers, these directions are even more critical for pilots, who do not have roads, guardrails, signs, marking lines, and traffic signals to follow while in the air. For airports, flight procedures provide operational capacity and ensure safe operations. There is likely no other information product that more directly supports the underlying objectives of an airport (i.e., the take-off and landing of aircraft) than a flight procedure.

Currently, more than 33,000 active flight procedures are in use in the United States (FAA 2015a) and more than 5,000 flight procedures are in production (FAA 2015b). About half of these procedures are RNAV and Required Navigation Performance (RNP) procedures used for NextGen PBN.

PBN establishes an aircraft's ability to navigate based on the capabilities of its onboard systems in conjunction with ground- or space-based NAVAIDs. One of the more mature NextGen initiatives, PBN has already been implemented at most of the nation's largest airports, and many other airports also benefit. Benefits that PBN has delivered to airports include the following:

- **Fuel savings and emissions reductions.** Across 8 large metropolitan areas, or metroplexes, implementation of PBN has resulted in $65.6M in fuel savings and 293K fewer metric tons of CO_2 per year since 2011 (FAA 2015c).
- **Increased flight operations.** Memphis International Airport (MEM) realized a 17% increase in flight operations per hour by FedEx due to PBN-enabled wake recategorization (FAA 2013b).
- **Increased departures per hour.** Dallas/Fort Worth International Airport (DFW) has seen a 15–20% increase in departures per hour and a 40% decrease in pilot-controller communications while American Airlines has saved $10–12M worth of fuel per year as a result of PBN implementation (FAA 2014i).
- **More options during poor weather conditions.** PBN has facilitated access for aircraft to more than 2,500 runway ends in poor weather conditions with minimums as low as 200 ft. (FAA 2012c). The increased access has provided a significant boost to many general aviation (GA) airports. For example, Beverly Regional Airport (BVY) in Beverly, Massachusetts, has attracted new corporate operators and boosted fuel sales at their fixed-base operator (FBO).

These benefits of PBN would not be possible without spatial data. Like all flight procedures, PBN flight procedures are developed using coordinates for runway ends, obstacles, NAVAIDs, as well as elevation data for terrain, existing traffic flow patterns, and airspace restrictions. The spatial data commonly mentioned by FAA, airline, and consultant flight procedure designers interviewed for this project includes:

- Runway end locations;
- Runway profile-point elevations;
- Obstacle locations, types, heights, and lighting characteristics;
- NAVAID locations and types;
- Airfield marking lines, areas, and colors;
- Terrain elevations;
- Air traffic flows, waypoints, and historical flight tracks;
- Airspace restrictions in the vicinity of the airport; and
- Areas covered by certificates of waiver or authorization (COAs) for unmanned aerial systems (UAS).

In addition to the primary data sets listed above, spatial data related to the environmental impact of flight procedures is often used, particularly if a categorical exclusion (CatEx) is not granted and an Environmental Assessment (EA) is therefore required under the National Environmental Policy Act of 1969 (NEPA). The spatial data typically needed for such assessments is sometimes used regardless of whether an EA is required, and includes the following:

- Noise contours showing day-night average sound (or noise) levels (DNLs), are typically prepared as a part of a Federal Aviation Regulation (FAR) Part 150 study or specifically for an EA;
- Noise-sensitive areas where residents, businesses, or other occupants may be particularly impacted by aircraft noise;

- Population density data showing locations where high proportions of residents or businesses may be affected by aircraft noise;
- Land use zones that help identify sensitive areas or areas for compatible development;
- Noise abatement procedures established by an airport to reduce noise impact on sensitive areas;
- Habitats that may attract wildlife that are not conducive to safe aircraft operations; and
- Water bodies and wetland areas that may attract wildlife or that are protected from certain types of development.

These spatial data sets, which are used for flight procedure development, currently come from a variety of sources. Airports supply some of this data—namely runway, NAVAID, and obstacle data deemed safety-critical by FAA AC 150/5300-18—via the FAA's AGIS. The AGIS data is provided to procedure designers via universal data delivery format (UDDF) files that are exported from AGIS to the FAA's third-party surveying system (TPSS). The data also is loaded into the FAA's aviation system standards information system (AVNIS) database on the 56-day aeronautical information regulation and control (AIRAC) schedule established by the International Civil Aviation Organization's (ICAO) Annex 15 Aeronautical Information Services (AIS) document. Flight procedure design software, such as instrument approach procedures automation (IAPA), terminal area route generation and traffic simulation (TARGETS), and the instrument procedure development system (IPDS) directly read file-based updates or are linked to online updates of the AVNIS data. Other sources of spatial data used by pilots and flight procedure developers include the following:

- National airspace system resources (NASR) data from the National Flight Data Center (NFDC) which is updated based on the 56-day AIRAC cycle;
- Internet Obstruction Evaluation/Airport Airspace Analysis (iOE/AAA) program data on obstacles;
- Digital Obstacle File (DOF) data, which provides information on all known human-made obstacles relevant to aviation users and which also is updated on the 56-day AIRAC cycle;
- Shuttle radar topography mission (SRTM) 3 arc-second elevation data;
- United States Geological Survey (USGS) scanned topographical maps that show major terrain and human-made features (but which may not be current);
- Airport navigation aid database application (AIRNAV 2.0) data, which is expected to become the authoritative source for airport navigational data; and
- Operational analysis and reporting system (OARS) data, which is expected to become the authoritative source for obstacle data and soon will be merged into AIRNAV 2.0.

Noise, land use, and demographic information used to support EAs or the FAA environmental prescreening process, which guides users through the environmental requirements of their procedure design, is sought on an as-needed basis from airports or sometimes from local agencies. Some of the procedure designers who were interviewed for this study do not use this data and rely on FAA environmental specialists to conduct these assessments. Other procedure designers seek this data only when it is needed because a CatEx cannot be obtained.

Although spatial data is essential to flight procedure design, the spatial data developed by airports is not being utilized to its full potential, which limits its benefit to NextGen. Despite the theoretical availability of AGIS data to flight procedure designers, few of those interviewed knew if or how this data was getting to them. Some designers explicitly stated that it was not. Some indicated that they may request it directly from the airport if they learn that an AGIS survey has been completed. These responses suggest that while AGIS data can be an enabler of NextGen, and specifically an enabler of

PBN flight procedure development, the potential uses of AGIS data for procedure design have not yet been fully realized.

One objective of FAA's NAV Lean initiative is to streamline this process and establish a more consistently applied, systematic approach of conveying spatial data to procedure designers. Under NAV Lean, authoritative sources for airport, NAVAID, and obstacle data are being established. It is unclear how much of the data required by procedure designers is currently available. Furthermore, procedure designers can only use the GIS data that airports, consultants, and other stakeholders collect but do not upload to AGIS if they are aware the data exists. Typically, designers are made aware of this data when the airport is a proponent of the new procedure; but that seldom occurs, as the FAA is the proponent for the vast majority of flight procedures.

Similarly, airports have not yet realized the full potential benefits of spatial data collected for use in NextGen initiatives. Airports have benefited indirectly when new procedures developed, but the spatial data developed and submitted to AGIS in support of these procedures is perceived as being of limited direct use to the airport. This data can be used by airports to identify and mitigate obstacles, for land use compatibility planning, to obtain navigation easements, and for other activities that protect current and future air service capacity. Although the number is growing, relatively few airports have used this data for these purposes. (For more details, see the section on cost-benefit information in Chapter 3.)

Furthermore, few airports are aware of or use the available external sources of data because the information they provide has not traditionally been needed to support airport requirements. As the challenge of obstruction mitigation and land use-compatible planning grows, however, some airports have begun to implement ongoing obstruction analysis and mitigation programs. Some state departments of transportation (DOTs), such as the South Carolina DOT, have established statewide legislation requiring such activities and providing resources to help. Similarly, planning organizations like the Puget Sound Regional Council in Washington State are working in collaboration with the FAA to develop regional programs and capabilities to help smaller GA airports.

This growth in the use of spatial data by airports has been fueled by increasing demand for comprehensive and accurate obstruction data by the FAA, which in turn has been largely driven by the increase in new procedure design associated with NextGen. In the near future, the issuance of COAs for UAS will further propel this demand. Land development near many airports in the United States has also increased the encroachment issues faced by airports. For these reasons, the need for airports to proactively seek and use AGIS safety-critical data and other airspace related data sets is likely to grow.

Improved Surface Operations

A few NextGen programs provide a variety of capabilities that support communications with, data exchange between, and the coordination of aircraft and surface vehicles operating on the airfield. Air traffic controllers, vehicle operators, and airport personnel use this information to improve the safety and efficiency of surface operations such as the taxiing of aircraft and the movement of ground service vehicles. The following capabilities related to surface operations have been implemented at several core and non-core airports:

- Advanced electronic flight strips (AEFS);
- Airport surface detection equipment, Model X (ASDE-X);
- Airport surface surveillance capability (ASSC);
- External surface data release; and
- Situational awareness and alerting of ground vehicles (FAA n.d.f).

In addition to these airport-specific implementations of NextGen capabilities, cockpit display of traffic information (CDTI) with traffic information service-broadcast (TIS-B), ADS-B for surface, moving map with own-ship position, traffic flow management system (TFMS), and time-based flow management (TBFM) new data sharing via SWIM subscription capabilities have been implemented across the NAS. The surface visualization tool also has been implemented at several ATC facilities.

Many of these systems and tools provide pilots, controllers, dispatchers, and ground personnel with maps that display the locations of aircraft and properly equipped surface vehicles. Symbols depict the vehicles on the maps at their specific locations, and additional details are given such as vehicle or flight identification numbers and the time each vehicle was at that location. This information represents spatial data, attributes, and metadata that become far more useful when displayed in conjunction with other layers of information, such as runway, taxiway, and apron boundaries, turning the base map into a critical visual reference.

It appears that these base maps are assembled on a case-by-case basis, using the best sources that can be identified. These sources may include AMDBs that adhere to the requirements documented in RTCA DO-272, airport spatial data that is uploaded to the FAA's AGIS, traditional ALP drawings, airport diagrams prepared by the FAA, and other sources.

Airports are more likely to benefit from NextGen surface operations capabilities if they collect and maintain spatial data that accurately depicts the current layout of their airfield. Some airports have provided such information to the FAA so that capabilities can be implemented. Others have provided data to vendors that they have selected to provide similar airfield map displays. Although some airports have begun to develop and share such data, there is significant room for growth as NextGen capabilities continue to be rolled out.

MRO

Another portfolio of NextGen capabilities that continues to benefit airports is improved MRO. Airports that have closely spaced parallel runways, runways with converging paths, and other multiple runway configurations have begun to benefit from a variety of NextGen capabilities that improve access to the airport and increase air service capacity while preserving high safety standards. These capabilities include:

- Converging runway display aid (CRDA);
- Dependent approaches to closely spaced parallel runways (CSPR), discussed in FAA Order JO 7110.308;
- Additional approach options for new independent runway separation standards;
- Satellite navigation (SATNAV) or instrument landing system (ILS) for parallel runway operations; and
- Wake turbulence mitigation (FAA n.d.g).

These capabilities are supported by adjustments the FAA has made to standards and specifications for arriving and departing aircraft, including amended dependent runway separation standards in FAA Order JO 7110.65, amended independent runway standards in FAA Order JO 7110.65, and amended simultaneous dependent approaches to closely spaced parallel runways in FAA Order JO 7110.308.

The studies that supported these adjustments to FAA operating specifications benefited from spatial data to some degree, but the ongoing benefit is gained through the use of spatial data to provide a base map to the map displays and input to new procedures upon which these capabilities rely. Improved MRO will continue to improve air service at numerous airports, resulting in higher revenues, reduced operating costs, and higher customer satisfaction. Spatial data is one of many essential ingredients that help deliver these benefits to aircraft operators and airports.

NextGen Programs That Produce or Enhance Spatial Data

Although not abundant, some spatial data that benefits airports is produced explicitly by NextGen programs. In addition, NextGen programs produce data that enhances existing spatial data sets.

NextGen-related technologies such as ASDE-X can produce a rich data set that has the ability to enhance existing spatial data for an airport's noise program or for situational awareness. One capability of ASDE-X is determining the position of an aircraft on the airfield or on final approach. When added to an airfield base map or overlaid on a map showing noise complaint locations, the ASDE-X data can greatly add to the value of these spatial data sets and provide the airport with greatly enhanced safety and public outreach benefits.

When designing and installing new NAVAIDs and facilities in support of NextGen capabilities, an airport may install new utilities and construct new infrastructure and support buildings. These new facilities will produce as-built records that contain information such as underground utility locations. Some design and installation data may have security protocols attached to it, but such data could be made available to certain departments of an airport if it is protected under the shield of the airport's own security plans and requirements. For example, the airport's public safety office may require certain data in case an issue occurs at or near the location. Sharing data that is not restricted or that is protected by the airport's security protocols can help the airport maintain a complete utility network for modeling and quickly resolving any issues that may come up such as a utility break.

3 Cost-Benefit Considerations

The spatial data that airports collect benefits NextGen, other FAA programs, and the NAS overall. Although the cost of collecting this data is relevant, when viewed system wide, the cost appears relatively small in comparison to the benefits provided by new NextGen-enabled flight procedures. The resulting cost-benefit ratio is extremely small. From an individual airport's perspective, however, the benefits seem indirect and prolonged whereas the costs appear immediate, tangible, and non-optional.

Conversely, airports also can benefit from the spatial data that the FAA produces. Thus far, however, many airports have been unaware of or have found this data largely inaccessible. Fortunately, airports can take steps to identify and improve the returns they receive from their investments in spatial data. This chapter addresses these cost-benefit considerations.

Airport Data Benefits NextGen

The spatial data that airports collect that benefits NextGen primarily falls into two categories. The first category is safety-critical data that is used for the development of flight procedures, as was described in Chapter 2. The second category is airfield configuration data that is used to support improved surface operations. From a cost-benefit perspective, these two data categories have very different characteristics.

Safety-Critical Data

As defined in FAA AC 150/5300-18, safety-critical data includes information about runway end, airport control point, NAVAID equipment, obstacle, obstruction identification surface, and obstruction area features. To meet the FAA's accuracy requirements, this data must be collected using field surveys or photogrammetry. Collecting this data requires on-the-ground surveying and aerial photography. The collected data must be analyzed, attributed, and checked before it is submitted to the FAA. GIS data submitted to the FAA also must include a detailed report and extensive supporting information. The collection and analysis work often requires specialized training, equipment, and software. These factors drive up the cost of collecting and submitting this data. The cost also can vary greatly based on the number and type of obstruction identification surfaces to be analyzed, the terrain around the airport, and the relative number of vertical features posing potential hazards to air traffic.

Although safety-critical data must be updated as it changes, full airspace analyses are completed infrequently. Ongoing data maintenance costs for safety-critical data are therefore generally low.

After being validated by the FAA and/or NGS, safety-critical data is used by procedure designers to develop IFPs. This type of data is essential to flight procedure development and represents a relatively small portion of the cost of developing a procedure, which can exceed $1M in some cases. New PBN procedures, however, are a fundamental part of NextGen, which is estimated to provide $133B in benefits through 2030 (FAA 2014b). These procedures have and will continue to streamline air traffic flow, reduce minimums, increase operational efficiencies, and reduce emissions at small, medium, and large airports. In addition, the improved air service generates indirect economic benefits such as job creation. The cost-benefit ratio for this data is, therefore, relatively small.

The cost for these safety-critical aeronautical surveys is borne directly by airports, which means that many airports perceive that they bear new data collection costs but do not reap corresponding rewards. In fact, airports are gaining new capacity, reducing minimums, and increasing safety because they have collected this data; unfortunately, these benefits have been less apparent to airports than the costs. The FAA, RTCA, industry associations, and others are trying to change this perception. To help federally obligated airports fulfill their grant assurances and, ultimately, realize the benefits safety-critical data can offer them, airports are encouraged to:

1. Integrate clear definitions of safety-critical data requirements into internal data maintenance procedures and policy manuals, as well as relevant consultant contracts.
2. Proactively monitor airport and community projects that could impact airport airspace and other safety-critical data. Doing this would help satisfy the airport's obligations to (1) submit safety-critical data changes in a timely manner, (2) protect instrument and visual operations at the airport, and (3) report new obstacles to the FAA (DeLeon 2012; FAA 2014b; 14 CFR Part 77.7). To achieve these goals, some airports have worked with local communities to implement zoning restrictions and permitting requirements.
3. Establish an ongoing program to manage obstacle mitigation activities. This program can help satisfy an airport's obligation to develop, submit, and annually update an Obstacle Action Plan (OAP) to the FAA (FAA 2015d).
4. Provide safety-critical data to airport planners and designers, and, as applicable to, consultants, community representatives, and developers.

Particularly in the short term, when safety-critical spatial data has highlighted potential safety concerns, some airports have experienced reductions in service or increased costs to maintain their current service levels. For example, guidance that went into effect on January 6, 2014, prompted the FAA to remind airports of the importance of identifying and mitigating obstacle or terrain penetrations to 20:1 Visual Area Surfaces (DeCleene and O'Donnell 2013; FAA Order 8260.3B). Subsequently, airports were required to provide proof that such penetrations were not valid or, depending on their severity, to mitigate them within a period of time. Increased minimums and/or reduced nighttime service were possible results. Moreover, combined with the initial costs of collecting the spatial data, many airports faced negative benefit in the form of immediate and largely unforeseen costs to analyze and mitigate the obstacles and penetrations identified by the data.

Airfield Configuration Data

Airfield configuration data includes runway, taxiway, apron, marking line and area, airport sign, airfield light, and shoulder features that depict the current and possible future layout of an airfield. The majority of this data is collected photogrammetrically and attributed to features of the airport by experienced analysts with input from airport planners and engineers. This data has been commonly collected by airports for decades in support of master plans, pre-construction design, and other activities.

The cost of collecting this data can range from a few thousand dollars on small projects that implement minor configuration changes, to approximately $1M for large data collection efforts incorporating major configuration changes. AGIS data requirements are a large driver of these costs; previously, two-dimensional (2-D) data could be collected to support airport needs, at a lower accuracy, with little or no attribution, and with fewer topology constraints. The additional cost of acquiring data that meets the FAA's specifications has gone down, however, as consultants become more familiar with the processes required, vendors provide tools that help, and the FAA's guidance is refined.

Although the FAA's requirements increase the cost of collecting airfield configuration data, the collection of this data also promises to provide new benefits, such as the following:

- **Reduced data maintenance.** Airports that maintain their non-safety-critical data as required by the FAA benefit by having up-to-date, accurate information to support airfield operations and maintenance activities, which increasingly rely on maps integrated with FAR Part 139 reporting, maintenance management, and gate allocation systems. A small but growing number of airports that have implemented such GIS applications are beginning to reap these benefits. Furthermore, the cost of preparing a comprehensive set of airfield configuration data (often called "eALP data") should be a one-time expense provided the data is updated as the airport's configuration changes. The need for data maintenance has prompted some airports to hire GIS analysts or impose a surcharge on construction projects. Over time, however, the costs of ongoing data maintenance are likely to be less than the costs of periodic comprehensive mapping efforts.
- **Reuse of aeronautical data.** Airports for which wide-area augmentation system (WAAS) aeronautical studies have been performed may experience a cost savings toward an ALP update or eALP data collection project (Woolpert 2015).
- **New capabilities.** As the FAA continues to roll out AGIS modules such as the eALP, modification of standards, and surface analysis and visualization tools, airports will continue to gain new capabilities that directly benefit their ongoing needs. Already, airports have begun to benefit from additional data development tools that can leverage the standardized data model the FAA requires.
- **Operational efficiency.** NextGen programs such as surface operations will improve operational efficiencies as they are rolled out at larger commercial airports.
- **Growth of available imagery.** Aerial imagery that is collected to support the development of safety-critical and airport configuration data is being loaded by the FAA to a secure cloud-based service that airports and other entities will be able to access in the future. A growing number of other government and commercial sources also are collecting imagery that potentially enriches the pool of useful information available to airports.

The cost-benefit ratio of airport configuration data soon promises to pass breakeven and provide a positive return to airports that maintain their data and take advantage of the growing number of FAA and vendor-supplied tools that use this data. To achieve this improved return, the research team suggests that airports take the following steps:

1. Structure spatial data in a manner that is compatible with the FAA's requirements as defined in FAA AC 150/5300-18. Airports that choose to maintain data in another format can establish a strategy for converting the data to an FAA-compliant format when it is to be submitted or used with tools that leverage the FAA's data structure.
2. Record and store metadata sufficient to determine the source, quality, and methods used to create spatial data.
3. Maintain and update the data as airfield configuration changes are made, as opposed to conducting periodic updates when the data is needed. Effective maintenance requires an ongoing dialog between airport project managers who are responsible for physical changes and GIS technicians who are responsible for depicting those changes on a map.
4. Avoid redundant and repetitive data collection efforts that do not consider or trust existing data. Encourage consultants and contractors that are concerned about the liability of using data col-

lected by others to at least review and attempt to validate existing data to determine if it can meet their needs.

5. Promote the awareness and use of existing data across airport divisions, among consultants, and where appropriate, in communications with the public. Data can be distributed and used in its native format, published as maps or services, and incorporated into applications. Regardless of how it is distributed, the more data is used, the greater is its benefit.

Safety-critical and airfield configuration data are the primary categories of data collected by airports that are used in support of NextGen programs. In addition, noise contours developed by airports to support EAs or FAR Part 150 studies and utilities data shared to facilitate NextGen equipment installations are also relevant. These data types, however, have been previously collected by airports, face few new FAA requirements, and are typically not exchanged between airports and the FAA. For these reasons, the marginal costs and benefits are insignificant when compared with the more significant impacts described above for safety-critical and airfield configuration data.

FAA Data Benefits Airports

Airports also stand to benefit from spatial data that is produced by the FAA. This is especially true for airports that chose to take an increased role in planning and protecting their airspace. Their cost-benefit implications for airports are described in this section.

- The FAA notes that "airports have a need for access to real-time FAA flight track data for their surface situational awareness and noise monitoring programs" (Black 2015). Awareness and noise monitoring programs use in-flight and on-the-ground aircraft locations to help airports plan, make decisions about, and protect their airspace. These locations also help airports establish and maintain a safe and efficient operating environment on the ground.
- Flight procedures define a path for aircraft to follow. These paths, or tracks, are published on the 56-day AIRAC schedule as "approach plates." Textual information about the parameters of each flight track also is available from the FAA. Although this data is spatial, it is not published in a common geospatial format that allows airports to easily view and analyze the data in GIS and CAD programs they may use. This data is beneficial to airports looking to understand the impacts new or proposed flight procedures may have on their operations and surrounding community.
- Data about utilities installed by the FAA or its contractors to support FAA NAVAIDs and facilities often are not available to the airports concerned with the location of these utilities during project design and construction phases. The FAA's computer-aided engineering graphics (CAEG) program is taking steps to alleviate this problem, but airports currently must request utilities data on a case-by-case basis.

In accordance with the Office of Management and Budget's (OMB's) Open Data Policy (White House memorandum May 9, 2013), the FAA is taking steps to provide the spatial data it collects to the public. Meanwhile, airports can take steps to proactively seek data that may be of benefit to them. The following steps are suggested:

1. Airports can request a direct connection to the FAA's Aircraft Situation Display to Industry (ASDI) data or subscribe to the services of commercial vendors who offer such data. Airports also can request a direct connection to the FAA's ASDE-X data. For more details, airports can consult the FAA memorandum, Requests for Release of FAA Real-time NAS Data to Airports for Surface Situational Awareness and Noise Monitoring Programs (FAA 2015e).

2. Airports can obtain current and upcoming instrument flight procedure information via the FAA's IFP Information Gateway at https://www.faa.gov/air_traffic/flight_info/aeronav/procedures/.
3. Airports can contact representatives in their Air Traffic Organization (ATO) Service Center to request and obtain copies of as-built drawings of facilities and utilities installed by the FAA and its contractors. Service center points of contact can be found at https://www.faa.gov/foia/foia_coordinators/ato_service_centers/?section=service_center_contact.
4. Once airports receive data from the FAA, they are encouraged to incorporate it into the airport's geospatial data resources, which are kept current and published to their staff and consultants who require this information.

