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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP RESEARCH REPORT 180

Guidebook for Quantifying Airport Ground Access Vehicle Activity for Emissions Modeling

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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.

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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.

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FOREWORD

By Joseph D. Navarrete
Staff Officer
Transportation Research Board

ACRP Research Report 180 provides guidance with regard to accounting for ground access vehicle (GAV) activity in airport emissions studies. This guidance will be of particular interest to airport environmental and transportation planners, air quality modelers, and regulatory agencies desiring clarity and consistency with regard to determining data needs based on study objectives and for collecting the data in an accurate, cost-effective manner.

Airports conduct air quality studies for various reasons, including emissions inventories, conformity determinations, NEPA studies, and health studies. GAVs (typically, private vehicles, taxis, shuttles, rental cars, and delivery vehicles) can be significant contributors to airport emissions and often need to be considered in airport air quality studies. Practitioners use various means for collecting activity data, including airport surveillance systems, toll booth records, and traffic counting mechanisms. In addition, when GAV counts and speeds are surveyed, they must be scaled to represent the base year and future years. The limits of the study area also must be established and can affect data requirements. The variety of approaches and assumptions used to collect and analyze these data has resulted in inconsistent methods and results. Research was therefore needed to develop guidance for quantifying airport GAV activity for the purposes of emissions modeling.

The research, led by KB Environmental Sciences, began with a review of recent literature on the topics of regulatory framework, significance of GAV emissions in an airport setting, GAV fleet and operational characteristics, airport GAV infrastructure (e.g., roadways, parking facilities, and hold areas), data collection techniques, trip generation models, and emissions and dispersion models. The research team then conducted an outreach effort to stakeholders (including airports, regulatory agencies, transportation planners, air quality modelers, and associations) to understand the current state of the practice and to solicit suggestions for desired features of the guidebook. The research team then developed the guidebook and interactive tutorial.

The guidebook and tutorial cover such topics as establishing study area boundaries, identifying areas with GAV activity, defining types of GAVs, determining data requirements, evaluating and selecting data collection techniques, modeling future conditions, and obtaining off-airport GAV data. The tutorial can be accessed and downloaded from a link on the report webpage, available at www.trb.org by searching “ACRP Research Report 180”.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

SUMMARY

This guidebook provides analysts an approach to determining the appropriate level of emissions data needed to model emissions for airport projects. Using a Tier I (Basic), Tier II (Intermediate), or Tier III (Advanced) approach, projects may be categorized based on the type of document that is being prepared, the air quality conditions within the project area, the need for accuracy in the GAV-related emissions estimates, and the public's interest in the project.

The guidebook also discusses methods to obtain and/or derive GAV-specific data for input into various computer models (e.g., MOVES, EMFAC, AEDT, and CAL3QHC/CAL3QHCR). For this purpose, the following topics are presented and discussed:

- Airport-specific GAV and their operational characteristics (Chapter 3);
- General and specific infrastructure where GAV would be expected to operate as well as the identification of individual types of GAV that would operate in each area (Chapter 4);
- Specific data requirements for performing emissions modeling (Chapter 5); and
- Methods/techniques to efficiently collect and develop existing and future GAV data (Chapter 6).

A separate, interactive PowerPoint *tutorial* has been made available with the guidebook to aid in its application. The tutorial is available for download from the guidebook webpage, which can be found at www.trb.org by searching "ACRP Research Report 180". For brevity and ease of use of the guidebook, additional information and data are contained in the *Contractor's Final Report* on ACRP Project 02-63, "Quantifying Airport Ground Access Vehicle Activity for Emissions Modeling," which is accessible from a link on the project webpage. A link to the