In summary, since 2006, when AGIS data requirements were first published, the marginal cost of collecting data to meet NextGen and other FAA requirements has been high. This has been especially apparent since 2013, when the FAA's transition policy solidified the roll-out of these requirements. At the same time, the relative benefits have been low, as not all procedure designers have had access to airport spatial data, AGIS modules have only begun to be rolled out, and airports have only begun to implement or integrate with internal systems to use the data to address their needs. Furthermore, the availability of FAA-produced spatial data has been unclear to or elusive for many airports, and a sometimes costly challenge to overcome for others. The result is that the return on investment (ROI) for collecting spatial data to both the FAA and to airports has been lower than it could be. In particular, the ROI to airports has been perceived as very low, if not negative. Fortunately, airports have an opportunity to change this perception and receive greater benefit from FAA-collected spatial data by taking the steps described above. Moreover, as more NextGen programs, FAA lines of business, and airports begin to use this data for expanded purposes, the ROI will grow to the point at which both the FAA and airports can recognize the benefits and cost-benefit analyses of these activities are no longer of concern.

Airport Data Can Benefit Carriers

Spatial data produced by airports also can benefit air carriers. This data can support both aircraft operations and facility management. For aircraft operations, many air carriers employ flight procedure specialists who seek to optimize the arrival and departure procedures of their aircraft. Some seek to hone flight procedure parameters based on the specific configuration of their aircraft. Others have become proponents of PBN procedures that benefit their operations. Carriers with significant operations at an airport often work with the FAA and the airport to plan the future configuration of airspace around an airport. For these activities, air carrier flight procedure specialists need the same information as their counterparts who work for the FAA (see the section on flight procedures in Chapter 2). Spatial data on obstacles, terrain, runway configuration, and NAVAIDs are essential. Airlines also can take into consideration land use, population, and other factors that affect stakeholders around the airport.

Airline dispatchers can benefit from spatial data that depict runways, taxiways, aprons, gates, parking locations, fueling locations, deicing pads, and other components of airport infrastructure that affect their safe and efficient operations. Dispatchers may use this data in moving map displays, similar to those being implemented for FAA controllers as a part of NextGen, while schedulers may use this information to predict taxiing times.

Airline station managers, maintenance staff, and other personnel assigned to work at airports served by an airline often need information on the physical layout of the facility, airport and airline assets, interior floor plans, and other spatial data. Airlines lease and reconfigure space to suit their needs.

This requires floor plans from the airport to support the planning and design needs. Most airports will require airlines and other tenants to submit as-built drawings once these projects are complete. Although this facilities data is important to airlines and airports, it is outside the scope of NextGen and therefore only briefly mentioned in this guidebook.

An increasing number of airports collect and maintain the types of spatial data airlines need. Informing airport lease managers, operations personnel, and other staff members who work directly with airlines about the spatial data resources their airport offers helps them better support their airline customers. Furthermore, sharing this data is a means of helping airlines operate more efficiently, which can bring more revenue to an airport and further improve the return an airport is able to achieve on its investment in spatial data.

Public Agency Data Can Lower Costs

Another way to improve the return on investment (ROI) in spatial data is to lower its cost. One way to do so is to take advantage of the increasing amount of spatial data that is made available by public agencies, much of which is available at a low cost, or even free. This opportunity, as well as effective practices several airports have used to exchange spatial data with local agencies, has been documented in *ACRP Synthesis of Airport Practice 59: Integrating Airport Geographic Information System (GIS) Data with Public Agency GIS.* This synthesis report found that airports require spatial data "from surrounding communities to support planning and development, airspace analysis, property acquisition, noise mitigation, environmental protection, customer service, and other procedures." Conversely, the study found that "public agencies require geographic information from airports for transportation planning, compatible land development, emergency response, and zoning." Furthermore, some airports rely on their parent organizations, such as municipal or county agencies and, in some cases, regional planning organizations for software, hardware, and personnel. Some airports have collaborated with regional agencies to cost-effectively procure aerial imagery on a periodic basis (Murphy and Bannura 2014).

The spatial data and related resources exchanged between airports and public agencies benefit the implementation of NextGen in a few ways. Primarily, the exchange of data helps collaborative land use planning that can protect airspace for new NextGen PBN procedures. The data makes it easier for flight procedure specialists to balance airspace configuration changes among the sometimes competing needs of airport, airline, and community stakeholders. Spatial data also can help in developing maps that are an essential component of the stakeholder engagement that supports NextGen implementation (a finding of ACRP Project 01-28 further documented in *ACRP Report 150: NextGen for Airports, Volume 2: Engaging Airport Stakeholders: Guidebook*). By seeking existing data from local agencies, airports can lower their costs by avoiding the generation of duplicative spatial data while increasing the likelihood that NextGen procedures will be implemented in a manner that benefits the airport, its operators, and the surrounding community.

The Importance of Data Maintenance

The quickest way to lose an investment in spatial data is to not maintain it. Airports are dynamic environments with ongoing development and maintenance activities that constantly change the physical facilities and assets depicted by spatial data. Airports also are transportation hubs, which attract off-airport development that can change the areas of interest to the airport and to NextGen. If the relevant spatial data does not keep up with these changes, users lose confidence and seek alternatives or, worse, make decisions based on invalid data. The result is that benefits dwindle and the ROI rapidly erodes.

The solution is to continuously maintain data so that it is kept as up to date as possible. This goal has been challenging for many airports to achieve for a variety of reasons. Spatial data is often produced as a part of a specific project such as a master plan update, facility construction, boundary survey, airspace analysis, or environmental study. An ACRP study into subsurface utility engineering (SUE) noted that "the desire to complete projects and bring new facilities into use often eclipses the need for information necessary to efficiently operate and maintain them" (Anspach and Murphy 2012). When the project ends, so does the mechanism to update the data. As a consequence, the data that is delivered remains a snapshot in time until a similar project emerges. Furthermore, a risk exists that the data that is delivered will not meet the airport's requirements, and therefore will not improve the overall quality of the airport's geospatial data.

This problem often occurs because airports lack data standards that sufficiently define their needs, or because existing standards are not enforced. In addition, consultants and contractors often prefer to re-collect spatial data on each project to minimize the risk of mistakenly relying on poor data. As a result, variations can occur across time that make using the data less efficient and effective.

A growing number of airports have attempted to address these challenges by implementing and enforcing data standards and by assigning data maintenance responsibilities to qualified staff or on-call consultants. These airports establish procedures to maintain the data and enforce those procedures through policies endorsed by senior management. This approach requires management education and oversight, ongoing funding, and interdepartmental coordination. Because time, funding, and staff resources are always limited, those airports that have been successful have focused on data sets that frequently change and have many users. These data sets include:

- Utility locations that are established or discovered during airfield construction activities;
- Tenant space utilization that changes as tenants come and go or when facilities are altered;
- Maintenance and repair histories of airfield pavement and other location-specific assets; and
- Environmental monitoring and mitigation.

Interestingly, despite airports' commitment to their ongoing maintenance, these data sets are not among those most needed by the FAA for NextGen or other internal activities. This allocation of resources again suggests that airports do not currently perceive a positive (beneficial) cost-benefit ratio in maintaining the data the FAA requires. To remedy this situation, the FAA has established several requirements, including the following:

- Submission of up-to-date spatial data that the FAA defines as safety critical for flight operations, as well as "as-built" data reflecting airfield changes as a condition of AIP grant offers and passenger facility charge (PFC) decisions (DeLeon 2012);
- Tracking and accounting for land or property rights acquired by airports using federal funds, often using spatial data to depict airport parcels;
- Submission of noise contours depicting day-night average sound (or noise) levels (DNLs) of current and forecast aircraft operations for FAR Part 150 noise studies; and
- Under FAR Part 77.9, the filing of spatial data with the FAA about objects that may impact the safety of navigable airspace (14 CFR 77.9).

In addition to these federal mandates, a small but growing number of states are requiring spatial data to be developed for airports. South Carolina, for example, requires "a map of each public use airport in the State showing airport property, runways, taxiways, runway approach and departure zones, airport safety zones and airport land use zones," also mandating that "these maps should be updated as needed, but at least every 5 years" (SC Code § 55-13-5 [2015]).

Whether driven by airport needs, federal regulations, or state statutes, the requirement to maintain spatial data is increasing. No single approach will work for all airports, but it is prudent for each airport to consider their options and to develop a program to maintain their valuable spatial data. As this occurs, increasing amounts of spatial data will become available to support NextGen implementation and other FAA initiatives, ultimately to the benefit of airports and their stakeholders.

4 Financial and Legal Considerations of Spatial Data

This chapter of the guidebook considers the financial and legal considerations of working with spatial data. It examines the potential for airports and airport sponsors to receive financial gains through the monetization or the selling of spatial data to third parties, and further considers the legal liabilities related to the use and distribution of spatial data by airports. Both of these issues have a strong legal connection, so the research and documentation for this chapter were conducted by the Washington Progress Group, LLC, and the research team's legal experts. Accordingly, the tone of the writing and the methods used to convey and document the information differ from other sections in this guidebook.

Prospects for Monetization of Airport GIS Data

Airports collect a variety of GIS data sets that may have the potential for reuse by third parties. Typical GIS data sets gathered by airports deal with obstructions to takeoff and landing areas, but other data sets frequently include climatological information, wildlife attractants on or around the airport, storm water management systems, surrounding buildings and structures, and so forth.

On the basis of the research, meetings, and interviews conducted for ACRP Project 09-12, it appears that airports have not explored the potential for selling to third parties some of the GIS data that they generate for their own purposes. Certainly, some data derived from FAA-required airport surveys could be useful to airlines seeking to improve their navigation procedures. Airlines typically pay aviation engineering consultants for such information, so airports may find that making this particular data set available to airlines could offer a revenue stream that helps to offset the costs of the required surveys.

Airports are advised to refer to their chartering documents to make sure nothing in these documents prohibits the airport from charging for data or otherwise recovering costs. Publicly owned airports are subject to state or local freedom of information laws that treat airport GIS data as a public record and require that data to be surrendered upon request. Legal cases have tested whether GIS data is exempt. One such case—*Sierra Club v. Orange County*—went to the California Supreme Court in 2013, resulting in a decision that GIS databases are not exempt from the Public Records Act (California's equivalent to the federal Freedom of Information Act, or FOIA). These laws effectively negate the prospects for public airports selling GIS data.

If legal constraints are not a deterrent, airports considering a foray into the business of selling GIS data should take into consideration the track record of entities that have attempted to do so. The findings from the Open Data Consortium (ODC) project[1] suggest that most agencies that have attempted to sell public data failed to realize significant revenues, and in many cases, the effort lost revenues.[2] The ODC gathered 265 GIS professionals from city, county, metropolitan, regional, state, and federal government levels to analyze the merits of "fee versus free" as a data distribution policy. Some examples from the project highlight the challenges of making money from selling GIS data:

- Ventura County in California sold its data for $1 per parcel. It raised $15,000 per year, compared with the annual cost of nearly $1 million to maintain a 10-person team that updated GIS data and created GIS applications.
- San Francisco (city and county) reported that it cost more in staff time to sell their GIS data than the revenues they received.
- A March 2001 study by KPMG Consulting, Inc., found that "U.S. agencies reporting data income had revenues equal to 2% of their expenses."[3]

GIS experts confirm that little has changed in the course of a decade and caution against expecting a meaningful ROI from attempts to monetize GIS data.[4] The practical reality is that even when GIS data is a strategic asset, converting it into a money-generating commodity entails costs that frequently outweigh the value.

Airport executives establishing a distribution policy for GIS data will be informed by "give-away" models and "pay" models, described below. Overall the practice has been that the federal and state governments and their subdivisions and regulated entities offer data to the public for free. Good reasons exist for an airport to adopt the give-away practice even aside from the legal rules that may require it: free dissemination of GIS data demonstrates transparency and can contribute to productive business-to-business relations. Airport executives are focused on global policies and decision making for the airport, so their perspectives may be somewhat distant from those of air operations personnel. As a result, executives may sometimes fail to recognize how the airport's GIS assets could be helpful to planning for higher capacity. If an airport works in partnership with airline operators by supporting their efforts to design RNP procedures aimed at achieving increased operations, economic benefits may inure to the airport as well as the airline.[5]

Sharing data for free can support such civic concerns as regional planning, public safety, and the management of natural resources, engendering positive relations in the community.

The "free" model of data distribution may take various forms. One model is Open Data Commons, an Open Knowledge Foundation project dedicated to providing a set of legal tools to help entities provide and use open data. Open Data Commons proposes three types of license for free data:

- *Public Domain*—no restrictions, meaning users can do what they want with the data;
- *Attribution*—use of the data requires attribution, but nothing beyond that; and
- *Open Database*—use of the data requires that users also share any "value adds" as an open data set.

With so much data being accessed via the Internet, establishing the user's consent to a license is generally accomplished online by requiring the user to check a box to indicate agreement with terms specified by the license holder prior to downloading the subject files.[6]

Open Knowledge International (a nonprofit organization created by the Open Knowledge Foundation) offers an Open Data Handbook[7] that provides practical advice and steps for managing data in a way that keeps access open. Recommendations include: keep the data set simple (it is not necessary to include every data file); communicate as often as possible with users to determine their needs; and take time to allay any fears within the organization about making the data available to external users. Naturally, other steps include determining the format of the data, organizing a central catalog to list the data sets, and posting the catalog and the data sets on the web.

Methods for offering data for free online include the following:

- Placing data on the airport's or airport sponsor's existing website for download.

- Placing data on a third-party site where other data sets of a similar nature reside. Large data sets can be made available on sites that allow public sector agencies to store massive quantities of data for free. It is advised that airports check the policies of third-party sites in advance to ensure the platform does not restrict access or impose conditions to which the airport or airport sponsor does not agree.
- Using a file distribution system that splits the cost of distributing files across all of the individuals accessing those files.[8] This kind of system is efficient for very large volumes of data (such as sharing movies).
- Using an application programming interface (API),[9] which allows a select portion of a database to be available (rather than all of the data in bulk as a large file), and for the file to be updated in real time. APIs can be costly to develop and, if they are not maintained, access to the data may be impeded.

Regardless of the format of the data or the method of distribution, a crucial step is making the data discoverable so users can find it. Tools are available online that catalog data, making it possible for users to find it.[10] Airports also can register their databases with any one of the many aviation database websites.

For the intrepid airport determined to sell its data, the mechanisms for charging fees from users are well established. Fee-based models for data distribution are commonplace for purveyors of information and customers:

- For well over a decade, data sets have been available for purchase on CD-ROM, normally coupled with a “shrink-wrap license” (i.e., by removing the cover of the CD-ROM, the user accepts the license terms).
- As use of the Internet has expanded, data sellers have increasingly offered users the ability to download data sets to their own computers, either through subscriptions (allowing access for a limited time period for a fee) or through pay-as-you-go arrangements (in which each download of data is separately charged).
- More recently, data sellers have begun to provide cloud-based services under which the data resides permanently on the seller’s server and the paying user accesses it on demand by going to a password-protected Internet address (URL).

Should an airport desire assistance with formulating its database, businesses known as “conversion firms” will build a data set to meet the client’s specifications. Conversion firms are usually contracted to build special-purpose data sets.[11] Other firms make money by selling tools for manipulating GIS information rather than by selling the information itself.[12]

In sum, GIS data is not a likely candidate for monetization by most airports due to legal constraints stemming from public records laws, nor has it proven economically viable in most cases. However, GIS data is local by its very nature, and special circumstances may exist under which the data collected by an airport has value to a third party. The technical and business aspects of charging for data are now relatively uncomplicated when accomplished through the Internet.

Ownership and Protection of GIS Data

This section of Chapter 4 discusses principles, rules, and constructs for analyzing ownership of GIS databases. Because the methods of generation and the derivation of GIS data vary, each data set—

including and especially all component and/or source data and information—must be analyzed separately for ownership interests. This section also suggests concepts, methods, and tools for protection of databases, and the potential for compromise of ownership rights by disclosing or sharing data with public agencies.

AGIS Program and GIS Data Ownership

For the purposes of NextGen, the FAA created an initiative to streamline the airport survey process and centralize airport data storage into one integrated, web-based GIS called "Airports GIS (AGIS)."[13] The FAA intends that the airport or airport sponsor be the owner of any GIS data it submits to AGIS.[14] As owner of the AGIS data, the airport sponsor must define and protect its ownership rights in GIS databases through contractual arrangements such as statements of work (SOWs) with data providers and surveyors.

The AGIS approach to ownership of airport databases is consistent with general laws and principals applicable to GIS database ownership and protection. Ownership in a GIS database may be protected by copyright, or protected pursuant to a contract between the generator and the user. In addition to legal protection, unauthorized use can be deterred through technical means.

On the other hand, submission of GIS data to AGIS may make the material vulnerable to public disclosure by the federal government under FOIA, addressed specifically below.

Patent Protection

If GIS data is generated using a unique and innovative device, patent protection of the device may be available.[15] Absent a patentable device or machine, however, patent protection for a process, including processes embodied in computer software, is very limited. For more information, see *Alice Corporation Pty. Ltd. v. CLS Bank International et al.*, (Sup Ct.) June 19, 2014.[16]

Copyright Protection

For the purpose of copyright, databases are "compilations." As defined by the Copyright Act of 1976, a compilation is a work formed by the collection and assemblage of preexisting materials or data that are selected, coordinated, or arranged in such a way that the resulting work as a whole constitutes an original work of authorship. Copyright in a compilation extends only to the material contributed by the author of such work, as distinguished from the preexisting material employed in the work, and does not imply an exclusive right in the preexisting material. In no case does copyright protection of an original work of authorship extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described explained, illustrated, or embodied in such work. This statutory language has been interpreted to exclude copyright protection of facts as well.[17]

Application of these principles to computerized databases has been well stated by legal scholars as follows:

> A factual compilation can be protected by copyright law if the selection, coordination, or arrangement of data constitutes an original work of authorship. The facts themselves are not copyrightable. If the factual compilation qualified for copyright protection, the protection would extend only to the selection, coordination, or arrangement that made the compilation original. Protection would not extend to the facts contained in the factual compilation. As a result, the facts in a factual compilation may be freely copied. With the computer revolution, many factual compilations are taking the form of computerized databases. With the ease of copying electronic information, "free riders" may take a first database creator's database, copy the uncopyrightable elements, and make a second competing database without incurring the cost of producing it.[18]

Despite this limitation, which allows legitimate users to extract and re-package or disseminate the underlying factual content, copyrighting the manner of expression is still the primary means available for protecting databases, including GIS. Inherent in this protection are legal enforcement rights and penalties against infringement, subject to fair use and other statutory exceptions.[19]

Contractual Protection

Unauthorized use of GIS databases can also be deterred through contractual means such as clauses in sales or licensing agreements between the database owner and users that prohibit dissemination, re-use, and/or extraction and repackaging of the data. Such "authorized use" agreements—usually in the form of "shrink-wrap" language or comparable language requiring the user to click an online button indicating agreement to such restrictions before getting access to the data—are ubiquitous in the software industry today.[20]

Technical Protection

Unauthorized use can also be prevented through technical means such as encryption, watermarking, or other modifications or enhancements to the document or database that make it physically difficult or impossible to copy or extract the underlying data, or that signal or identify unauthorized derivative sourcing.[21]

GIS and Disclosure under FOIA

Airports are invited to upload qualified survey data into the AGIS database.[22] Inclusion in the AGIS database may subject otherwise-proprietary airport GIS data to public disclosure.

Except for explicitly defined categories of records that are specifically excepted, the federal FOIA (5 U.S.C. §552) requires the federal government to make available to the public, for the cost of production, all records in its possession. The only GIS materials explicitly exempted from FOIA are "geological and geophysical information and data, including maps, concerning wells." Unless the GIS data in the government's possession falls under another of the FOIA exemption categories,[23] it is subject to disclosure under FOIA. FOIA does provide an exemption from disclosure for "trade secrets and commercial or financial information obtained from a person and privileged or confidential."[24]

To the extent that an airport develops a data set that has commercial value, consideration should be given to whether inclusion of that material in AGIS might make it discoverable for free under FOIA. If this is a concern or consideration, airport sponsors are advised to explore with the FAA how proprietary databases can be included in AGIS without eviscerating their commercial value (e.g., by restricting access to a particular data set to other airport sponsors and/or by requiring permission of the owner airport).

A similar concern about unintended disclosure arises if GIS data having commercial value is shared or submitted to state or local governments. Airport sponsors also are advised to thoroughly research state and local FOIA statutes, regulations, and common law before sharing any commercially valuable privately owned databases with government agencies.[25]

Potential Liability When Sharing or Providing GIS Data

This section discusses whether, on what basis, and to what extent providers of GIS data might be liable to consumers of the data, and suggests ways to eliminate or minimize potential liability.

Theories of Liability

Although legal scholars have written about the risk of liability inherent in providing GIS information to third parties,[26] very few actual legal case decisions exist. Rather, scholars have used the principles that apply to lawsuits against providers of aeronautical charts to predict the potential liabilities of GIS providers.[27]

However, not all experts agree that aeronautical charting cases are applicable in other situations. GIS liability may depend on whether courts decide that GIS is more like the highly technical tool of an aeronautical chart or more like the ideas and expressions in a book.[28]

There are at least three theories under which a provider of GIS might be sued for insufficient or erroneous data: contract, negligence, and strict liability.

Contract

A GIS provider might be held liable under theories of contract law if it contracted to provide GIS data and then failed to perform or provided inadequate or erroneous data. This liability could extend to third parties explicitly intended to benefit from the GIS data or information.[29] Potential damages under contract would be loss of the bargain to the customer and possibly consequential damages. A defense might be breach of contract by the customer (e.g., failing to make progress payments on time as provided in the contract, or preventing performance by the GIS provider, for example by not providing information the GIS provider needs to do the work). To limit an airport's liability, a contract could also include a disclaimer regarding accuracy or completeness of the data. Such a disclaimer could extend to possible liability to third parties that might be beneficiaries of the contract.

Negligence

A GIS provider might be held liable under the theory of negligence if it undertook to provide GIS information and then gave erroneous or insufficient information that led to damage or injury to someone relying on that information, providing that it was reasonable for the GIS provider to have anticipated that the injured party would rely on that information. This theory is described in Section 311 of the Restatement (Second) of Torts (1965), in which it is stated that an entity can be subject to liability if it "negligently gives false information to another," resulting in "physical harm" caused by "reasonable reliance upon such information." Liability could arise when either incorrect or incomplete data is supplied or the data is misapplied.[30] The liability award would be based on actual damage to the person relying on the GIS data, and possibly punitive damages if the error or omission was the result of gross negligence or recklessness. A defense to such an action would be that the injured party contributed to the injury by not being reasonably careful.[31]

Strict Liability

Some legal cases have considered charting information (and by analogy, GIS data) as a "product" to which "strict liability" rules apply in the same way that liability rules apply to consumer products. Under this theory, the provider of such data would be liable to someone damaged by defective data, regardless of whether the generator/provider of the data exercised reasonable care.[32] The measure of damage would be whatever it takes to compensate the customer (compensatory damages), plus punitive damages if the GIS provider was grossly negligent or reckless. This theory is described in Section 402(a) of the Restatement (Second) of Torts (1965) as follows:

> (1) One who sells any product in a defective condition unreasonably dangerous to the user or consumer or to his property is subject to liability for physical harm thereby caused to the ultimate user or consumer, or to his property, if
>
> (a) the seller is engaged in the business of selling such a product, and
>
> (b) it is expected to and does reach the user or consumer without substantial change in the condition in which it is sold.
>
> (2) the rule stated in Subsection (1) applies although (a) the seller has exercised all possible care in the preparation and sale of his product, and (b) the user or consumer has not bought the product from or entered into any contractual relation with the seller.

Minimizing Liability

The discussion presented so far in this chapter suggests by analogy that both a producer and a manipulator of GIS data could potentially be held liable for errors in that data.[33] This potential is especially true if that data is provided to a particular, narrow group of users such as pilots (as opposed to an indeterminate numbers of the general public),[34] and if one of the users is injured as a result. Indeed, liability for damages or injuries suffered through reliance on an inaccurate map or survey is not uncommon.[35]

Some defenses or mitigations to liability may, however, be available. Although not within the scope of this guidebook, the defense of sovereign immunity may under some circumstances be available to publicly funded airports. Whether and to what extent sovereign immunity would apply depends on state and local law, and on the characterization of the activity in question as governmental or "discretionary."[36]

Liability might also be avoided by explicitly stating that the accuracy of the data is not guaranteed.[37] For example, in *Rozny v. Marnul,* 250 N.E.2d 656 (Ill. 1969), a surveyor was held liable because he absolutely guaranteed the accuracy of the plat but in *First Equity Corp. v. Standard & Poor's Corp.*, 869 F.2d 175, 176 (2d Cir. 1989), the corporation was not held liable to someone who relied on its report because it specifically did not guarantee the accuracy or completeness of the information contained within that report.

Another way to minimize liability would be by following existing government or professional GIS standards.[38] The FAA has issued such standards in AC 150/5300-18. Although these standards are mandatory only for those airports using AIP or PFC revenue to collect data, voluntary adherence to the standards in the FAA's AC would help minimize an airport's potential liability.

Endnotes

1 Information available online at www.OpenDataConsortium.org.

2 The ODC's findings are described in the article "Ten Ways to Support GIS Without Selling Data," by Bruce Joffee, *URISA Journal*, *Vol. 16,* No. 2 (2005).

3 "Geospatial Data Policy Study," by Garry Sears, KPMG Consulting, Inc., March 28, 2001 (Canada), p. 18.

4 August 2015 interview with Bruce Joffe, Principal, GIS Consultants; and with Gary Darling, former Chief Information Officer for the California Natural Resources Agency.

5 Comments of Tim Haney, Manager of Flight Operations Engineering, Virgin America.

6 Some websites and user agreements contain clauses that require the user to hold the data provider harmless from errors/deficiencies in the data. *See, e.g.,* disclaimer "shrink-wrap" language of the Montgomery MD DTS-GIS site (http://www.montgomerycountymd.gov/gis/maps/disclaimer.html); disclaimer language of the Ohio Department of Health (https://www.odh.ohio.gov/privacy/disclaimer.aspx); disclaimer language of OpenSha (http://www.opensha.org/license); FindLaw sample user agreement language (http://smallbusiness.findlaw.com/intellectual-property/sample-software-license-agreement-provisions.html); St. Mary's and Montgomery Counties, MD, GIS Data Licensing Agreements (http://www.co.saint-marys.md.us/docs/GISorderform&agreement.pdf) and (http://www.montgomeryplanning.org/gis/documents/license.pdf).

7 The handbook can be found online at www.OpenDataHandbook.org.

8 Information is available online at https://en.wikipedia.org/wiki/Torrent_file.

9 For a discussion of APIs, see the webpage at Project-open-data.cio.gov/api-basics/.

10 Information about one such tool is available online at http://datahub.io.

11 An example is www.Ramtech-corp.com, which largely supports utilities.

12 Information is available at www.esri.com.

13 A Guide to Airport Surveys, Federal Aviation Administration (2009), p. ii, available at https://airports-gis.faa.gov/public/data/Airport_Survey_White_Paper.pdf. Nothing in the FAA Airport Grant Assurances is inconsistent with airport sponsors' ownership of their GIS data. *See* http://www.faa.gov/airports/aip/grant_assurances/media/airport-sponsor-assurances-aip.pdf.

14 "The core of the AGIS program places Airport Sponsors and Proponents (AS/P) as the owner of all data for their airport. Through the use of the AGIS system, the AS/P has complete control (outside FAA) of their airport data." *Ibid*. p. 2. Although federal government works themselves cannot be copyrighted, the federal government can acquire and hold copyrights of others: "Copyright protection under [USC Title 17] is not available for any work of the United States Government, but the United States Government is not precluded from receiving and holding copyrights transferred to it by assignment, bequest, or otherwise." *See* 17 U.S.C. §105, available online at http://www.copyright.gov/title17/92chap1.html#105. GIS data can be generated using airport grant funds. *See* https://airports-gis.faa.gov/public/airportsSteps.html. Works produced under federal government contract or grant can be copyrighted by the contractor or grantee, subject to license rights on the part of the government. *See* http://www.cendi.gov/publications/04-8copyright.html#43. State and local governments can determine for themselves whether and to what extent their own materials, or materials of their political subdivisions other than public edicts, are copyrightable: "State and local governments may and often do claim copyright in their publications. It is their prerogative to set policies that may allow, require, restrict or prohibit claim of copyright on some or all works produced by their government units." *See* http://www.cendi.gov/publications/04-8copyright.html#313. State law will determine whether or not a publicly owned airport can acquire and hold a copyright in its GIS data. For a sampling of state laws relating to public ownership of copyrights, *see* https://en.wikipedia.org/wiki/Copyright_status_of_work_by_U.S._subnational_governments.

15 "Legal Issues in the Use of Geospatial Data and Tools for Agriculture and Natural Resource Management, A Primer," Longhorn, Herson-Apollonio, and White, ISBN: 970-648-094-3 (2002), p. 21, available online at http://www.cgiar-csi.org/wp-content/uploads/2012/10/CSI-2002-IPR-Primer-full.pdf.

16 Slip Op., http://www.supremecourt.gov/opinions/13pdf/13-298_7lh8.pdf. As a result of the confusion generated by the Alice decision, the U.S. Patent and Trademark Office in February 2015 issued extensive guidance on subject matter eligibility. *See* http://www.uspto.gov/patent/laws-and-regulations/examination-policy/2014-interim-guidance-subject-matter-eligibility-0.

17 For a comprehensive review of the history of statutory and common law of copyright protection as it applies to databases, *see* the U.S. Copyright Office Report on Legal Protection of Databases, August 1997, available online at http://www.copyright.gov/reports/dbase.html.

18 "A Thoughtful and Practical Analysis of Database Protection Under Copyright Law, and a Critique of *Sui Generis* Protection," Wesley L. Austin, *Journal of Technology Law and Policy, Vol. 3,* Issue 1 (1997), available online at http://jtlp.org/vol3/issue1/austin.html#ENI.

19 For a comprehensive review of copyright and other tools for protecting intellectual property associated with GIS data, *op. cit.*, note 4 *infra*, Longhorn, Herson-Apollonio, and White, ISBN: 970-648-094-3 (2002), available online at http://www.cgiar-csi.org/wp-content/uploads/2012/10/CSI-2002-IPR-Primer-full.pdf.

20 Ibid., p. 30.

21 Ibid. p. 18. *See*, e.g., "Watermarking GIS Data for Digital Map Copyright Protection," Tao, Dehe, Chengming, and Jianguo, available online at http://icaci.org/files/documents/ICC_proceedings/ICC2009/html/nonref/16_4.pdf. For a contrary view, *see* http://www.georeference.org/doc/public_access_to_public_data.htm.

22 A Guide to Airport Surveys, FAA, p.19, available online at https://airports-gis.faa.gov/public/data/Airport_Survey_White_Paper.pdf.

23 *See* 5 U.S.C. 552(b) for FOIA exemption categories, available online at https://www.law.cornell.edu/uscode/text/5/552. Refer to the U.S. Department of Justice Guide to the Freedom of Information Act, available online at http://www.justice.gov/oip/doj-guide-freedom-information-act, for comprehensive information on FOIA, exemptions from FOIA, and judicial and agency interpretations of FOIA and exemptions.

24 For a comprehensive and definitive analysis of what data qualifies for this exemption, *see* the Department of Justice Guide, Exemption 4, available online at http://www.justice.gov/sites/default/files/oip/legacy/2014/07/23/exemption4_0.pdf.

25 *See,* e.g., the Virginia Guide to Handling FOIA Requests for GIS Data (2014), available online at http://foiacouncil.dls.virginia.gov/ref/GIS_Records.pdf/.

26 *See*, e.g., Phillips, *Information Liability: The Possible Chilling Effect of Tort Claims Against Producers of Geographic Information Systems Data*, 26 *Florida State University Law Review* 743 (1999).

27 *See Saloomey v. Jeppeson and Company,* 707 F.2d 671 (2d Cir. 1983); *Aetna Casualty & Surety Co. v. Jeppesen & Co.,* 642 F.2d 339, 342-43 (9th Cir.1981); and *Fluor Corp. v. Jeppesen & Co.,* 170 Cal.App.3d 468, 475, 216 Cal.Rptr. 68, 71 (1985) for some examples of aeronautical charting cases.

28 In *Birmingham v. Fodor's Travel Publications, Inc.,* 833 P.2d 70 (1992), the court decided that a travel publication was not like an aeronautical chart and that the publisher was not liable for failing to warn readers of dangerous surf. In *Winter v. G.P. Putnam's Sons,* 938 F.2d 1033 (9th Cir. 1991), the court decided that the publisher of a book about mushrooms could not be held liable even if errors in the book caused people to get sick from eating bad mushrooms. The court explained, at 1036, that such publications are not similar to aeronautical charts because aeronautical charts are highly technical tools. They are graphic depictions of technical, mechanical data. The best analogy to an aeronautical chart is a compass. Both may be used to guide an individual who is engaged in an activity requiring certain knowledge of natural features. Computer software that fails to yield the result for which it was designed may be another. In contrast, The *Encyclopedia of Mushrooms* is like a book on how to use a compass or an aeronautical chart. The chart itself is like a physical "product" while the "How to Use" book is pure thought and expression.

29 *See* https://en.wikipedia.org/wiki/Third-party_beneficiary.

30 In *Brocklesby v. United States,* 767 F.2d 1288 (9th Cir. 1985), cert. denied, 474 U.S. 1101 (1986), a World Airways plane crashed in Alaska and several people were killed. The airline and the widows sued the government, which had developed the instrument approach procedure on which the pilots had relied, and Jeppesen, the company that produced the chart that depicted this procedure. The airline and the widows sued under the theories of strict liability (discussed below) and negligence. The court found that Jeppesen was negligent for failing to adequately test the data that had been supplied to it by the government and to adequately warn pilots that there might be errors in the data. The court stated, in footnote 12, that the "manufacturer of a potentially hazardous product has a duty to conduct reasonable tests and inspections to detect latent defects" and that the "failure of the manufacturer to warn consumers of defects of which the manufacturer is or should be aware constitutes negligence." The court acknowledged that if Jeppesen had merely republished the data in the form that the government had given it, it would not be held liable. But in this case the court stated that Jeppesen had converted a government procedure from text into graphic form and had represented that the chart contained all necessary information.

31 For example, in *Reminga v. United States,* 631 F.2d 449 (6th Cir. 1980), a pilot and his passengers were killed when their small plane struck a guy wire that supported a tall television tower. It was undisputed that the location of the TV tower was not shown accurately on the aeronautical chart that the pilot was using. The widows of the pilots argued that the government should be held liable for the deaths of their husbands because the government was negligent for publishing a chart that showed the TV tower in the wrong location. The government argued that the pilots were contributorily negligent for flying so low and in bad weather. The court recognized that there was evidence from which a finding of contributory negligence might have been made but ultimately found the evidence to the contrary more persuasive. Therefore, it concluded that the failure to show the location of the tower accurately on the chart rendered the United States liable for injury to those who relied upon the chart.

32 For example, in *Brocklesby v. United States*, described *infra* note 30 involving the World Airways crash in Alaska, the airline and widows sued under the theories of strict liability in addition to negligence. Under strict liability, they alleged that the Jeppesen chart was a product in a defective condition unreasonably dangerous to the pilots who relied on it. Jeppesen countered that the instrument approach procedure depicted in the chart was not a "product" and that the errors in the chart were the result of faulty information given to Jeppesen by the government and not the fault of Jeppesen. But the court determined that even though the approach procedure was not a product, the chart on which the procedure was depicted *was* a product and

the fact that the defect in the product was not the fault of Jeppesen was irrelevant. Under strict liability, injured parties need only show that the product was defective, not where fault for the defect lies. The court suggested that if Jeppesen believed the defect was the government's fault, it should seek indemnification from the government but could not avoid paying damages to the airline and the widows.

33 So one could not avoid liability simply by stating that the bad data was received from someone else.

34 *Smith v. Linn,* 48 Pa. D. & C.3d 339, 357 (Pa.Com.pl. 1988).

35 *Capitol Reproduction, Inc., v. Hartford Insurance Company,* 800 F.2d 617 (6th Cir. 1986). [An inaccurate aerial survey resulted in economic damages.]

36 *See Seay Law International, ACRP Legal Research Digest 24: Sovereign Immunity for Public Airport Operations* (2015), for guidance on this analysis.

37 *Op cit*., fn. 7.

38 *See*, e.g., *De Bardeleben Marine Corp. v. United States,* 451 F.2d 140, 149 (5th Cir. 1971) (stating that the government was not liable when it complied with statutes regulating updates to navigational charts).

5 Conclusions and Technology Trends

NextGen began in December 2003 with the Vision 100 Century of Aviation Reauthorization Act. Its goals were to "take advantage of data from emerging ground-based and space-based communications, navigation, and surveillance technologies; [and to] integrate data streams from multiple agencies and sources to enable situational awareness and seamless global operations for all appropriate users of the system." Airports play a critical role in achieving these goals. Along with the accompanying volumes in the ACRP Report 150 (NextGen) series, this guidebook is intended to help airports fulfill this important role and maximize the benefits they receive in return. This volume focuses on one key aspect of airports' role in NextGen: the creation, maintenance, and use of spatial data that is critical to many NextGen programs.

This chapter summarizes key facts relevant to spatial data and NextGen and documents the findings and conclusions of the research conducted in ACRP Project 09-12. Technical trends discovered through the research are also described.

Overview of Airport Spatial Data Relevant to NextGen

Facts

NextGen encompasses a variety of technologies, standards, and processes, which are implemented as a series of programs that, together, improve the entire NAS. Those technologies and programs that improve capacity, efficiency, and safety of aircraft approaching, departing, and operating at airports are directly relevant to airports. Specifically, the NextGen priorities that are most relevant to airport operators in the near future are PBN, MRO, and surface operations.

- The spatial data that is needed to support these programs includes accurate information on runway ends, NAVAIDs, obstacles, and other data critical to the safe operation of aircraft. Accurate maps of airfield movement areas, including runways, taxiways, and aprons, also are needed to support NextGen surface operations capabilities.
- The geographic extent of the data required encompasses airfield movement areas as well as areas under airspace protection surfaces. An example of this extent is shown in Figure 5-1. Most notably, these geographic areas are where airports develop or need spatial data to support their everyday operational requirements. For example, airports are responsible for ensuring that objects affecting navigable airspace are identified, removed, and/or mitigated according to certain standard requirements.

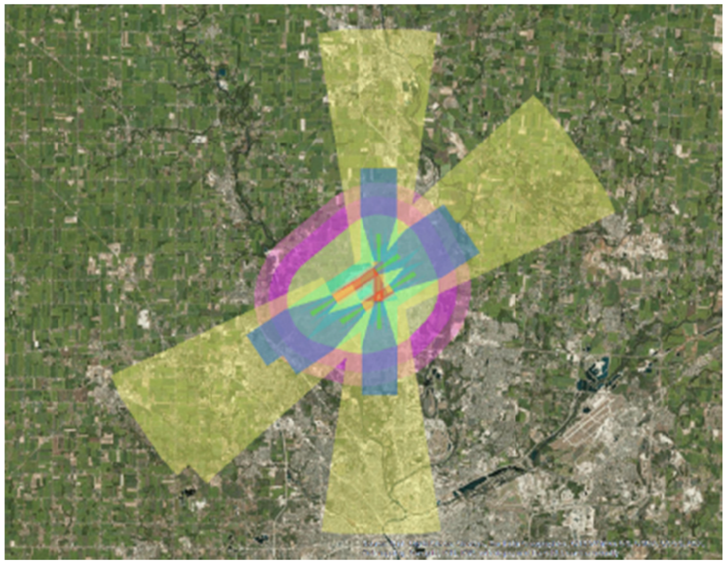


Figure 5-1. *Extent of airport spatial data relevant to NextGen (Woolpert, Inc.).*

Conclusion

- Not all aspects of NextGen programs require or produce spatial data, but those that do often relate to safety-critical operations. The locations of obstacles, runway ends, NAVAIDs, and other safety-critical spatial data are key ingredients of PBN procedure, development, and planning for improved MRO. Up-to-date maps of airfield surface configurations also are critical for surface operations situational awareness displays. These programs could not be implemented without these key spatial data sets.

Spatial Data Requirements

Fact

- The FAA requires airports to collect and submit data that it considers critical to the safe operation (i.e., landing and take-off) of aircraft. This data includes runway ends, NAVAIDs, and potential obstructions to navigable airspace. Additional requirements for submitting spatial data for airfield construction, master planning, NAVAID citing, and other projects are defined in FAA's AC-150-5300-18, Survey and Data Standards for Submission of Aeronautical Data Using AGIS.

Conclusions

- Many airports find it difficult to understand what is required of them to support the implementation of NextGen. This challenge is specifically evident with regard to spatial data, as many airports are not clear what they are to collect, maintain, and submit to the FAA that either supports NextGen programs or will, in turn, provide benefit back to the airport.
- A gap exists between airport spatial data that is developed and submitted to the FAA via AGIS to comply with AC 150/5300-18 and airport spatial data that is developed to comply with RTCA

DO-272 and sold by vendors to aircraft operators and others. Efforts to harmonize AC 150/5300-18 and DO-272 have helped close this gap, but further resolution of data structure and specifications—and of the data development process—may reduce any redundant data development and ultimately make more airport spatial data available to all who need it.

- Data security is an increasingly important requirement as use of the Internet and connected technology continues to proliferate. Although cybersecurity attacks against government agencies and commercial organizations have frequently made headlines, airports have also been directly targeted or indirectly fallen victim to cyber-attack. This is relevant to spatial data in that some spatial data depicts security systems, and operations can be considered sensitive security information (SSI) as defined in 49 CFR Part 1520. Some sensitive data is relevant to airports and to NextGen. Utilities that support critical communications, the location of essential NAVAIDs, GPS signals used for navigation, and maps delivered to cockpits or ground personnel are examples of spatial data that, if compromised, could impact the efficiency and potentially the safety of aircraft and airport operations. Further information on airport cybersecurity concerns and best practices can be found in *ACRP Report 140: Guidebook on Best Practices for Airport Cybersecurity* (Murphy et al. 2015).
- Other users of spatial data are viewers who are not necessarily using the data for analysis, but rather to view a map for information such as present location of an aircraft, locations of other aircraft relative to that airplane, or where the next taxiway is. This kind of spatial data applies to digital flight bag map displays, surface movement mapping applications, and others.

The Importance of a Single Authoritative Source

Fact

- In 2010, NAV Lean was created to improve and streamline processes used for developing and implementing all IFPs, including PBN, and to support EAs and NextGen operational improvements to surface operations and MRO. The FAA's goal for NAV Lean is to create a single authoritative source for each IFP data element in an accessible data repository available to the FAA staff that has need of it.

Conclusions

- A challenge encountered by many users of spatial data has been the many sources of data that are sometimes redundant, not broadly accessible, and of varying degrees of quality. Duplications, redundancies, and inconsistencies may occur across data sets that reside at the FAA and those being developed by airports, other public-sector agencies, and third-party sources.
- One result of having disparate data sources is that an abundance of spatial data that could be utilized in support of NextGen programs that is not being used.
- Under NAV Lean, authoritative sources for airport, NAVAID, and obstacle data are being established to help address the problem of disparate data sources. Significant progress has been made, but the objectives of NavLean have not yet been fully realized due to funding constraints.
- As more airports develop data that complies with FAA requirements, AGIS can eventually fulfill the role of being the single authoritative source for airport spatial data.

AGIS's Important Role in Fulfilling Requirements

Facts

- On March 29, 2006, concurrent with the cancellation of FAA No. 405, the FAA published AC 150/5300-18 and began AGIS. In 2009, AGIS requirements became official with the publication of an updated version of AC 150/5300-18. The current (2015) version of AC 150/5300-18 provides a comprehensive set of standards for collection for all features associated with an airport.
- Published in 2011, AC 150/5300-17 establishes requirements for imagery collection. The collection of airport features utilizing photogrammetry, including obstacles, has greatly enhanced the ability to efficiently and accurately collect aeronautical data. Photogrammetry also materially assists in validating coordinate data. Concurrent with publishing AC 150/5300-18, the FAA canceled Survey Standard 405 (FAA No. 405).
- The FAA's primary objective for AGIS is to collect, collate, validate, store, and disseminate airport aeronautical information to the NAS. This objective includes the collection of survey data and the integration of this data with FAA systems and products, and the management of airport data to ensure that the most up-to-date information is available.

Conclusions

- The AGIS program has long been called an "enabler" of NextGen. Although AGIS has provided high-quality data required for the development of PBN and other flight procedures, many programs within NextGen do not currently utilize AGIS data to the fullest extent possible. Flight procedures and airspace analysis clearly take advantage of AGIS-compliant data where it exists, but many NextGen capabilities rely on spatial data produced by third-party vendors. The main reason for this is the existence of an immediate need for this data as these new map-based technologies are rolled out. Thus far, AGIS has not been able (nor expected to be able) to provide airfield configuration maps for a comprehensive number of airports.
- The AGIS database is not complete for all of the NPIAS airports, or even for all the major airports in the United States. Approximately one-third of the busiest 30 airports currently do not have a full airfield AGIS project in the system. Aside from those airports for which AGIS data has been used in developing flight procedures—and until the AGIS database is complete—other NextGen programs will look elsewhere for their map data.
- Some reasons airports have not developed and submitted data to AGIS include: (1) they do not perceive that the benefits exceed the costs of doing so; (2) the local FAA ADO is not enforcing or strongly encouraging it; and (3) many airports lack the resources needed to maintain this data over time.
- The nexus of AGIS and NextGen can be expected to generate increasing positive gains for the NAS and for airports. It is apparent that both programs have focused attention toward airports and aspects of the NAS that impact the largest percentage of the aviation market. More recently, attention has been given to the larger metroplexes and larger airports. NextGen capabilities that are easier to achieve and have a very positive impact, such as PBN, have been stressed.
- As AGIS continues to expand, the potential exists that the more accurate data developed under AGIS will be incorporated into many of the viewing-based applications, and will be used more and more by airlines, ATC tower staff, and pilots. However, more airports will need to obtain a completed AGIS data set for these program applications to take advantage of this data.

- The utility data definitions available in AC 150/5300-18 do not accommodate all of the details airports typically require, such as material, size, and ownership information. This data could be invaluable to the FAA and specifically to NextGen programs that install NAVAIDs, communications facilities, and other equipment at or near airports. A complete and accurate understanding of an airport's utility infrastructure can help FAA projects avoid costly design changes or utility breaks. FAA employees participate on an ASCE committee that is developing a utility "as-built" standard that includes a model for data exchange.
- Airports will benefit from up-to-date, accurate information to support airfield operations and maintenance activities, which are increasingly reliant on maps integrated with FAR Part 139 reporting, maintenance management, and gate allocation systems. (For a full description of the benefits airport could realize, see Chapter 3).

Benefits and Costs of Spatial Data

Facts

- Submitting up-to-date spatial data defined by the FAA as safety critical for flight operations, along with as-built data reflecting airfield changes, is a condition of AIP grant offers and PFC decision documents.
- To meet the FAA's accuracy requirements, spatial data must be collected using field surveys or photogrammetry, which require local on-the-ground and/or aerial data collection. The data that is collected must be analyzed, attributed, and checked before being submitted to the FAA, and submissions should include a detailed report and extensive supporting documentation. This work must be done using specialized software and experienced analysts. These factors drive the costs of collecting this spatial data, and costs can vary greatly based on the number and type of surfaces to be analyzed, the terrain around the airport, and the relative number of obstacles.

Conclusions

- Some airports have expressed concern that the data they submit to AGIS is not of direct benefit to them.
- Many airports perceive that they bear new costs but do not reap new rewards for the collection of spatial data. Airports are in fact gaining new capacity, reducing minimums, and increasing safety because they have collected this data. These benefits, unfortunately, have been less apparent than the costs, an issue which the FAA, RTCA, the ACRP Project 01-28 research team, and others are trying to address.
- The system-wide benefit-to-cost ratio of spatial data for procedure design is immeasurably high. The challenge is that, from an airport's perspective, the costs are immediate, tangible, and mandatory whereas the benefits are prolonged and indirect.
- Although the FAA's requirements do increase the cost of collecting airfield configuration data, they also hold promise of providing new direct benefits. If airports maintain their non-safety critical data as required by the FAA (DeLeon 2012), they will benefit by having up-to-date, accurate information to support airfield operations and maintenance activities, which are increasingly reliant on maps integrated with FAR Part 139 reporting, maintenance management, and gate allocation systems.
- There are benefits to airports from NextGen initiatives that require spatial data. Not all spatial data is generated by the airport; nevertheless, benefits such as situational awareness technologies using

ASDE-X data and spatial data technologies that share data between the TRACON and the airport tower provide better safety and airfield movement efficiencies. A lot of the spatial data associated with these benefits comes from third-party vendors rather than from the airport; however, the airport is receiving benefit.

- As more NextGen programs, FAA lines of business, and airports use spatial data for more purposes, the ROI will grow, the benefits will become more apparent, and cost-benefit analyses of these activities will no longer be of concern.

Monetization and Liability of Spatial Data

Facts

- Airports develop spatial data that is of interest to third-party groups such as developers, contractors, and airlines.
- If data is provided or sold directly to these third parties without any stipulation or guarantee as to the accuracy of the data—or, conversely, without appropriate disclaimers—airport sponsors are potentially liable.

Conclusions

- GIS data is not a likely candidate for monetization by most airports due to legal constraints stemming from public records laws, nor has it proven economically viable in most cases. Furthermore, airport data that is uploaded to AGIS may subject otherwise-proprietary data to public disclosure. However, GIS data is local by its very nature, and there may be special circumstances under which the data collected by an airport has value to a third party such as an airline.
- Liability may be an issue if the data is provided to a particular, narrow group of users such as pilots (as opposed to the general public) and one of the users is injured as a result. Indeed, liability for damages or injuries suffered through reliance on an inaccurate map or survey is not uncommon.

PBN

Fact

- PBN procedures cannot be designed without spatial data. Like all flight procedures, PBN procedures use coordinates for runway ends, obstacles, and NAVAIDs, as well as elevation data for terrain, existing traffic flow patterns, and airspace restrictions.

Conclusions

- One objective the FAA has for NavLean is to establish a more consistently applied, systematic approach of conveying spatial data to procedure designers. The extent of data required by procedure designers that is currently available is unclear.
- Spatial data showing noise impacts, land use, and demographic information is needed to support the FAA's environmental pre-screening process and EAs for new procedures. Some procedure designers do not use this data because it is not readily available and can slow their process down.

Instead, where required, they rely on environmental specialists to conduct the necessary assessments. Many new procedures are exempt from the NEPA EA process because they are covered by CatExes under which a Finding of No Significant Impact (FONSI) is issued.

- Cases have occurred in which, because of these exclusions, procedures designers did not use spatial data that could have allowed them to evaluate alternative procedures with less noise impact. Together with effective community engagement, the use of spatial data could have prevented or mitigated noise issues in tightly spaced corridors over local neighborhoods, reducing political turmoil for many of the parties involved and avoiding negative press for the airport and the FAA.

Improved Surface Operations

Facts

- Third-party spatial data sets support NextGen programs that support communications with, data exchange between, and the coordination of, aircraft and surface vehicles operating on the airfield. Air traffic controllers, vehicle operators, and airport personnel use this information to improve the safety and efficiency of surface operations such as the taxiing of aircraft and the movement of ground service vehicles.
- These capabilities provide pilots, controllers, dispatchers, and ground personnel with maps that display the locations of aircraft and properly equipped surface vehicles.
- Base maps used in these applications are assembled from third-party sources that rely on data from AMDBs, which adhere to the requirements documented in RTCA DO-272, airport spatial data uploaded to AGIS, traditional ALP drawings, airport diagrams prepared by the FAA, and other sources.

Conclusions

- Airports are more likely to benefit from NextGen surface operations capabilities if they collect and maintain spatial data that accurately depicts the current layouts of their airfields. Some airports have begun to develop and share such data, but significant room for growth remains as NextGen capabilities continue to be rolled out.
- NextGen-related technologies such as ASDE-X produce a rich data set that has the ability to enhance existing spatial data for an airport's noise program or for situational awareness. One of the capabilities of ASDE-X is determining the position of an aircraft on the airfield or on final approach. When added to an airfield base map or overlaid on a map showing noise complaint locations, this data can greatly add to the value of these spatial data sets and provide the airport with greatly enhanced safety and public outreach benefits.

Improved MRO

Fact

- Another portfolio of NextGen capabilities that will continue to benefit airports is improved MRO. Improved MRO have already improved air service at numerous airports and will continue to do so, resulting in higher revenues, reduced operating costs, and higher customer satisfaction.

Conclusions

- Airports that have CSPRs, runways with converging paths, and other multiple runway configurations have begun to benefit from a variety of NextGen capabilities that improve access to air service capacity while preserving high safety standards.
- Spatial data is one of many essential ingredients that help deliver these benefits to aircraft operators and airports.

Relevant Information Technology Trends

The methods of developing, exchanging, and using spatial data will continue to evolve as new technologies become available. If applied prudently, new technologies can offer better spatial data, delivered more quickly and cost-effectively. They will not only support NextGen implementation, but will help the FAA, airports, airlines, and other stakeholders analyze, plan, communicate, implement, operate, and maintain their respective components of the NAS.

- **Cloud-based services** have become a critical component of many data and software solutions. These data storage, software application, and other information technology (IT) services provide robust, scalable, and cost-effective capabilities to organizations without the burden of procuring, operating, and maintaining the infrastructure in-house. The AGIS program, for example, has loaded aerial imagery for numerous airports into cloud-based storage, and will be making that imagery available via a cloud-based imagery server. Airports are increasingly moving some of their IT needs into the cloud as well. As this trend continues, more spatial data and more GIS capabilities will be available to airports and to the FAA to support NextGen and other aeronautical and aviation platforms.
- **Digital sensors,** including cameras that collect imagery and lasers that collect LiDAR, continue to offer increased resolution and accuracy. Aerial sensors can now collect high-resolution data over the typical area of interest around an airport very cost-effectively. Satellite-based sensors also have improved to the point that they can be used to develop spatial data to meet many aviation needs. Several vendors of DO-272-compliant AMDBs use satellite data as their primary data source. Some airports have used airborne or ground-based LiDAR to collect millions of laser beam returns that measure the location of the objects they hit, ultimately providing rich 3-D spatial data. A few airports have used multi-spectral imagery to collect environmental data to assess tree growth rates, wildlife habitats, and carbon emissions. The use of this remotely sensed data will continue to expand as the capabilities of remote sensors continue to improve and the costs of using them go down.
- **Automatic feature extraction** is anticipated to become more widely available via these new digital sensors. The sensors will be able to see a feature, map that feature, and automatically determine what type of feature it is. As this technology continues to mature, it promises to bring down the cost of mapping by a small to medium order of magnitude. This type of capability requires lots of testing, however, and automatic detection and feature identification will need to be proven to work at an accuracy level that does not have an adverse impact on safety.
- **UAS** already offer capabilities that serve a variety of commercial purposes in some jurisdictions, and they may soon be approved for similar uses in the United States. One such use is collecting high-resolution spatial data, such as that required by airports. Regardless of their purpose, however, UAS must be controlled to operate safely within specified areas that do not conflict with other aircraft

operations. Spatial data will also be needed to identify these areas and plan UAS missions. While use of UAS is not directly tied to a NextGen program, these constraints must be planned in a manner that is compatible with the airspace and flight procedures that NextGen enables.

- **The platforms on which digital sensors are mounted** also are rapidly evolving. UAS are bringing aerial sensors closer to the ground, allowing higher resolution and accuracy than aircraft-based or satellite-based sensors can offer. Vehicle-mounted sensors of different types allow different data sets to be merged, creating a more complete picture of the immediate surroundings. Improvements to the sensors used in cellular phones and tablet computers have allowed field personnel and others to collect useful imagery, much of which can be easily geocoded to provide spatial data. These platform improvements will continue to result in spatial data that is closer in position and time to the objects that pilots, airports, and others look to see in maps.

6 Guidance for Airport Sponsors and the Aviation Community

This chapter builds upon the findings and conclusions of the previous chapter to offer guidance that will help airports submit and use spatial data that is required by the FAA specifically for NextGen.

Fundamental Resources

- Airports interested in or impacted by NextGen can become familiar with the FAA's NextGen website (http://www.faa.gov/nextgen). The site offers an abundance of material, ranging from summary documentation to technical descriptions of many of the critical components of NextGen. Given the speed at which NextGen programs evolve and new capabilities are implemented throughout the country, it is advisable to check this important site regularly.
- Airport sponsors, consultants working on AGIS-related programs, and other aviation organizations can become familiar with the FAA's AGIS website (https://airports-gis.faa.gov/public/index.html). This site is where new AGIS projects are set up and authorized users can access data and tools relevant to a specific airport. The site also offers a lot of information that is helpful to those who are new to AGIS.
- FAA ACs 150/5300-16A, 17C, and 18B are the three main required ACs that must be followed when implementing FAA-funded AGIS projects. In 2012, the FAA published an official policy document reinforcing the requirements of AGIS, called the AGIS Transition Policy for Non-Safety-Critical Projects (see https://www.faa.gov/airports/planning_capacity/airports_gis_electronic_alp/media/airportsGISTransitionPolicy.pdf).
- The FAA also offers formal and informal AGIS training online (see http://www.faa.gov/airports/engineering/training/agis/). The Independent Distance Learning Environment (IDLE) resource offers Level 1 for those who wish to become familiar with the requirements of AGIS and Level 3 for those who want to dive deeper into the requirements. Level 2 focuses on the needs of FAA managers.

Spatial Data Considerations

Airports perceive that they are bearing more cost and not receiving an adequate return benefit from the creation of new spatial data mandated by the FAA or in support of NextGen. To help alleviate this perception and realize tangible benefits, airports are encouraged to:

- Clearly define spatial data requirements, data maintenance procedures, and policy requirements. Reference these as binding terms and conditions within consultant contracts. Data that is created through an AGIS project—or any GIS project—but that is not maintained over time is a wasted investment.

- Record and store metadata sufficient to determine the source, quality, and methods used to create spatial data. Users need to understand the source, the currency, and the quality of the data before it is used in any analysis or design, or to support any decision making.
- Although airports are encouraged to maintain their spatial data and its supporting documentation (i.e., metadata) in a manner that is sufficient to meet FAA requirements, using and storing this data in the FAA-required format does not always meet an airport's needs. If an alternative format will be used by the airport, a process for converting it to an FAA-compatible format should be developed.

Spatial Data Related to Airspace

The design of the airspace around an airport is critical to safety, efficient arrival and departure procedures, and airport community/surrounding community impacts. NextGen programs such as PBN and MRO can have a tremendous positive impact on the traffic flow within the airspace. High quality spatial data is one of the requirements for these programs to be successful. To help in providing this data, airports are encouraged to:

- Provide new safety-critical data to the FAA in a timely manner. This data includes changes to surveyed runway ends, runway profiles, thresholds, newly identified obstacles, as well as newly mitigated obstacles that may still be in an FAA database.
- Monitor airport and community projects that could impact obstacles and other safety-critical data. Actively monitoring such projects helps anticipate issues and protect the airport's instrument and visual operations, and ensures timely reporting of new obstacles to the FAA.
- Work with local communities to implement zoning restrictions and permitting requirements for new development around the airport.
- Establish an ongoing program to manage obstacle mitigation activities. Such a program can help satisfy an airport's obligation to develop, submit, and annually update an Obstacle Action Plan (OAP) to the FAA.
- Airports that are interested in the improved capacity offered by NextGen-enabled MRO can coordinate with the FAA Flight Procedures Team in their service area. For more details on this process, see FAA Order 8260.43B, Flight Procedures Management Program, available online at http://www.faa.gov/documentLibrary/media/Order/8260.43B.pdf.

Spatial Data Related to Surface Operations

Whether developed as part of a NextGen initiative or by third-party vendors or consultants, surface operations applications will continue to evolve. These applications include applications for situational awareness; maps in the cockpit that depict airfield locations; moving maps with heads-up displays; applications utilized by TRACON, ATC, and gate agents that indicate the locations of aircraft and other vehicles on an active airfield; digital flight bags; digital NOTAMs with a map interface; and mobile Part 139 inspection applications, among others. All of these applications require airfield base maps with current and accurate spatial data. To better take advantage of these applications, airports, airlines, and third-party vendors will need to:

- Maintain current data as airfield configuration changes are made, as opposed to conducting periodic updates when specific data is needed. Effective maintenance requires an ongoing dialogue between airport project managers, who are responsible for physical changes, and GIS technicians, who are responsible for depicting those changes on a map.

- Avoid redundant and repetitive data collection efforts that do not consider or trust existing data. Airports and airport sponsors can encourage consultants and contractors that are concerned about the liability of using data collected by others to review and attempt to validate existing data to determine if it can meet their needs.

Spatial Data of Benefit to Airports Available from the FAA

Airports also stand to benefit from spatial data that is produced by the FAA. Although the FAA is beginning to take steps to provide the spatial data it collects to airports, it is suggested that airports actively seek data that may be of benefit to them. Airports and airport sponsors can take the following steps:

- Request a direct connection to the FAA's ASDI data or subscribe to the services of commercial vendors who offer such data. Airports can also request a direct connection to the FAA's ASDE-X data where available. For more details, see the FAA memo "Requests for Release of FAA Real-time NAS Data to Airports for Surface Situational Awareness and Noise Monitoring Programs" (available online at https://www.faa.gov/airports/planning_capacity/media/Real-Time-NAS-Data-Release-to-Airports.pdf).
- Obtain current and upcoming instrument flight procedure information via the FAA's IFP Information Gateway (available online at https://www.faa.gov/air_traffic/flight_info/aeronav/procedures/).
- Contact representatives in the ATO Service Center to request and obtain copies of as-built drawings of facilities and utilities installed by the FAA and its contractors. Service center points of contact are available online at https://www.faa.gov/foia/foia_coordinators/ato_service_centers/?section=service_center_contact.
- Incorporate data received from the FAA into the airport's internal geospatial data resources, which are kept current and published to airport staff and consultants who require this information.

Suggested Guidance Related to Monetization and Liability of Data

- Following existing government or professional GIS standards is one way to minimize liability of spatial data provided to a third party.
- Data distributed to other agencies outside the airport or to consultants or contractors should always be provided with a disclaimer as to its reliability, currency, and accuracy. An example of such a disclaimer is:

> All data, information, and maps are provided "as is," without warranty or any representation of accuracy, timeliness, or completeness. The burden for determining accuracy, completeness, timeliness, merchantability, and fitness for or appropriateness for use rests solely on the requester.

Communication and Input Are Essential

Airports constitute a very complex environment that must deal with a multitude of laws, regulations, and protocols in the name of safety and security. These requirements are ever changing and both the FAA and the airport have responsibility to ensure that they are followed and implemented. To ensure that this happens, it is important that all entities at the local, district, regional, and national level stay in constant communication. Such communication can happen through one-on-one meetings, international conferences and workshops, or other mechanisms. Related directly to the spatial data and NextGen requirements, it is important that:

- A continuous flow of information keeps the aviation industry apprised of any significant changes to NextGen programs, AC requirements, standards, new technologies, and so forth. This flow of information happens through many modes, ranging from one-on-one meetings to international conferences and workshops. The FAA is doing its part by educating ADO and FAA regional staff about any new changes that may impact airports.
- Airports and their consultants also provide input to the ongoing evolution of the FAA's programs by participating in public reviews of draft ACs, communicating back up the chain through the ADO and the region.

Volume 2 in the ACRP Report 150 series focuses on engaging airport stakeholders regarding NextGen. This guidebook provides additional information on how to establish and maintain the communication required between airports, the FAA, airlines, community representatives, and others.

Suggestions for Further Study

Spatial data and NextGen will both continue to grow, change, and evolve over time, as will the discovery and documentation on this subject matter. This section summarizes suggestions that the ACRP Project 09-12 research team believes warrant further research, but which fell outside the scope of this project. These suggestions exemplify some, but not all, of the possibilities of NextGen and its growing use of spatial data.

- Integration of UAS into the national airspace is a high priority for the FAA and related agencies. Spatial data and GIS applications supporting planning and flight operations of UAS are only now beginning to be studied. An in-depth study of the spatial data needs for UAS planning and operations, and ways in which GIS can support UAS, is suggested.
- RTCA DO-272 and FAA AC 150/5300-18 are two data standards that cover airport spatial data development. An independent review of these two standards and an assessment of the potential for merging them into one industry standard is suggested.
- A clear need exists to develop methods and content for further educating the aviation community on the benefits and requirements of NextGen and AGIS. A suggested abstract and presentation file are available for download from the webpage for this guidebook. These documents, which have been provided as examples of content to be presented on this subject matter, can be used to help meet this need.

References and Bibliography

The reports, webpages, and data sources listed were used as background materials for this guidebook and include but are not limited to sources cited in Chapters 1–3, 5, and 6. For readers' convenience, given the nature of the content in Chapter 4, references for that chapter appear as endnotes to the chapter. A separate list of referenced advisory documents, orders, and standards also is included.

AASHTO. "Enterprise GIS and ROI: About Quantifying those Benefits." Presented at GIS-T (May 7, 2013). American Association of State Highway and Transportation Officials. Available at: http://www.gis-t.org/files/dB650.pdf (accessed December 3, 2014).

Abraham, B., 2014. "Aircraft Access to SWIM (AAtS) Working Group Meeting." U.S. Department of Transportation, Federal Aviation Administration. NextGen Technology and Prototyping Development. *SWIM Connect* 2014.

ACI-NA. 2014. *NextGen Working Group.* Available at: http://www.aci-na.org/opstechnextgen (accessed November 21, 2014).

Administration, William J. Hughes Technical Center. 2012. *Airport Technology Research Plan … for the NextGen Decade.* Available at: http://www.airporttech.tc.faa.gov/Portals/0/Documents/airport_rd/Airport%20Technology%20Research%20Plan.pdf.

Airport Technology.com. 2006. "On the Ground or in the Air: GIS for Aviation—ESRI." On "Features" page, *Airport Technology.com* (September 1, 2006). Available at: http://www.airport-technology.com/features/feature760/ (accessed December 3, 2014).

Anspach, J. H. and R. J. Murphy. 2012. *ACRP Synthesis of Airport Practice 34: Subsurface Utility Engineering Information Management for Airports.* Transportation Research Board of the National Academies, Washington, D.C., 2012. Available at: http://www.trb.org/Publications/Blurbs/167502.aspx.

Bakowski, D. L., B. L. Hooey, D. C. Foyle, C. A. Wolter, and L. W. S. Cheng. 2014. NextGen Surface Trajectory-Based Operations: Contingency-Hold Clearances. Paper presented at 32nd Digital Avionics Systems Conference, San Jose State University at NASA, Ames Research Center (October 5–10, 2003). Available at: http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6712512&url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D6712512 (accessed December 4, 2015).

Barich, F., J. Phy, D. Jividen, M. Gartenfeld, R. Agnew, R. Meyers, and C. Cofer. *ACRP Report 88: Guidebook on Integrating GIS in Emergency Management at Airports.* Transportation Research Board of the National Academies, Washington, D.C., 2013. Available at: http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_088.pdf.

Black, E. 2015. Requests for Release of FAA Real-time NAS Data to Airports for Surface Situational Awareness and Noise Monitoring Programs. January 16, 2015. Available at: https://www.faa.gov/airports/planning_capacity/media/Real-Time-NAS-Data-Release-to-Airports.pdf.

Bonanni, R. 2011. Airport GIS Update. Presented at Nebraska Aviation Symposium (January 26, 2011). U.S. Department of Transportation, Federal Aviation Administration National Resource Office. Available at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=3&ved=0CCkQFjAC&url=http%3A%2F%2Fwww.aero.nebraska.gov%2F2.ppt&ei=hbGqVOLoDciHyASG94CYAw&usg=AFQjCNGnp7LcZG3kIsP8HHtkLkEKEjzuzw (accessed December 4, 2014).

Brunk, B. 2009. Airport GIS and Special Activity Airspace (Military). Presentation to U.S. Department of Transportation, Federal Aviation Administration. May 2009. Available at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0CDkQFjAD&url=http%3A%2F%2Fwww.aixm.aero%2Fgallery%2Fcontent%2Fpublic%2F2009_AIXM_Honduras%2FDay%25202%2520PM%2FDay%25202%2520PM%252001%2520Airport%2520GIS%2520and%2520and%2520SUA%2520(EN).ppt&ei=BESOU8KBC5HgsASP_4HADQ&usg=AFQjCNFDyHCggKLoaARXu8W0lDu18zrpvQ&sig2=EuCHDBKYspnB51SICgACmQ.

DeCleene, B., and M. J. O'Donnell, Interim Policy Guidance for Mitigation of Penetrations to the 20:1 Visual Area Surface. Memorandum (Nov. 15, 2013). Federal Aviation Administration. Available at: https://www.michigan.gov/documents/aero/20_1_memo_signed_November_15_2013_442269_7.pdf.

DeLeon, B. 2012. Airports Geographic Information System (AGIS) Transition Policy for Non-Safety Critical Projects. Memorandum to Regional Airports Division Managers, August 23, 2012.

DeMerrit, M. "Turning a Requirement into a Benefit. Enterprise GIS helps airport use the data it collects." *ArcUSER.* Winter 2014 (December 3, 2014). ESRI. Available at: http://www.esri.com/esri-news/arcuser/winter-2014/turning-a-requirement-into-a-benefit.

Dillingham, G. L. 2008. GAO: Aviation and the Environment—NextGen and Research and Development Are Keys to Reducing Emissions and Their Impact on Health and Climate. DIANE Publishing. Available as ebook or in print from http://books.google.com/books?id=-tr-xjPfDMAC&pg=PA19&lpg=PA19&dq=NextGen+stakeholders&source=bl&ots=HAMNpKQXch&sig=zh8hLZO1J7xUctByOaS8oW_L_ec&hl=en&sa=X&ei=sdV8U_vOFYfmsATIzYKAAg&ved=0CFoQ6AEwBTgK#v=onepage&q=NextGen%20stakeholders&f=false.

Duncan Aviation. 2014. "Straight Talk About NextGen." Available at: http://adsbforgeneralaviation.com/wp-content/uploads/2011/12/Duncan_NextGen.pdf (accessed December 4, 2014).

FAA. n.d.a. "Aviation Environmental Design Tool (AEDT) Version 2b." *Aviation Environmental Design Tool.* U.S. Department of Transportation, Federal Aviation Administration. Available at: https://aedt.faa.gov/2b_information.aspx.

FAA. n.d.b. Collaborative Air Traffic Management Technologies (CATM-T). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/portfolio/trans_programs/catm-t/ (accessed December 3, 2014).

FAA. n.d.c. Data Communications (DataComm). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/atc_comms_services/datacomm/ (accessed November 21, 2014).

FAA. n.d.d. "FAA NAS Architecture (NASEA) Portal." *NAS Systems Engineering Portal (SEP).* U.S. Department of Transportation, Federal Aviation Administration. Available at: https://nasea.faa.gov/ (accessed December 5, 2014).

FAA. n.d.e. "*NAS Enterprise Architecture (EA) Model." NAS Systems Engineering Portal (SEP).* U.S. Department of Transportation, Federal Aviation Association. Available at: https://nasea.faa.gov/products/main# (accessed November 21, 2014).

FAA. n.d.f. *NextGen Portfolio - Improved Surface Operations.* Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/snapshots/portfolios/?portfolioID=7 (accessed January 27, 2016).

FAA. n.d.g. NextGen Portfolio – Improved Multiple Runway Operations. U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/snapshots/portfolios/?portfolioId=9 (accessed 2016).

FAA. n.d.h. SATnav News FAA Publication. U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/ (accessed December 12, 2014).

FAA. n.d.i. *System Wide Information Management (SWIM).* U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/programs/swim/.

FAA. 1998. FAA No. 405, Standards for Aeronautical Surveys and Related Products, 4th ed. (September 1996 - Including Change 1 to FAA No. 405 effective April 15, 1998). U.S. Department of Transportation, Federal Aviation Administration, Document Available at: http://www.ngs.noaa.gov/AERO/aerospecs.htm#FAA405.

FAA. 2007. General Guidance and Specifications for Aeronautical Surveys: Establishment of Geodetic Control and Submission to the National Geodetic Survey. FAA AC 150/5300-16A (September 15, 2007). U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.faa.gov/documentLibrary/media/advisory_circular/150-5300-16A/150_5300_16a.pdf.

FAA. 2011. Standards for Using Remote Sensing Technologies in Airport Surveys. U.S. Department of Transportation, Federal Aviation Administration. FAA AC 150/5300-17C (September 30, 2011). Available at: http://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5300_17c.pdf.

FAA. 2012a. Airport Geographic Information System Transition Policy for Non-Critical Safety Critical Projects. U.S. Department of Transportation, Federal Aviation Administration, Memorandum (August 23, 2012). Available at: https://www.faa.gov/airports/planning_capacity/airports_gis_electronic_alp/media/airportsGISTransitionPolicy.pdf.

FAA. 2012b. Challenges with Implementing Near-Term NextGen Capabilities at Congested Airports Could Delay Benefits. U.S. Department of Transportation, Federal Aviation Administration, Office of the Inspector General, *Audit Report* (August 02, 2012). Available at: https://www.oig.dot.gov/sites/default/files/FAA%20NextGen%20Near-Term%20Capabilites%20(RTCA%20Task%20Force%20Recommendations)%5E8-1-12.pdf.

FAA. 2012c. New WAAS Coverage Clears the Way for New Access to Airports. Presentation (March 2012). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/snapshots/stories/?slide=5.

FAA. 2013a. AVS Work Plan for NextGen 2013. Federal Aviation Administration. *NextGen.* 2013. Accessed December 03, 2014. http://www.faa.gov/nextgen/media/AVS-Work-Plan-for-NextGen-2013.pdf.

FAA. 2013b. FAA Wakes Up Separation Standards. Presentation (April 2013). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/snapshots/stories/?slide=18.

FAA. 2013c. *Why NextGen Matters.* U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.faa.gov/nextgen/library/media/WhyNGMatters_2013.pdf.

FAA. 2014a. Airports GIS Strategic Plan. August 23, 2012. U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.faa.gov/airports/planning_capacity/airports_gis_electronic_alp/media/airportsGISTransitionPolicy.pdf (accessed December 3, 2014).

FAA. 2014b. Airport Sponsor Assurances 3/2014. U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/airports/aip/grant_assurances/media/airport-sponsor-assurances-aip.pdf.

FAA. 2014c. An Airport Technology Research Plan...for the NextGen Decade: 2012–2021. January 16, 2014. U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.airporttech.tc.faa.gov/10YearPlan/Airport%20Technology%20Research%20Plan.pdf.

FAA. 2014d. General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards. FAA AC 150/5300-18B-Change 1 (February 24, 2014). U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5300-18B-chg1-consolidated.pdf.

FAA. 2014e. "NextGen Network Enabled Weather (NNEW)." Presentation (November 21, 2014). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/search/?omni=MainSearch&q=nextgen+enabled+weather.

FAA. 2014f. NextGen Priorities: Joint Implementation Plan. Executive Report to Congress (October 2014). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/media/ng_priorities.pdf.

FAA. 2014g. "NextGen Works for Airports." Brochure (June 2014). U.S. Department of Transportation, Federal Aviation Administration. Available at: http://www.faa.gov/nextgen/media/nextgenForAirports.pdf.

FAA. 2014h. "Off the Ground and into the Air Faster with NextGen at DFW." Presentation. U.S. Department of Transportation, Federal Aviation Administration (January 2014). Available at: https://www.faa.gov/nextgen/snapshots/stories/?slide=28.

FAA. 2014i. Performance Based Navigation Implementation Process. FAA Order 7100.41 (April 03, 2014). Available at: http://www.faa.gov/documentLibrary/media/Order/FAA_JO_7100.41_Performance_Based_Navigation_Implementation_Process.pdf.

FAA. 2014j. The Business Case for the Next Generation Air Transportation System. U.S. Department of Transportation, Federal Aviation Administration (December 2014). Available at: https://www.faa.gov/nextgen/media/BusinessCaseForNextGen-2014.pdf.

FAA. 2015a. Instrument Flight Procedures Inventory Summary. U.S. Department of Transportation, Federal Aviation Administration (October 15, 2015). Available at: https://www.faa.gov/air_traffic/flight_info/aeronav/procedures/ifp_inventory_summary/.

FAA. 2015b. Instrument Flight Procedures Production Plan. U.S. Department of Transportation, Federal Aviation Administration (October 23, 2015). Available at: http://avnweb.jccbi.gov/schedule/production/.

FAA. 2015c. "NextGen From Where We've Come." *NextGen Program Update: 2015*. U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/update/from_where_weve_come/ (accessed October 23, 2015).

FAA. 2015d. Reminder of Responsibilities for FAA Personnel and Airport Sponsors for Protecting Approach and Departure Surfaces. U.S. Department of Transportation, Federal Aviation Administration (August 18, 2015). Available at: https://www.faa.gov/airports/engineering/media/Policy-Reminder-Protecting-Approach-and-Departure-Surfaces.pdf.

FAA. 2015e. Requests for Release of FAA Real-time NAS Data to Airports for Surface Situational Awareness and Noise Monitoring Programs. U.S. Department of Transportation, Federal Aviation Administration, Memorandum (January 16, 2015). Available at: https://www.faa.gov/airports/planning_capacity/media/Real-Time-NAS-Data-Release-to-Airports.pdf.

Fiorino, F. 2014. "ADS-B Ins and Outs." *FAA Safety Briefing* (July/August 2014). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/nextgen/ga/media/Safety-Briefing-ADS-B.pdf.

Ghee, R. "How new technology is influencing the design of the future airport." Terminal Design (October 13, 2013) page on *Future Travel Experience.* Available at: http://www.futuretravelexperience.com/2013/10/new-technology-influencing-design-future-airport/ (accessed November 21, 2014).

Gillespie, S. R. 2000. An Empirical Approach to Estimating GIS Benefits. *URISA Journal, Vol. 12* (No. 1), Winter 2000. Available at: http://downloads2.esri.com/campus/uploads/library/pdfs/7706.pdf.

GTAA. 2008. Greater Toronto Airports Authority *CSR Report 2008.* Available at: http://www.torontopearson.com/uploadedFiles/GTAA/Content/Publications/Other_Corporate_Documents/GTAA_CorporateReport_2008.pdf (accessed December 3, 2014).

Guven, U (supervisor). 2010. *GIS and Software Application in Aviation and Airport Industry.* Student bachelor's degree project (completed May 1, 2010), University of Petroleum & Energy Studies, Dehradun, India. Available at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.drguven.info%2Fprojects%2FGIS%2520aviation.pdf&ei=0pOyVITYF4q9yQTs04GgBw&usg=AFQjCNHF4NbWZ10wlPtFvImEhNAo86uhmQ&sig2=etbwNM9rF9loiJQX-2F_dg&bvm=bv.83339334,d.aWw.

Huerta, M. P. 2014. NextGen Implementation Plan, 2014. U.S. Department of Transportation, Federal Aviation Administration, NextGen Office, released August 2014. Available at: http://www.faa.gov/nextgen/library/media/NextGen_Implementation_Plan_2014.pdf.

Huerta, M. P. 2015. NextGen Implementation Plan, 2015. U.S. Department of Transportation, Federal Aviation Administration, NextGen Office, released May 2015.

Huerta, M. P. 2016. NextGen Implementation Plan, 2016. U.S. Department of Transportation, Federal Aviation Administration, NextGen Office, released June 2016. Available at: https://www.faa.gov/nextgen/media/NextGen_Implementation_Plan-2016.pdf.

ICAO. 2009. Annex 15: Aeronautical Information Services (AIS). International Civil Aviation Organization, Montreal, Canada, 2009.

Jeppesen. 2013. "The Need for eTOD Information from an Industry Perspective." Presented at11th Workshop/Meeting of the SAM Implementation Group, Lima, Peru (June 5, 2013). International Civil Aviation Organization, South American Regional Office. Available at: http://gis.icao.int/icaoetod/SAMIG11Jeppesen.pdf (accessed December 4, 2014).

Joffe, B. 2015. A Personal Account of Guidelines for Estimating GIS Return on Investment. *Journal of the Urban and Regional Information Systems Association, Vol. 27,* No. 1. URISA. Available at: http://www.urisa.org/clientuploads/directory/Documents/Journal/Vol27No1.pdf.

Kunkle, C. "Eye-Tracking Analysis of Next Generation Air Transportation (NextGen) Taxiing and Departure Concepts" Master's thesis, San Jose State University (February 19, 2014). Available at: http://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=7785&context=etd_theses.

Laing, K. 2014a. "FAA Touts DC NextGen Implementation." *The Hill* online. Available at: http://thehill.com/policy/transportation/225288-faa-touts-dc-nextgen-implementation (accessed November 25, 2014).

Laing, K. 2014b. "FAA Touts NextGen Implementation in Texas." *The Hill* online. Available at: http://thehill.com/policy/transportation/224752-faa-touts-texas-nextgen-equipment (accessed November 19, 2014).

Leigh Fisher. *ACRP Report 38: Understanding Airspace, Objects, and Their Effects on Airports.* Transportation Research Board of the National Academies, Washington, D.C., 2010. Available at: http://www.trb.org/Publications/Blurbs/164477.aspx.

Levin, A., and M. Schiangenstein. 2014. "Weather sensors help improve aircraft safety." *Bloomberg News.* June 23, 2014. Print.

McNerney, M. T. "Airport GIS Program Update." Presentation to FAA Northwest Mountain Regional Conference (April 18, 2012). U.S. Department of Transportation, Federal Aviation Administration. Available at: https://www.faa.gov/airports/northwest_mountain/airports_news_events/annual_conference/2012/media/airports-gis-update.pdf.

Mitre Corporation. 2015. Concept of Operations for Aircraft Access to System Wide Information Management (AAtS). Presented at U.S. Department of Transportation, Federal Aviation Administration, Public Forum (June 2015).

Murphy, R. J. and R. K. Bannura. 2014. *ACRP Synthesis of Airport Practice 59: Integrating Airport Geographic Information System (GIS) Data with Public Agency GIS.* Transportation Research Board of the National Academies, Washington, D.C. Available at: http://www.trb.org/Publications/Blurbs/171387.aspx.

Murphy, R. J., M. Sukkarieh, J. Haass, and P. Hriljac. 2015. *ACRP Report 140: Guidebook on Best Practices for Airport Cybersecurity.* Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine, Washington, D.C. Available at: http://www.trb.org/Publications/Blurbs/172854.aspx.

Neumann, G. n.d. "Airports GIS Update and Transition Policy" Presentation to 34th Annual Airports Conference, Hershey, PA (March 2011). Available at: http://www.faa.gov/airports/eastern/airports_news_events/hershey/media_11/session_e/Airports%20GIS%20Update.ppt (accessed December 4, 2014).

Norton, J. 2010. "AIXM Operational Perspectives." Presentation to 2010 AIXM/WXXM Conference (May 26, 2010). Available at: http://www.aixm.aero/gallery/content/public/2010_05_Conference/Day%202%20-%20AIM%20-%2001%20-%20Airports%20GIS.pdf (accessed December 4, 2014).

Panayotov, A. 2009. *High Resolution Airport Airspace Model Using Geographic Information System.* Masters thesis. University of Colorado (June 3, 2009). Available for a fee at: http://search.proquest.com/docview/305103473.

PSRC. 2013. "Preparing Busy General Aviation Airports for Next Generation Technologies." Puget Sound Regional Council (May 2013). Available at: http://www.psrc.org/assets/7340/NextGen.pdf.

Rehm, Z. 2013. "Houston Airport System – Airspace Map. Advanced GIS." April 7, 2013. Information on the Houston Airport System Airspace Map is Available at: http://www.houstontx.gov/planning/GIS/GIS.html.

RTCA. 1998. DO-200A: Standards for Processing Aeronautical Data (September 1998). Available at: http://www.rtca.org/store_product.asp?prodid=889 (accessed December 3, 2014).

RTCA. 2011. DO-272C: User Requirements for Aerodrome Mapping Information. Radio Technical Commission for Aeronautics (September 2011). Available at: http://www.rtca.org/store_product.asp?prodid=695 (accessed December 3, 2014).

RTCA. 2013a. DO-342: Guidelines for Verification and Validation of Aerodrome Mapping Databases (AMDB) Aerodrome Surface Routing Networks (ASRN) for Routing Applications. RTCA SC-217 Aeronautical Databases Committee, 2013. Available at: http://www.rtca.org/content.asp?pl=108&sl=33&contentid=81.

RTCA. 2013b. NextGen Prioritization: A Report of the NextGen Advisory Committee in Response to Tasking from the Federal Aviation Administration. RTCA (September 2013). Available at: http://www.rtca.org/Files/Miscellaneous%20Files/NextGen%20Prioritization%20NAC%20Sept%202013%20final.pdf.

Runnels, M. "ASDE-X and NextGen Total Airport Management." *The Hill* online (March 12, 2009). Available at: http://thehill.com/sites/default/files/Sensis_ATCA_08_Runnels_Total_0.pdf (accessed November 21, 2014).

SAAB. 2014. "World's Busiest Airport Upgrades to Saab's Latest Collaborative Decision Making & Efficiency Tool Suite." *Saab Sensis News* (September 8, 2014). Available at: http://www.saabsensis.com/worlds-busiest-airport-upgrades-to-saabs-latest-collaborative-decision-making-efficiency-tool-suite/ (accessed December 3, 2014).

Seay Law International. 2015. *ACRP Legal Research Digest 24: Sovereign Immunity for Public Airport Operations.* Transportation Research Board of the National Academies, Washington, D.C. Available at: http://www.trb.org/Publications/Blurbs/172457.aspx.

U.S. GAO. 2010. "Next Generation Air Transportation System: Challenges with Partner Agency and FAA Coordination Continue, and Efforts to Integrate Near-, Mid-, and Long-term Activities Are Ongoing." U.S. Government Accountability Office Testimony Before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives. GAO-10-649T (Released April 21, 2010). Available at: http://www.gao.gov/new.items/d10649t.pdf.

U.S. GAO. 2015. *Next Generation Air Transportation System: Improved Risk Analysis Could Strengthen FAA's Global Interoperability Efforts.* U.S. Government Accountability Office Report to Congressional Requesters. GAO-15-608. Published July 29, 2015, publicly released August 28, 2015. Available at: http://www.gao.gov/products/GAO-15-608.

Usmani, A. 2012. Global Harmonization Through Collaboration. U.S. Department of Transportation, Federal Aviation Administration. (August 30, 2012).

White House. 2013. "Open Data Policy-Managing Information as an Asset." White House Office of Management and Budget. OMB M13-13 (May 09, 2013). Available at: http://www.whitehouse.gov/sites/default/files/omb/memoranda/2013/m-13-13.pdf (accessed December 14, 2014).

White House. 2014. Open Data Policy: Managing Information as an Asset. Memorandum OMB M13-13 (May 9, 2013). Available at: http://www.whitehouse.gov/sites/default/files/omb/memoranda/2013/m-13-13.pdf. Accessed December 14, 2014.

Woolpert, Inc. 2015. *Existing WAAS Imagery for Use at AGIS.* Final Summary Report of Technical Support Services Contract Task 587, June 2, 2015.

FAA Advisory Circulars, Standards, Orders, and Regulations

FAA AC 150/5300-16, General Guidance and Specifications for Aeronautical Surveys: Establishment of Geodetic Control and Submission to the National Geodetic Survey
At publication the current AC is FAA AC 1500/5300-16A, issued September 15, 2007.

FAA AC 150/5300-17, Standards for Using Remote Sensing Technologies in Airport Surveys
At publication the current AC is FAA CA 150/5300-17C, issued September 30, 2011.

FAA AC 150/5300-18, General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards
At publication the current AC is FAA CA 150/5300-18B, issued May 21, 2009.

Up-to-date information about FAA ACs can be found at: https://www.faa.gov/regulations_policies/advisory_circulars/.

FAA No. 405, Standards for Aeronautical Surveys and Related Products.
At publication FAA No. 405 had been superseded by the current version of FAA AC 150/5300-18.

FAA Order JO 7110.65, Air Traffic Control
At publication the current order is FAA Order JO 7110.65W, Air Traffic Control, issued November 10, 2015.

FAA Order JO 7110.308, 1.5-Nautical Mile Dependent Approaches to Parallel Runways Spaced Less Than 2,500 Feet Apart
At publication the current order is FAA Order JO 7110.308A, Simultaneous Dependent Approaches to Closely Spaced Parallel Runways, issued May 1, 2015.

FAA Order 8260.3B. United States Standard for Terminal Instrument Procedures (TERPS) with Changes 1–26.
At publication the current order is FAA Order 8260.3C, United States Standard for Terminal Instrument Procedures (TERPS), issued March 14, 2016.

FAA Order 8260.43B. Flight Procedures Management Program
At publication the current order is FAA Order 8260.43B, issued April 22, 2013.

FAR Part 77.9, Construction or Alteration Requiring Notice (14 CFR Part 77.9)

FAR Part 139, Airport Certification (14 CFR Part 139)

FAR Part 150, Airport Noise Compatibility Planning (14 CFR Part 150)

RTCA Documents

RTCA DO-272. User Requirements for Aerodrome Mapping Information
At publication the current standard is RTCA DO-272C, issued September 28, 2011. RTCA DO-272 is equivalent to EUROCAE ED-99.

RTCA DO-276. User Requirements for Terrain and Obstacle Data (eTOD)
At publication the current standard is RTCA DO-276C, issued September 22, 2015. RTCA DO-276 is equivalent to EUROCAE ED-98.

RTCA DO-291. Minimum Interchange Standards for Terrain, Obstacle, and Aerodrome Mapping Data
At publication the current standard is RTCA DO-291C, issued September 22, 2015. RTCA DO-291 is equivalent to EUROCAE ED-119.

RTCA DO-342, Guidelines for Verification and Validation of Aerodrome Mapping Databases (AMDB) Aerodrome Surface Routing Networks (ASRN) for Routing Applications
At publication the current standard is RTCA DO-342, issued March 20, 2013.

Other References

2015 South Carolina Code of Laws, Title 55: Aeronautics, Chapter 13, Protection of airports and Airport Property, Section 55-13-5, Public Use Airport Maps; Review of Plans for Development (SC Code § 55-13-5 [2015]).

A Acronyms & Initialisms

ACRONYM	DEFINITION
AC	Advisory Circular
ACARS	Aircraft Communication Addressing and Reporting System
ACRP	Airport Cooperative Research Program
ADF	Automatic Direction Finder
ADO	Airports District Office (FAA)
ADS-B	Automatic Dependent Surveillance-Broadcast
AEDT	Aviation Environmental Design Tool
AEFS	Advanced Electronic Flight Strips
AFSS	Automated Flight Service Stations
AGIS	Airports Geographic Information Systems
AIP	Airport Improvement Program
AIRAC	Aeronautical Information Regulation and Control
AIRNAV	Airport Navigation Aid Database Application
AIXM	Aeronautical Information Exchange Model
ALP	Airport Layout Plan
AMDB	Airport Mapping Database
API	Application Programming Interface
AR	Authorization Required
ARINC	Aeronautical Radio
ARTCC	Air Route Traffic Control Center
ASD	Aircraft Situational Display
ASDE-X	Airport Surface Detection Equipment, Model X
ASDI	Aircraft Situation Display to Industry
ASIAS	Aviation Safety Information and Analysis System
ASSC	Airport Surface Surveillance Capability
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Transportation System
CAD	Computer-Aided Design
CAEG	Computer-Aided Engineering Graphics
CAP	Civil Air Patrol
CatEx	Categorical Exclusion
CDTI	Cockpit Display of Traffic Information
COA	Certificate of Waiver or Authorization
CONOPS	Concept of Operations

ACRONYM	DEFINITION
COO	Chief Operating Officer
CPDLC	Controller-Pilot Data Link Communications
CRDA	Converging Runway Display Aid
CSPRO	Closely Spaced Parallel Runway Operations
DCL	Departure Clearance
DNL	Day-Night Average Sound Level
DOF	Digital Obstacle File
DOT	Department of Transportation
DSR	Display System Replacement
EA	Environmental Assessment
eALP	Electronic Airport Layout Plan
EFVS	Enhanced Flight Vision Systems
EoR	Established on RNP
ERAM	En Route Automation Modernization
ESRI	Environmental Systems Research Institute
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FANS	Future Air Navigation Systems
FAR	Federal Aviation Regulation
FBO	Fixed-Base Operator
FIDS	Flight Information Display System
FIS-B	Flight Information Services-Broadcast
FIXM	Flight Information Exchange Model
FOIA	Freedom of Information Act
FTI	Flight Telecommunications Infrastructure
GA	General Aviation
GBAS	Ground-Based Augmentation System
GIS	Geographic Information System
GPS	Global Positioning System
HCS	Host Computer System
IAF	Initial Approach Fix
IAPA	Instrument Approach Procedures Automation
ICAO	International Civil Aviation Organization
IF	Intermediate Fix
IFP	Instrument Flight Procedures
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IPDS	Instrument Procedure Development System
JAIS	Aeronautical Information Services
LiDAR	Light Detection and Ranging

ACRONYM	DEFINITION
MHz	Megahertz
MLAT	Multi-Lateration
MRO	Multiple Runway Operations
MSL	Mean Sea Level
NAS	National Airspace System
NASR	National Airspace System Resources
NAV Lean	Navigation Procedures Implementation Plan
NAVAID	Navigational Aid
NDB	Non-Directional Radio Homing Beacon
NEPA	National Environmental Policy Act of 1969
NextGen	Next Generation Air Transportation System
NFDC	National Flight Data Center
NGS	National Geodetic Survey
NIWG	NextGen Implementation Working Groups
NMI	Nautical Mile
NOTAM	Notice to Airmen
NPIAS	National Plan of Integrated Airport Systems
OAPM	Optimization of Airspace and Procedures in the Metroplex
OARS	Operational Analysis and Reporting System
ODC	Open Data Consortium
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
OPD	Optimized Profile Descent
PBN	Performance-Based Navigation
PFC	Passenger Facility Charge
RECAT	Recategorization of Separation Standards
RF	Radio Frequency
RNAV	Area Navigation
RNP	Required Navigation Performance
ROI	Return on Investment
RPZ	Runway Protection Zone
RSA	Runway Safety Area
RTCA	RTCA (see Glossary)
SATNAV	Satellite Navigation
SME	Subject Matter Expert
SMS	Safety Management System
SOW	Statement of Work
SRTM	Shuttle Radar Topography Mission
STAR	Standard Terminal Arrival Route
STDSS	SWIM Terminal Data Distribution System
SUE	Subsurface Utility Engineering
SWIM	System Wide Information Management
TAMR	Terminal Automation Modernization and Replacement
TARGETS	Terminal Area Route Generation and Traffic Simulation

ACRONYM	DEFINITION
TBFM	Time-Based Flow Management
TBM	Time-Based Metering
TERPS	Terminal Instrument Procedures
TFMS	Traffic Flow Management System
TIS-B	Traffic Information Services-Broadcast
TMA	Traffic Management Advisor
TMI	Traffic Management Initiative
TPSS	Third-Party Surveying System
TRACON	Terminal Radar Approach Control
UAS	Unmanned Aerial Systems
UAT	Universal Access Transceiver
UDDF	Universal Data Delivery Format
URL	Uniform Resource Locator
USGS	United States Geological Survey
VDL	VHF Data Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio Range
WAAS	Wide Area Augmentation System
WTMD	Wake Turbulence Mitigation for Departures
WXXM	Weather Information Exchange Model

B Glossary of Terms

TERM	DEFINITION
Above Ground Level (AGL)	The altitude expressed in the actual number of feet measured with respect to the underlying ground surface. The distance of the aircraft above the ground.
Accuracy	The degree to which information on a map or in a digital database matches true or accepted values. Accuracy is an issue pertaining to the quality of data and the number of errors contained in a data set or map. In discussing a GIS database, it is possible to consider horizontal and vertical accuracy with respect to geographic position, as well as attribute, conceptual, and logical accuracy.
Administrator for Airports	The Federal Aviation Administration's office responsible for reviewing and deciding on projects involving airports, overseeing their construction and operations, and ensuring compliance with federal regulations.
Airports Geographic Information System (AGIS)	AGIS helps the FAA collect airport and aeronautical data to meet the demands of the Next Generation National Airspace System.
Air Traffic Control (ATC)	A service provided by ground-based controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC is to promote the safe, orderly, and expeditious flow of air traffic.
Airport Cooperative Research Program (ACRP)	An applied research program that develops practical solutions to problems faced by airport operators. ACRP is managed by the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine and sponsored by the FAA.
Airport Surface Detection Equipment, Model X (ASDE-X)	A surveillance system using radar, multi-lateration, and satellite technology that allows air traffic controllers to track surface movement of aircraft and vehicles. ASDE-X feeds are also capable of being used to track aircraft on final approach, map flight tracks, with the data integrated into enhanced situational awareness and noise monitoring systems.
Area Navigation (RNAV)	A method of navigation that allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons. This can conserve flight distance, reduce congestion, and allow flights into airports without beacons.
Attribute	A characteristic of a geographic feature, typically stored in tabular format and linked to the feature in a relational database. The attributes of a well-represented point might include an identification number, address, and type.
Authorization Required (AR)	Refers to Required Navigation Performance (RNP) instrument approach procedures (IAP) with authorization required (AR). Authorization is typically associated with aircraft avionics equipment, operator requirements, and pilot training. These were previously known as RNP Special Aircraft and Aircrew Authorization Required (SAAAR) operations.

TERM	DEFINITION
Automatic Dependent Surveillance-Broadcast (ADS-B)	An element of the U.S. Next Generation Air Transportation System (NextGen), ADS-B is an air traffic surveillance technology that enables aircraft to be accurately tracked by air traffic controllers and other pilots without the need for conventional radar.
Aviation Environmental Design Tool (AEDT)	A comprehensive software system that dynamically models aircraft performance in space and time to produce estimates of noise, fuel burn, and emissions at global, regional, and local levels. AEDT is currently used by the U.S. government to consider the interdependencies between aviation-related noise, hazardous air pollutants (HAPs), and greenhouse gas (GHG) emissions, and fuel consumption.
Clean Air Act (CAA)	A United States federal law, first enacted in 1955, with major revisions in 1970 and 1977, designed to protect human health and the environment from the effects of air pollution. Under the CAA, the Environmental Protection Agency (EPA) is required to establish national ambient air quality standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants (HAPs). State and local governments monitor and enforce CAA regulations, with oversight by the EPA.
Closely Spaced Parallel Runway Operations (CSPRO)	A procedure used by air traffic controllers to space aircraft closer together on take-off and landing at major U.S. airports for the purpose of increasing airspace capacity. Under CSPRO, aircraft pairs arriving at an airport with parallel runways that are separated by 2,500 feet or less are staggered to observe 1.5 nautical mile diagonal separations between leading and trailing aircraft on the separate runways.
Cockpit Display of Traffic Information (CDTI)	CDTI is a generic display that provides the flight crew with surveillance information about other aircraft, including their position. Traffic information for a CDTI may be obtained from one or multiple sources, including ADS-B, traffic collision avoidance system (TCAS), and traffic information services-broadcast (TIS-B). Direct air-to-air transmission of ADS-B messages supports display of proximate aircraft on a CDTI.
Code of Federal Regulations (CFR)	The codification of the general and permanent rules and regulations published in the Federal Register by the executive departments and agencies of the federal government of the United States.
Day-Night Average Sound Level (DNL)	Expressed in decibels (dB), DNL is a 24-hour average noise level used to define the level of noise exposure on a community. The DNL represents the average sound exposure during a 24-hour period and does not represent the sound level for a specific noise event. A 10 dB correction is applied to nighttime (10:00 p.m. to 7:00 a.m.) sound levels to account for increased annoyance due to noise during the night hours.
Decibels (dB)	The logarithmic unit used to measure the intensity of a sound measuring from the threshold of human hearing, 0 dB, upward toward the threshold of pain, about 120 to 140 dB. An increase of 10 dB is perceived by human ears as a doubling of noise.
Distance Measuring Equipment (DME)	Equipment (ground and airborne) used to measure and report to the pilot the slant range distance, in NMI, of an aircraft from the DME navigational aid.
Environmental Assessment (EA)	Assessment performed the National Environmental Policy Act (NEPA), used to predict the environmental consequences of a plan, policy, program, or project prior to the decision to move forward with the proposed action. The EA will determine either the need to prepare an Environmental Impact Statement (EIS) or justify a Finding of No Significant Impact (FONSI).

TERM	DEFINITION
Environmental Impact Statement (EIS)	A document required by NEPA for certain actions that may significantly affect the quality of the human environment. The purpose of an EIS is to analyze and disclose the significant effects resulting from a federal action and also list alternative actions that may be chosen instead of the action described in the EIS.
Equivalent Lateral Spacing Operations (ELSO)	Procedures used by air traffic controllers to space aircraft closer together on take-off and landing at major U.S. airports for the purpose of increasing airspace capacity. ELSO reduce the divergence angle between the departure routes of aircraft on take-off, therefore allowing controllers to space routes more closely together and clear aircraft for take-off more efficiently.
Feature Class	A collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes. For example, highways, primary roads, and secondary roads can be grouped into a line feature class named "roads." In a geodatabase, feature classes can also store annotation and dimensions.
Flight-Deck-Based Interval Management-Spacing	A component of interval management (IM), which is a set of applications that enable more precise and consistent spacing between aircraft to yield increased throughput and efficiency. The IM system comprises a ground-based component (GIM) and a flight deck–based component (FIM). The FIM component involves the use of avionics that provide guidance to achieve and/or maintain a desired spacing interval relative to a target aircraft.
Flight Information Services–Broadcast (FIS-B)	A component of ADS-B technology that provides free graphical National Weather Service products, temporary flight restrictions (TFRs), and special-use airspace information.
Flight Management System (FMS)	A suite of avionics programs on board an aircraft used to calculate the most economical flying speeds and altitudes during a flight and to identify possible choices in emergencies.
General Aviation (GA)	All civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire. The majority of the world's air traffic falls into this category, and most of the world's airports serve GA exclusively.
Geospatial	Of or relating to the relative position of things on the earth's surface.
Global Positioning System (GPS)	A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver. In aviation, GPS data allows pilots to obtain precise three-dimensional or four-dimensional location data.
Government Accountability Office (GAO)	An independent, nonpartisan agency established by the Budget and Accounting Act of 1921 that investigates how the federal government spends taxpayer dollars.
Ground-Based Augmentation System (GBAS)	A system that provides differential corrections and integrity monitoring of global navigation satellite systems. GBAS provides navigation and precision approach service in the vicinity of the host airport, broadcasting its differential correction message via a very high-frequency radio data link from a ground-based transmitter. GBAS yields the extremely high accuracy, availability, and integrity necessary for Category I, and eventually Category II and III precision approaches.
Inertial Reference Unit	A type of inertial sensor which uses only gyroscopes to determine a moving aircraft's change in angular direction over a period of time.

TERM	DEFINITION
Instrument Flight Procedures (IFR)	A description of a series of predetermined flight maneuvers by reference to flight instruments, published by electronic and/or printed means.
Instrument Landing System (ILS)	A radar-based instrument approach system that provides precision lateral and vertical guidance to ILS-equipped aircraft approaching and landing on a runway, enabling a safe landing during instrument meteorological conditions (IMC) such as low ceilings or reduced visibility.
Integrated Noise Model (INM)	A computer model that evaluates aircraft noise impacts in the vicinity of airports. The INM can output either noise contours for an area or noise level at pre-selected locations. In the United States, INM is the preferred model used for Federal Aviation Regulation (FAR) Part 150 noise compatibility planning and for FAA Order 1050 EAs and EISs.
In-Trail Procedures (ITP)	An ADS-B application developed by the FAA. The use of flight level change procedures, enabled by ADS-B ITP, enables flight level changes for aircraft operating in oceanic airspace and being held at non-optimal flight levels due to conflicting traffic.
Lateral Navigation (LNAV)	GPS-based non-precision instrument approach procedure that provides horizontal approach navigation without approved vertical guidance. The approach minimums for LNAV approaches are higher than that of ILS approaches, and RNAV approaches that incorporate vertical guidance.
Light Detection and Ranging (LiDAR)	A remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.
Localizer Performance (LP)	An RNAV function using a final approach segment data block that computes, displays, and provides horizontal approach navigation using the horizontal accuracy and integrity of localizer performance with vertical guidance (LPV) without approved vertical guidance. The LP line of minima is provided at locations where issues prevent the use of vertical guidance, and provides a higher probability of achieving the lowest minimum at these locations.
Localizer Performance with Vertical Guidance (LPV)	An RNAV function using a final approach segment data block, which computes, displays, and provides both horizontal and approved vertical approach navigation to minimums as low as 200-foot ceiling and ½-mile visibility.
Metadata	Information about a data set. It may include the source of the data; its creation date and format; its projection, scale, resolution, and accuracy; and its reliability with regard to some standard.
Metroplex	Metroplex refers to a system of airports in close proximity and their shared airspace that serve one or more major cities.
National Airspace System (NAS)	The FAA created the NAS to protect persons and property on the ground, and to establish a safe and efficient airspace environment for civil, commercial, and military aviation. The NAS is made up of a network of air navigation facilities, ATC facilities, airports, technology, and appropriate rules and regulations that are needed to operate the system.
National Environmental Protection Act of 1969 (NEPA)	A congressional Act that established the national policy for disclosing the potential impacts of federal actions. Compliance with NEPA requires the completion of an environmental document that outlines impacts that may significantly affect the quality of the human environment.
Optimized Profile Descent (OPD)	An aircraft approach method designed to reduce fuel consumption and noise compared to other conventional descents. Instead of approaching an airport in a stair-step fashion, OPD allows for a smooth, constant-angle descent to landing.

TERM	DEFINITION
Performance-Based Navigation (PBN)	A term used to describe the broad range of technologies that move aviation away from a ground-based navigation system toward a system that relies more on the performance and capabilities of equipment on board the aircraft. PBN specifies that aircraft RNP and RNAV systems performance requirements be defined in terms of accuracy, integrity, availability, continuity, and functionality required for the proposed operations.
Polygon	A multisided figure that represents area on a map. Polygons have attributes that describe the geographic feature they represent.
Required Navigation Performance (RNP)	A type of PBN that allows an aircraft to fly a specific path between two 3D-defined points in space. RNP equipment provides onboard navigation capability that allows crews to accurately fly aircraft along a precise flight path. RNP also refers to the level of performance required for a specific procedure or a specific block of airspace. An RNP of 10 means that a navigation system must be able to calculate its position to within a circle with a radius of 10 nautical miles.
RTCA	A nonprofit U.S. volunteer organization that develops technical guidance for use by government regulatory authorities and by industry. Originally named the Radio Technical Commission for Aeronautics, it is now officially known solely as the RTCA.
Spatial	Relating to, occupying, or having the character of space
Standard Instrument Approach Procedure (SIAP)	A series of predetermined maneuvers for the orderly transfer of an aircraft under instrument flight conditions from the beginning of the initial approach to a landing, or to a point from which a landing may be made visually or the missed approach procedure is initiated. It is prescribed and approved for a specific airport by a competent authority.
Standard Instrument Departure (SID)	A preplanned instrument flight rule (IFR) departure procedure published for pilot use, in graphical or textual format, that provides obstruction clearance from the terminal area to the appropriate en route structure.
Standard Terminal Arrival Route (STAR)	A published IFR arrival procedure describing specific criteria for descent, routing, and communications for a specific runway at an airport.
System Wide Information Management (SWIM)	The digital data-sharing backbone of NextGen, SWIM infrastructure enables air traffic management (ATM)–related information sharing among diverse, qualified systems. SWIM also provides information governance.
Terminal Radar Approach Control (TRACON)	An FAA ATC facility that uses radar and two-way radio communication to provide separation of air traffic within a specified geographic area in the vicinity of one or more large airports.
Traffic Collision Avoidance System (TCAS)	An aircraft collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. TCAS is based on secondary surveillance radar transponder signals and operates independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft. The International Civil Aviation Organization (ICAO) mandates that the system be fitted to all aircraft with a maximum take-off mass of over 5,700 kilograms (12,600 pounds) or authorized to carry more than 19 passengers.
Traffic Information Services-Broadcast (TIS-B)	TIS-B is the broadcast of ATC-derived traffic information to ADS-B-equipped (1090ES or UAT) aircraft from ground radio stations. The source of this traffic information is derived from ground-based air traffic surveillance radar sensors. TIS-B service will be available throughout the NAS where there are both adequate surveillance coverage (radar) from ground sensors and adequate broadcast coverage from ADS-B ground radio stations.

TERM	DEFINITION
Vertical Navigation (VNAV)	A form of precise vertical (altitude) navigation using the aircraft FMS. VNAV is the vertical navigation flight profile that is the predicted flight trajectory of the airplane in the vertical plane as a function of distance along the horizontal flight path defined by the LNAV flight plan.
Wide Area Augmentation System (WAAS)	An air navigation aid developed by the FAA to augment the GPS, with the goal of improving its accuracy, integrity, and availability. WAAS is intended to enable aircraft to rely on GPS for all phases of flight, including precision approaches.
Wide Area Multi-Lateration (WAM)	A NextGen surveillance capability that enables air traffic controllers to track aircraft flying into and out of airports in mountainous areas with no radar coverage. WAM can complement ADS-B by providing transitional surveillance for non–ADS-B-equipped targets, and can be used for ADS-B validation.

C Interviews and Case Studies

To better understand how programs that are relevant to this study were utilizing or creating spatial data within a particular area tied to NextGen, a series of interviews were conducted with both public- and private-sector agencies. Many of the findings from these interviews have been incorporated into ACRP Project 09-12, as they were a key source of information used to develop the research team's findings and suggested actions for airports. The organizations interviewed via telephone are documented in Table C-1. Longer telephone interviews were conducted with a sampling of airports, and in-person interviews were conducted with two state aviation agencies. These more-detailed interviews were expanded to create the case studies and interview summary presented in this appendix. These case studies and interview summary document what is known about NextGen at these airports or agencies, how spatial data has helped to support the implementation of a particular NextGen program(s) at that airport or agency, and what the current status is of the use of spatial data at the airport or agency.

In July 2014, three major airports and one state agency were interviewed in order to better understand what these airports knew about the requirements of NextGen as it relates to spatial data, how they were learning what these requirements are, and whether they had ever developed and/or received spatial data (knowingly or not) tied to a NextGen program. These organizations included San Francisco International Airport (SFO), Portland International Airport (PDX), Seattle Tacoma International Airport (SEA), and Washington State Department of Transportation Aviation Division (Washington State DOT). These four organizations were chosen because they are considered sophisticated GIS users and implementers, GIS is employed in much of their daily business processes, and has been so for several years. In addition, two of these airports have completed a full Airports Geographic Information System (AGIS)–compliant airfield mapping project and submitted it to the FAA. As part of its upcoming State System Plan, Washington DOT will oversee the collection and conversion of AGIS data at a minimum of four airports within the Puget Sound area in 2015 and 2016, and potentially others in the coming years. These initial interviews were followed up by additional interviews with Dallas/Fort Worth International Airport (DFW)—one of the very first AGIS airports—and with the Texas Department of Transportation (Texas DOT).

In addition to these agencies, interviews were conducted with individuals whose work in some key way touches a particular NextGen program. A goal of this study was to restrain the research to NextGen programs that have or potentially could have a direct impact on airport operations, and of these programs, to focus on those that either have a need for or potentially could produce spatial data. The guidebook discusses how these specific NextGen programs were selected. In accordance with the project goals, the researchers limited the interview pool to agencies that have ties to the selected programs. In general, NextGen programs such as multiple runway operations (MRO), Performance-Based Navigation (PBN), and Surface Operations and Data Sharing all have a need for or produce spatial data, and were the focus

Table C-1. Interviews and webinar overview.

Agency	Date of Interview	NextGen Program
FAA Flight Procedures – Southern Region	August 31, 2015	• PBN/Flight Procedures • AGIS
FAA Office of Airports/AGIS	January 2016	• AGIS
Private Sector Aviation Firm	November 5, 2015	• NavLean SME/Past FAA NavLean Specialist
JetBlue	September 14, 2015	• PBN/Flight Procedures – airline perspective. • Surface operations • Cockpit avionics – moving map
American Airlines	September 9, 2015	• PBN/Flight Procedures – airline perspective. • Surface operations • Cockpit avionics – moving map
RTCA	June 1, 2015	• Multiple NextGen • DO 272
FAA – Office of the Assistant Administrator for NextGen	June 3, 2015	• Multiple NextGen • DO 272
Webinar	January 19, 2016	
In addition to the project team, webinar participants included airline and airport staff, FAA HQ and Southern Region representatives, a state DOT representative, and NextGen consultants.		

of these interviews. Because PBN has the most direct need for spatial data, multiple interviews were conducted about PBN with FAA staff, private-sector contractors, and the airlines.

In January 2016, a webinar was planned that included both follow-up contact with some of the participants who had previously been interviewed and other key stakeholders who in some way have an impact on or utilize spatial data for NextGen programs. The webinar included a briefing by the ACRP Project 09-12 team on the findings of the study and an open discussion with the group on the information presented as well as key issues that each of the participants felt were important to review.

Interview Summaries/Case Studies

The information in this section is current as of publication of *ACRP Report 150, Volume 4.* Airports documented here, such as San Francisco and Seattle Tacoma International, have realized direct benefit from NextGen, in particular PBN. Although the Greener Skies Initiative at Seattle is discussed in these case studies, the situation is still in flux. The same is true for San Francisco.

Washington State Department of Transportation, Aviation Division (Washington State DOT)

When: July 10, 2014

In May 2013 The Puget Sound Regional Council (PSRC) published a study titled, "Preparing Busy General Aviation Airports for Next Generation Technologies." This study "presents a regional/system planning approach to identifying the general aviation (GA) benefits that can be realized through the deployment and implementation of the Federal Aviation Administration's NextGen program" (PSRC 2013, p. 6). [Editor's note: for convenience, all author date references that appear in the Appendices are cited in the guidebook's References and Bibliography section.] In this study, 13 busy airports within the Puget Sound Region were identified that could benefit tremendously through the application and implementation of NextGen technologies. In order to benefit from these technologies—particularly through the implementation of new flight procedures (i.e., PBN)—it was recommend that one of the major elements that each of these airports undertake is the development of new AGIS-compliant spatial data.

While a few of these airports, such as Boeing Field and Renton, would apply for and receive FAA funding and be managed and implemented as individual projects, other airports in this study would be funded by a portion of federal dollars and state funding and managed by Washington State DOT as part of the State Aviation System Plan. The Aviation Division of Washington State DOT has managed a statewide GIS program of aviation and airport-specific information that is used for a variety of reasons, including land use compatibility, basic airspace analysis, and airport demographics, and to provide approved users with specific data sets of airports across the state of Washington.

It is now part of Washington State DOT's plans to oversee the development of new AGIS data at four airports initially in order to support the development of new performance-based procedures at these airports. The goal for these busy airports is to be able to continue or enhance their ability to efficiently operate in the Puget Sound airspace while supporting larger private aircraft as well as operations by Boeing at their facilities throughout Puget Sound.

Seattle-Tacoma International Airport (SEA)

When: July 10, 2014

Seattle-Tacoma International Airport (SEA) has been utilizing GIS technologies and developing spatial data for several years. The airport's GIS is integrated with other business systems and used by most departments/divisions at SEA. SEA has developed a full AGIS-compliant data set and had it approved by the FAA. However, they still utilize their own data developed by SEA staff for all of their airfield needs; that is, they have complied with the standards but have chosen to not to use the data for their everyday needs.

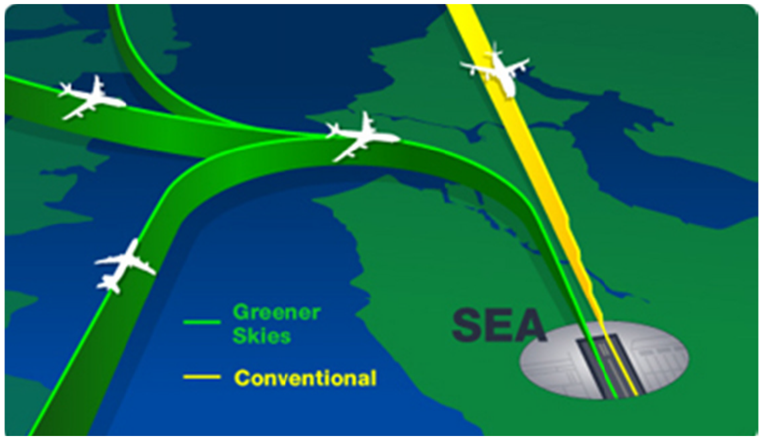


Figure C-1. *Greener Skies Over Seattle Initiative (FAA NextGen Snapshots).*

SEA is the 16th busiest airport in North America in terms of passenger traffic. Several NextGen capabilities have been implemented, including Airport Surface Detection Equipment, Model X (ASDE-X), PBN procedures (as part of the Greener Skies initiative—see Figure C-1), Optimized Profile Descent (OPD), and Time-Based Flow Management (TBFM). All of these NextGen capabilities either require or enable the use of spatial data that could benefit the airport. In addition, spatial data already generated by the airport could support any one of these NextGen capabilities or technologies.

The AGIS data that was submitted by SEA was used at least partially in the development of their PBN-based flight procedures. Interviews with flight procedures specialists from Ricondo, the Southern Region of the FAA, and others confirmed that certain features from AGIS are used in developing many of these new flight procedures at many airports around the country although it is nearly impossible to determine specifically which features are used for flight procedures design. What features are used is not publicized, and there is no public standard used as a guideline. In the case of several airports that now have new PBN-based procedures or simultaneous departures (e.g., Hartsfield-Jackson Atlanta International Airport), it is difficult to trace back directly to the spatial data source of the new procedures.

Portland International Airport (PDX)

When: July 9, 2014

Portland International Airport (PDX) is another sophisticated GIS user in the airports community. PDX has been using GIS for several years, with a focus on the airport's buildings and facilities. While PDX has airfield base map information, they have not currently completed a full AGIS-compliant project or submittal to the FAA. The airport does have plans for completing such a project in the next 1–3 years. PDX is an interesting case study because the staff possesses a very high level of technical skill in administering, developing, and customizing their GIS and require very little consulting help. They do utilize outside help from consultants when there is a need for additional resources to focus on a specific need.

PDX is part of the FAA's Northwest Mountain Region, a region that has been more apt to enforce the AGIS standards than other FAA regions. Considering their high level of GIS sophistication, the fact that the airport has not yet completed a full AGIS-compliant data set is noteworthy. Through questions that were raised during the interviews, it was generally stated that PDX just hasn't seen a strong need for

AGIS-compliant data yet. They understand the benefits of complying with a standard and developing the data to certain levels of accuracies and completeness; however, having data that is out of compliance has not yet had an adverse impact on the airport.

San Francisco International Airport (SFO)

When: July 8, 2014

An interview was conducted with some of the key management team that is responsible for all spatial data that is developed by SFO staff or developed by consultants and contractors and then utilized by SFO. The intent of this interview was to inquire about the use of the spatial data in support of their daily operations, how it is or potentially could be used to support NextGen-related programs that are either in place at SFO or somehow impact its operations, as well as to document the state of the airport's AGIS program and how and if any of that data has been provided to NextGen program work.

Several NextGen capabilities have been implemented at SFO, including PBN procedures and high-altitude PBN routes, tailored arrivals, TBFM, and Wake Turbulence Mitigation for Departures (WTMD), among others.

SFO completed one of the first AGIS-compliant projects in the country as part of the second phase of the FAA's pilot program. They have been using GIS for the past several years to support utilities management, airfield changes, providing accurate base map information to different divisions, and for specific project support across the airport. At the same time as the AGIS project was getting underway, SFO was also beginning the design and construction of seven runway safety areas (RSAs) and the shifting of one runway. The airport also had other major capital projects either in final stages (e.g., Terminal 2) or in the very early stages (e.g., Terminal 1 and the new FAA tower). One of the RSA projects had a critical deadline to achieve so that the airspace analysis and new flight procedures could be created to reflect the change in the runway end configuration, thresholds, and so forth. The AGIS project made this the high priority area for the initial deliverables. By having the new imagery, obstructions identification, and the new runway ends surveyed, the RSA could proceed with design and ultimately break ground for construction on time. At the same time, because SFO has a lot of terrain around the west side of the airport, the airspace analysis was also a critical need in the schedule. Over 35,000 obstacles were reviewed and mapped, and determinations on impacts to the airspace, climb gradients for certain types of aircraft, threshold placements, and other items all were analyzed. As the data conversion neared completion, it was immediately apparent that due to the many changes to the airfield and the areas around the terminals, the data that was created and utilized throughout the 2+ years of its conversion needed to be updated. Most of the airfield had not changed, so the original AGIS data set was still applicable; however, certain large areas had changed and needed to be reacquired, surveyed, and converted. Given the many issues of airfield changes, the multiple RSAs, and the fact that SFO is a major component of the Metroplex in the San Francisco Bay Area, having up-to-date and accurate AGIS data in the FAA's database has been essential.

Dallas/Fort Worth International Airport (DFW)

When: January 23, 2015

In 1999, Dallas/Fort Worth International Airport (DFW) was one of six airports in the FAA Southwest Region to participate in the FAA's National Phase I program to roll out the AGIS program. FAA's Phase I program included large and small airports. Some airports, such as DFW, had significant experience with GIS while other airports did not utilize the technology as part of their routine airport management. DFW completed the AGIS Phase I project in 2011 and has been utilizing the data since that time.

Several NextGen capabilities have been implemented at DFW, including ASDE-X, PBN procedures, basic rerouting, and TBFM.

DFW has a small but focused professional staff that has successfully integrated GIS technology into the organization. There are approximately 40–60 internal web-based GIS users throughout all organizational units. Management is keenly aware that the technology greatly improves collaboration and reduces costs/time to make important business decisions. A prime and oft-cited example is the GIS-based analysis that was conducted when a major air carrier was considering requesting fuel-saving modified flight routes for arrivals and departures that would expose non-compatible residential homes to overflights and materially increased noise exposure. GIS was used to quickly estimate the areas impacted by the proposed flight tracks, the number of residences within the associated noise contours, and the appraised values of the homes, supporting an estimate of the potential mitigation cost. As a result of the rapid analysis, a joint decision was made not to further pursue the flight path modifications.

During scoping of DFW's Phase I pilot program, the airport worked closely with the FAA and a consultant to determine imagery resolution, feature classes (layers) to be included, and the attributes to be collected. The decision was made to increase the imagery resolution above the minimum required to meet the Advisory Circular (AC) requirements for obstacle accuracy. Most feature classes were collected as part of the project, including generating 1 ft. ground contours. While all participants were aware that the higher resolution imagery and 1 ft. contours would increase cost, it was believed the costs were justified: the additional data layers would support upcoming engineering design projects. The higher resolution aerial photography was envisioned to:

- Support the asset capital maintenance program,
- Assist in justifying FAA grant program requests,
- Generate a terrain model, and
- Integrate with the work-order management system.

DFW believed the AGIS Phase I initiative would increase the essence of their "C3" partnering (communication, collaboration, and coordination). There was significant overlap of GIS data layers between DFW's existing database and those required by AGIS. The AGIS initiative increased the number of feature classes (GIS layers) by 40 (to 190 GIS layers). DFW uses 4–6 person-months per year to maintain GIS map layers.

DFW leveraged AGIS Data to improve C3 partnering and reduce costs/time in the following areas:

- Collecting AGIS-required layers, according to FAA criteria, when existing airport data layers were in the dataset, forced a detailed data reconciliation to ensure data integrity for accurate decision making.
- The high resolution imagery allowed DFW to separately map individual runway, taxiway, and apron panels. Combined with other data including pavement age, pavement distress, daily inspections, repair history, and airfield operations, the airport was able to reveal patterns in pavement condition to guide capital renewal decision and maintenance activities. The airport also mapped pavement with additional polygons to support Notices to Airmen (NOTAMs) and areas closed to operations.
- Collecting robust flora, fauna, and wetlands/hydrology data layers and combining them with bird strike events, avian radar data, and mowing areas, the airport was guided in assessing wildlife activity patterns to improve their wildlife management program.

- DFW sees value in the 3-D data model versus their legacy 2-D model; however, the value has not been exploited at this time.
- The ground contour data has been utilized substantially since being available to the airport.
- Utilizing the terrain and contour data, a hydrological model was developed that was the foundation for a hydraulic planning study.
- To support drilling 25 gas wells on the airport, the airport and the proponent utilized the 1 ft. AGIS contours to determine ground elevations exceeding FAA's highest level of survey accuracy (1A = +20 ft. horizontal, +3 ft. vertical). The FAA agreed to a certification from the proponent/airport that the remote sensing criteria exceeded these limits, thereby reducing the cost/time for a ground survey to be conducted and checked for each of the proposed drill sites.
- Dallas Area Rapid Transit (DART) and TEX Rail utilized the ground contours while planning rail service to the airport, thus reducing their time and costs.
- In 2013, the airport conducted a North and South Taxiway Crossover Study evaluating options for end-around taxiways and additional taxiway bridges over International Parkway. Again, the ground contour data from the AGIS initiative was utilized in the evaluations, eliminating the time and cost to conduct a ground-based survey.
- In 2014, DFW conducted a follow-on taxiway centerline profile feasibility study to refine the analysis for the most promising crossover and end-around taxiways. Again, the 1 ft. contour data was utilized.
- DFW is in a non-attainment area, and implementation of PBN, combined with the FAA's Optimization of Airspace & Procedures Modernization initiative, has reduced carbon emissions, providing improved air quality for the local community and benefits to the State Implementation Plan (SIP). With the tighter PBN flight paths and smaller noise contours, the opportunity exists to utilize undeveloped land for otherwise non-compatible development.

Texas Department of Transportation, Aviation Division (Texas DOT)

When: February 23, 2015

Texas is a block grant state, which means the Texas DOT functions very much like an FAA ADO in that the agency oversees multiple airports and their funding, including planning, programming, and providing grant money for improvement projects. Texas DOT does operate a significant GIS program at the agency level that provides some support to the Aviation Division. The agency enforces its own computer-aided design (CAD) standards for Airport Layout Plan (ALP) submissions from GA airports. The only GA airport in the Texas DOT system to have done a full AGIS-compliant data set is Fort Worth Meacham International Airport (FTW), which submitted its data to the FAA in 2014.

Texas DOT does not yet consider it cost effective to develop full AGIS-compliant data sets and is waiting for the FAA's system to mature to the point where the agency can see value provided back to Texas DOT airports. Texas DOT is enforcing the obstruction surveys needed at their GA airports in compliance with AC 150/5300-18B. The only NextGen program that the agency has had experience with is Area Navigation (RNAV) and related approach procedures.

According to Texas DOT, they frequently add additional scope to the remote sensing projects (imagery collection) to provide line work required for ALP updates. Texas DOT believes this is very cost-effective, as the imagery has been collected and is also being utilized for obstacle analysis. Because the resulting product is geospatially referenced, it is efficient and cost-effective to update existing ALP layers for the airport with the newly surveyed information.

The "18B" obstruction surveys (see FAA AC 150/5300-18B) have led to interesting challenges. In one situation, the survey allowed the airport to have ¾ mi. minima. This caused the approach runway protection zone (RPZ) outer width to increase from 700 ft. to 1,510 ft. As a result, nine non-compatible land use residences were included in the RPZ, and it was considered financially and politically expensive to acquire the homes to remove the non-compatible land use. An analysis of weather data indicated that visibility minimums were between ¾ mi. and 1 mi. only 0.27% of the time. As a result, a decision was made to increase the published approach minima to not less than 1 mi., allowing the airport to utilize the smaller approach RPZ and eliminating non-compatible land use.

It was noted by Texas DOT that the higher quality data acquired in the 18B-compliant obstruction surveys identified critical obstacles not previously identified on airports' radar screens. This led to additional obstacle removal, lighting, or loss of instrument approaches.

D Educational Forum Abstract Sample

Many benefits to airports can be derived from spatial data that is collected in support of the Next Generation Air Transportation System (NextGen). The presentation shown in Appendix E identifies the benefits airports can achieve from mapping (spatial) data that they and the FAA develop to support NextGen initiatives.

The FAA needs accurate and up-to-date locations for runways, obstacles, navigational aids (NAVAIDs), and other critical elements of the environment on and around airports to implement many NextGen capabilities. The FAA requires airports to supply much of this data. The FAA also develops spatial data identifying airspace restrictions and flight procedure routes. It is also installing sensors at many airports; these sensors provide data on the location of aircraft and surface vehicles that operate on an airfield. This data can provide a great deal of benefit to airports.

ACRP Project 09-12, "Leveraging NextGen Spatial Data to Benefit Airports," was conducted to document these benefits and to describe what spatial data is being used and how it is being collected and applied in certain NextGen programs. A thorough literature search was conducted as part of this study, as were a series of interviews with aviation industry stakeholders from all perspectives of spatial data and NextGen. How airports and other public agencies have utilized spatial data to support their own needs, as well as how their own data and spatial data from other agencies or third-party vendors is used in NextGen programs, was documented in a series of case studies. As part of this research, a legal team also documented the potential for airports to monetize the spatial data they create and realize added revenue from the data. Finally, a summary of findings and suggestions for further study was included in the research and documentation.

One of the major findings of the research identified a need for additional education of the public and the aviation community on the use and development of spatial data. In addition, it was determined that there is a gap in the understanding of NextGen programs, how airports are impacted by them, and what airports need to do to be prepared to take advantage of or support these programs.

This presentation provides an overview of the ACRP research study, the findings and conclusions of the study, and suggestions for continued research and documentation of the issues. The presentation seeks to address some of these information gaps by presenting the core findings of the ACRP study to add to the abundance of information that has been published or presented by others.

E Presentation Outline and Template

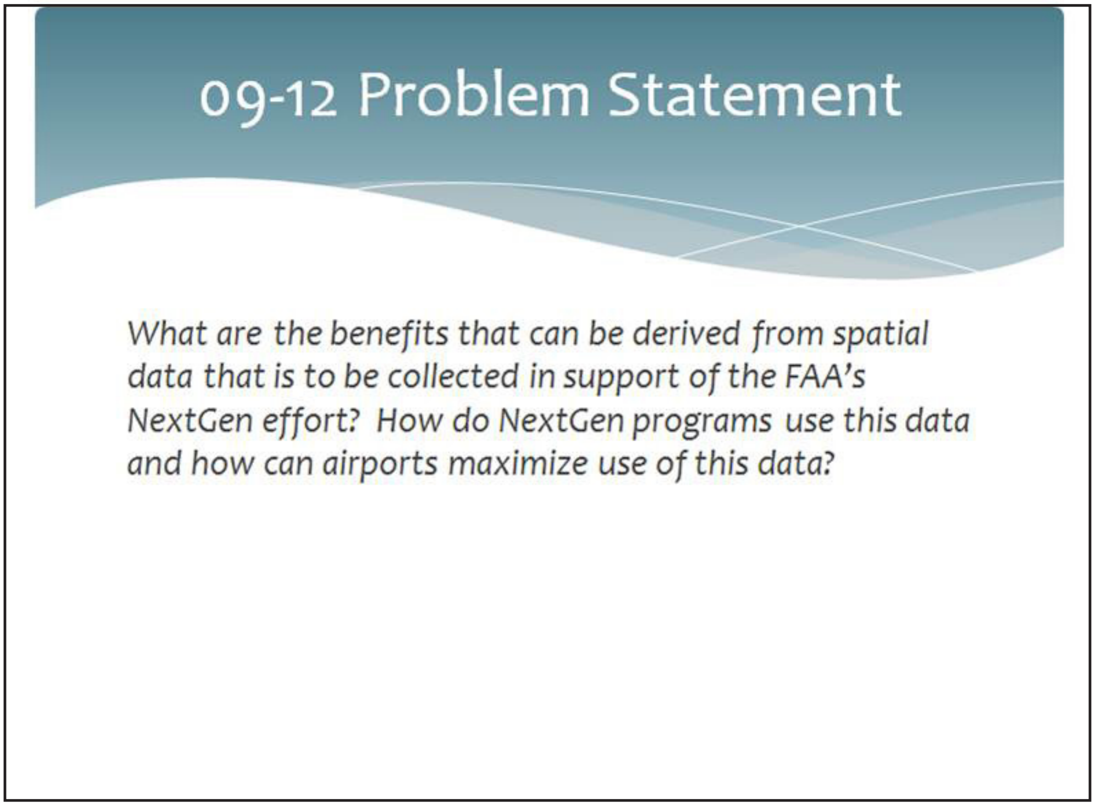
Agenda

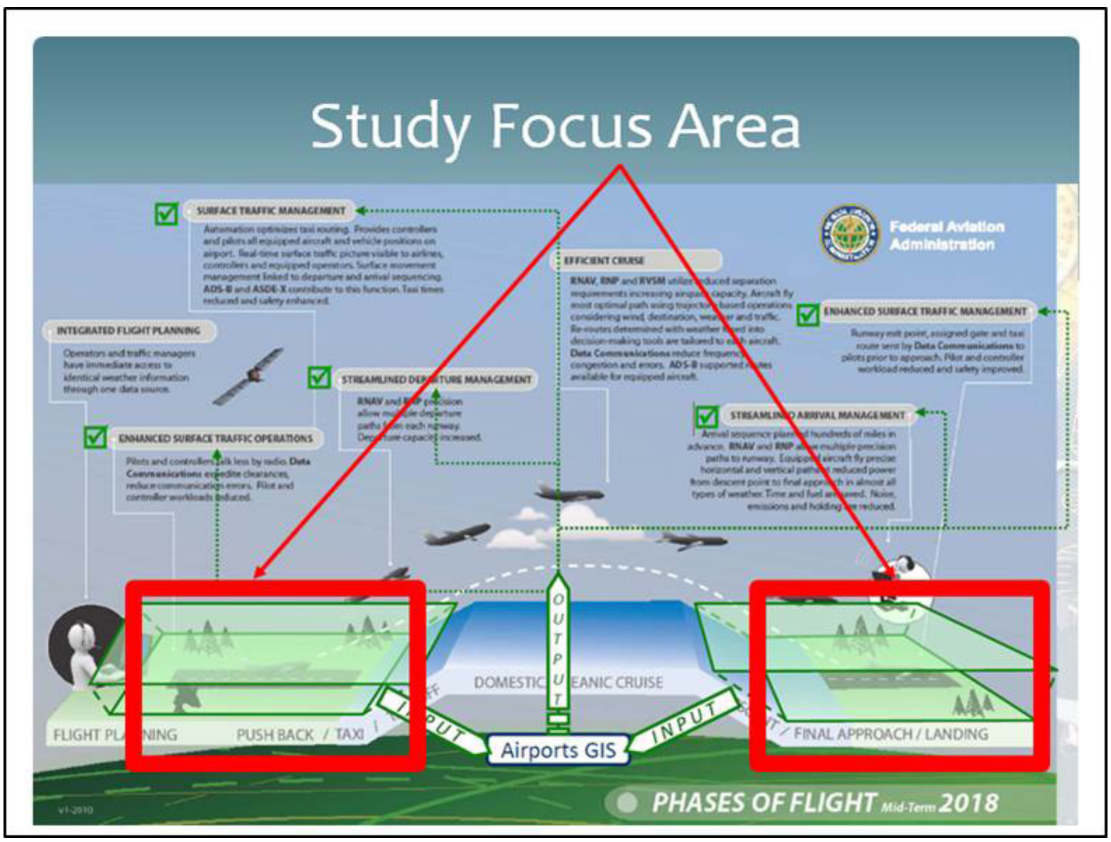
* ACRP Project 09-12
  * Problem Statement
* What is NextGen?
* Spatial Data and Why it's Important to NextGen
* Spatial Data Types
  * NextGen Programs That Use or Require Spatial Data
* Benefits & Costs to Airports
  * Discussion on Cost
  * Increasing Your Chances of Realizing These Benefits
* Summary & Recommendations for Further Research

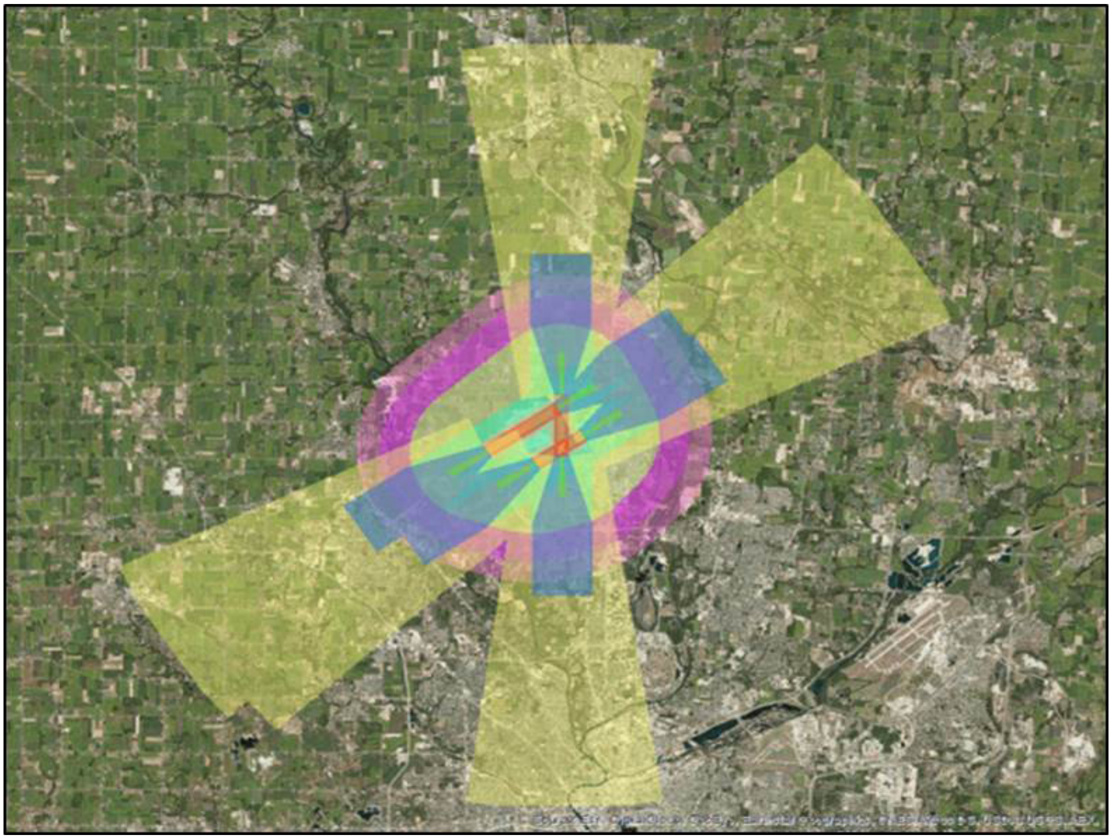
ACRP NextGen Projects

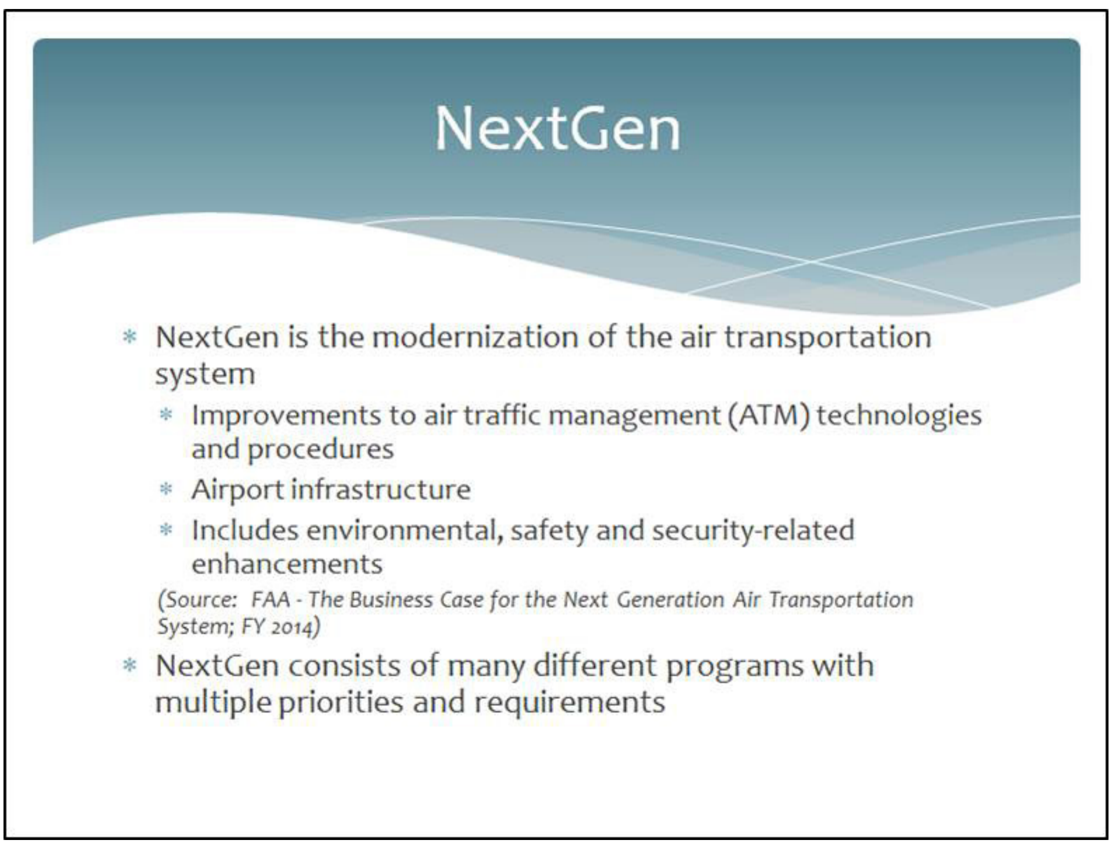
* 09-12 is one of five concurrent ACRP projects focused on NextGen, which are concluding in Spring 2016

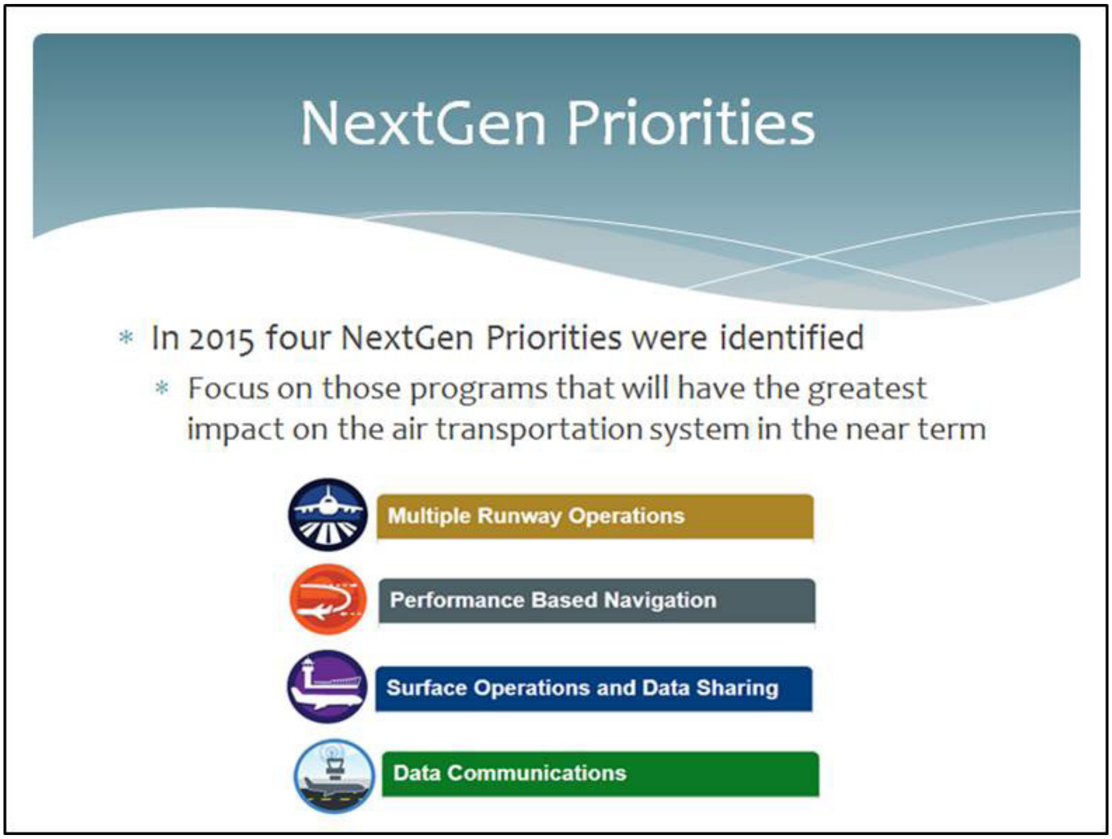
* 01-27, A Primer
* 01-28, Guidance for Engaging Airport Stakeholders
* 03-33, Airport Planning and Development
* 03-34, Understanding the Airport's Role in PBN
* **09-12, Leveraging NextGen Spatial Data to Benefit Airports**

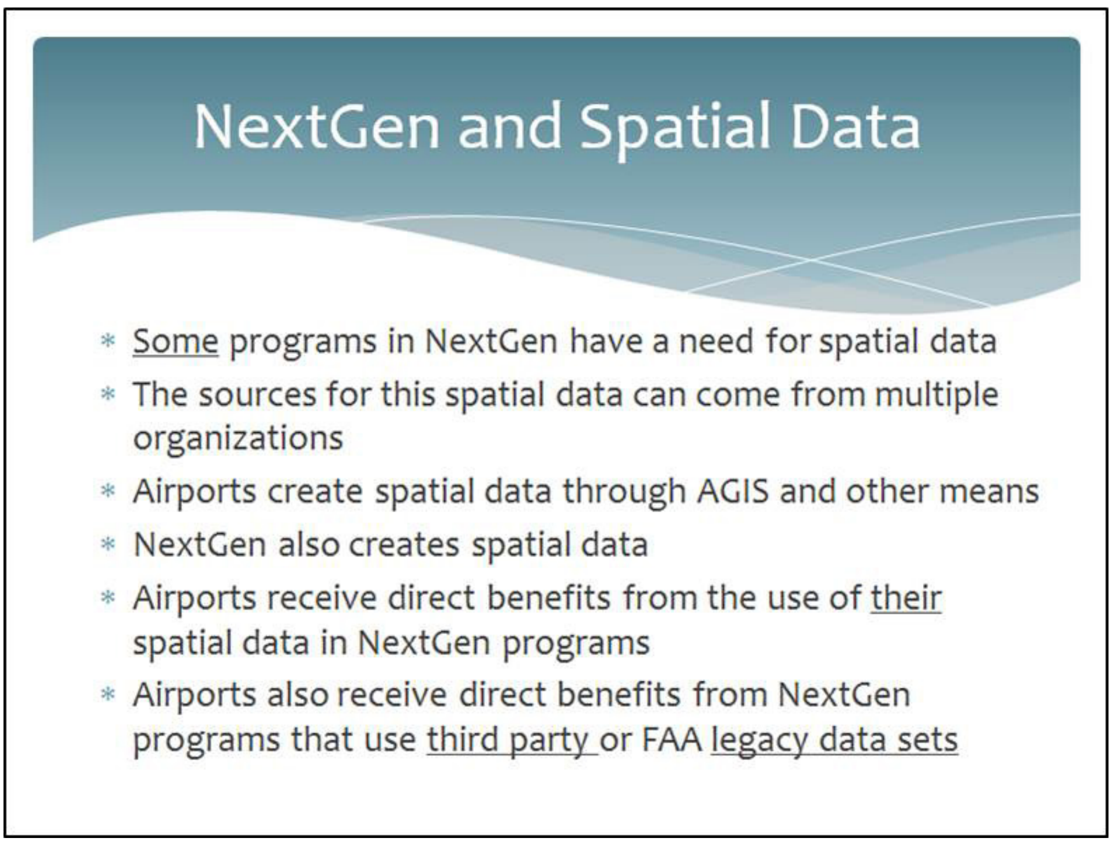

09-12 Problem Statement
What are the benefits that can be derived from spatial data that is to be collected in support of the FAA's NextGen effort? How do NextGen programs use this data and how can airports maximize use of this data?


Study Focus Area
SURFACE TRAFFIC MANAGEMENT
INTEGRATED FLIGHT PLANNING
STREAMLINED DEPARTURE MANAGEMENT
ENHANCED SURFACE TRAFFIC OPERATIONS
EFFICIENT CRUISE
ENHANCED SURFACE TRAFFIC MANAGEMENT
STREAMLINED ARRIVAL MANAGEMENT
Federal Aviation Administration
OUTPUT
INPUT
Airports GIS
FLIGHT PLANNING
PUSH BACK / TAXI
FINAL APPROACH / LANDING
PHASES OF FLIGHT Mid-Term 2018




NextGen
NextGen is the modernization of the air transportation system
Improvements to air traffic management (ATM) technologies and procedures
Airport infrastructure
Includes environmental, safety and security-related enhancements
(Source: FAA - The Business Case for the Next Generation Air Transportation System; FY 2014)
NextGen consists of many different programs with multiple priorities and requirements

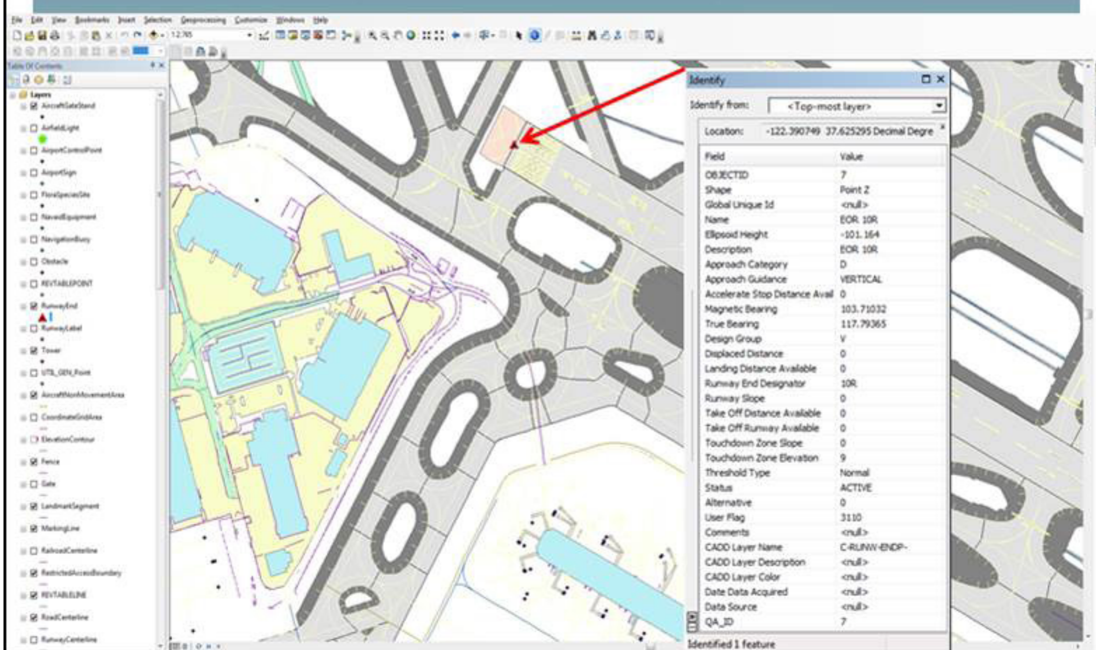

NextGen Priorities
In 2015 four NextGen Priorities were identified
Focus on those programs that will have the greatest impact on the air transportation system in the near term
Multiple Runway Operations
Performance Based Navigation
Surface Operations and Data Sharing
Data Communications


NextGen and Spatial Data
Some programs in NextGen have a need for spatial data
The sources for this spatial data can come from multiple organizations
Airports create spatial data through AGIS and other means
NextGen also creates spatial data
Airports receive direct benefits from the use of their spatial data in NextGen programs
Airports also receive direct benefits from NextGen programs that use third party or FAA legacy data sets

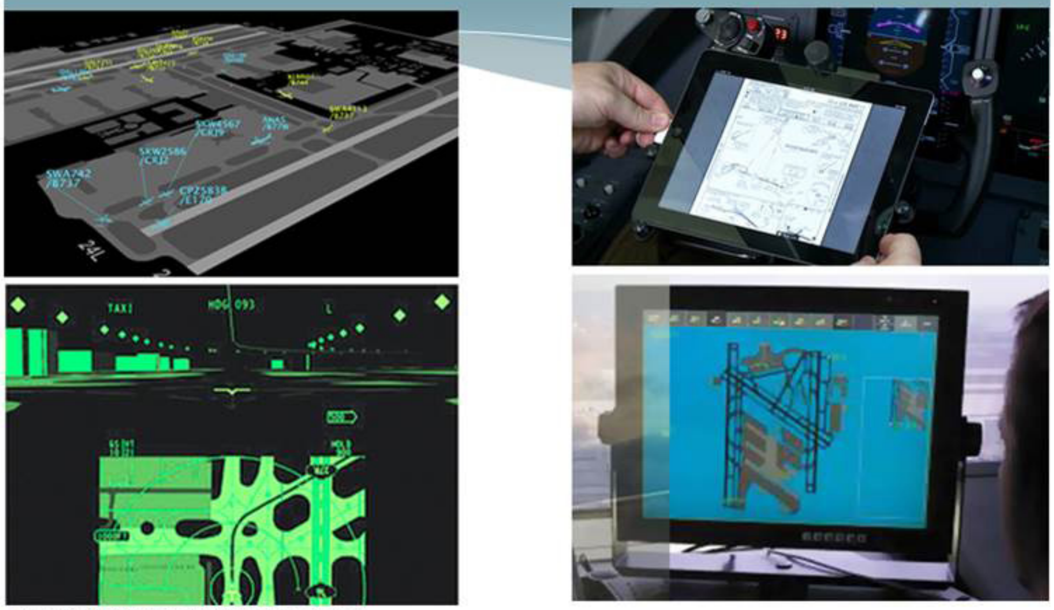
Why Spatial Data is Important to NextGen

* High accuracy data supports key programs such as PBN and Multiple Runway Operations
  * Safety
  * Improvements to the environment
  * Improved flight procedures
* Programs such as Surface Operations utilize third party sources that airlines and airports benefit from
  * Airfield operational efficiencies
  * Improved safety in aircraft and vehicle movements

An Example of AGIS Spatial Data



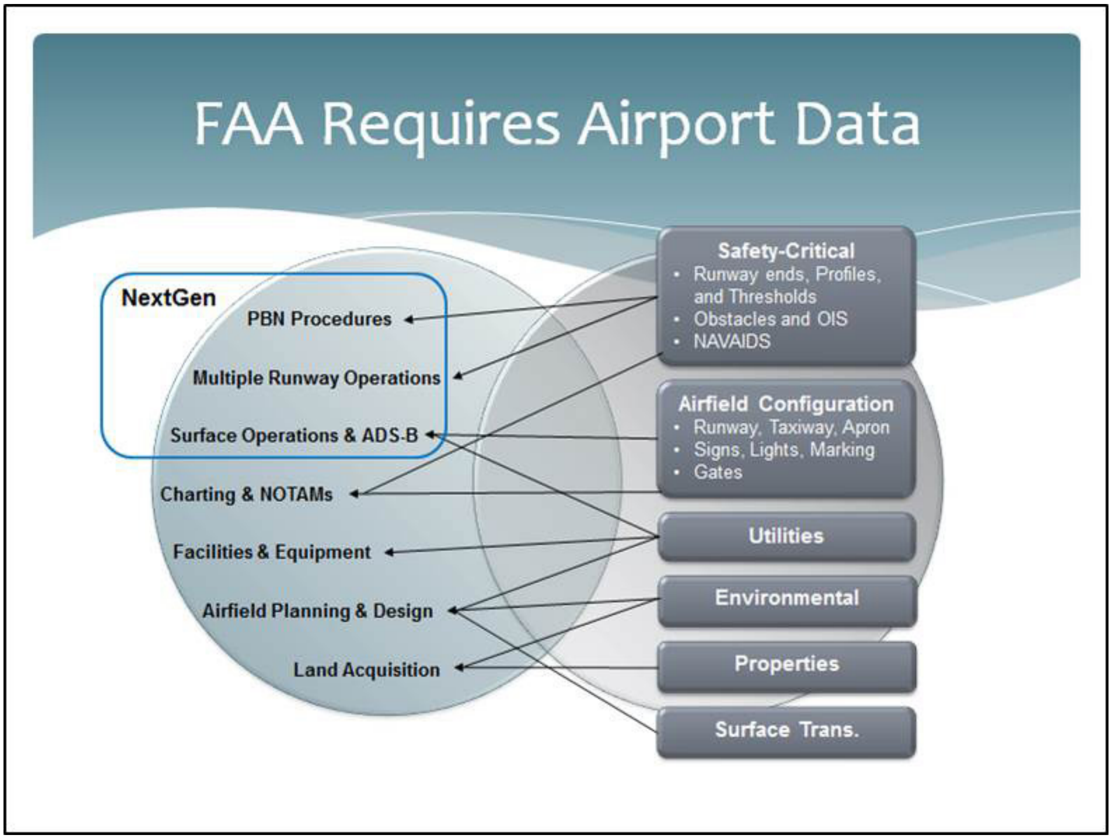
Other Spatial Data Applications

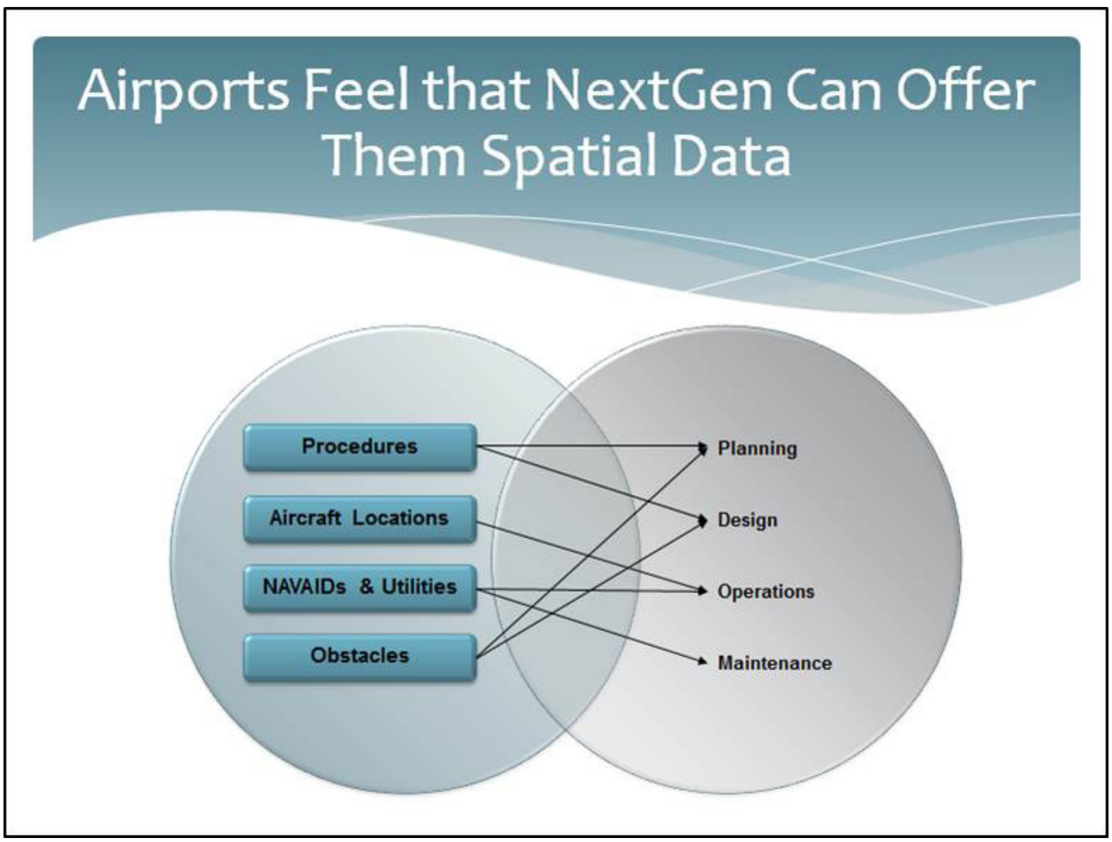


Source: Cockpit Guidance Gets Down To The Ground
Mar 25, 2013 John Croft | *Aviation Week & Space Technology*

Some Definitions

- **Spatial Data**
  - **Geometry** (e.g., points lines and polygons) that show the location and shape of tangible (e.g., runway), intangible (e.g., obstruction id surface), manmade (e.g., building), natural (e.g., tree), current (e.g., today's runway), and future (e.g., planned extension) objects in relation to their position on (i.e., 2D) and above (i.e., 3D) the face of the earth
  - **Attributes** add details about the object (e.g., size, color)
  - **Metadata** add details about the data itself (e.g., when it was collected)
- **Layers** are collections of similar objects (e.g., runways)
- **Maps** are collections of multiple layers (e.g., runways, taxiways, aprons, etc. = Airport Layout Plan) with symbology


FAA Requires Airport Data
NextGen
PBN Procedures
Multiple Runway Operations
Surface Operations & ADS-B
Charting & NOTAMs
Facilities & Equipment
Airfield Planning & Design
Land Acquisition
Safety-Critical
Runway ends, Profiles, and Thresholds
Obstacles and OIS
NAVAIDS
Airfield Configuration
Runway, Taxiway, Apron
Signs, Lights, Marking
Gates
Utilities
Environmental
Properties
Surface Trans.


Airports Feel that NextGen Can Offer Them Spatial Data
Procedures
Aircraft Locations
NAVAIDs & Utilities
Obstacles
Planning
Design
Operations
Maintenance

Benefits and Costs

* There is a perception that airports bear new costs but do not reap new rewards for the collection of spatial data.
* Airports are in fact gaining new capacity, reducing minimums, and increasing safety because they have collected this data.
* These benefits, unfortunately, have not been as apparent or as well documented as the costs.
* The system-wide benefit to cost ratio of spatial data for procedure design is immeasurably high.
* The problem is that from an airport's perspective the costs are immediate, tangible, and not-optional, but the benefits are prolonged and indirect.

Summary - NextGen

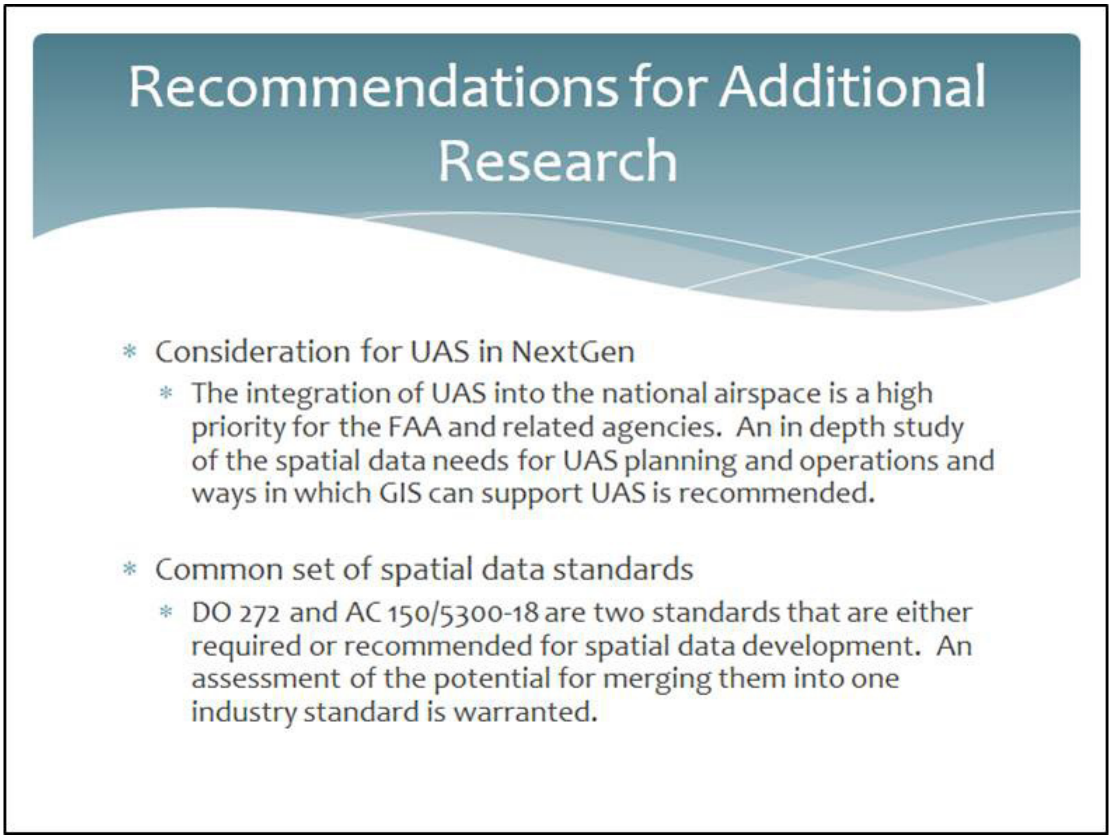
* "NextGen" has many meanings
* Airports find it difficult in clearly understanding what their roles and responsibilities are for NextGen
* Under NextGen, there is an increasing need for high quality, current, and accurate spatial data depicting airports, as well as airspace around airports
* Not all NextGen initiatives or programs within NextGen require or produce spatial data

Summary - AGIS

* FAA's Airports Geographic Information Systems (AGIS) program has long been called an "enabler" of NextGen
* While there is a clear and direct link between AGIS and PBN, many of the programs do not currently utilize the FAA's AGIS data
* For many of these programs, spatial data is now needed for more airports than AGIS can currently provide
* Many NextGen capabilities rely on spatial data produced by third party vendors
* 1/3 of top 30 airports have still not done a full AGIS project however there is a push by FAA to get these done

Summary - Spatial Data Outside of AGIS

* Airports can benefit from the spatial data that NextGen initiatives produce (e.g., aircraft positions, FAA-installed NAVAIDS & utilities)
* Through the use of third party or FAA legacy spatial data in NextGen, airports are receiving benefits.
  * Situational awareness technologies using ASDE-X data
  * Spatial data technologies that share data between the TRACON and the airport tower
  * Heads up displays in the cockpit for low-visibility
* These are indirect benefits; safety, efficiencies, revenue


Recommendations for Additional Research
* Consideration for UAS in NextGen
* The integration of UAS into the national airspace is a high priority for the FAA and related agencies. An in depth study of the spatial data needs for UAS planning and operations and ways in which GIS can support UAS is recommended.
* Common set of spatial data standards
* DO 272 and AC 150/5300-18 are two standards that are either required or recommended for spatial data development. An assessment of the potential for merging them into one industry standard is warranted.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
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	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
FAST	Fixing America's Surface Transportation Act (2015)
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
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
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
TDC	Transit Development Corporation
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

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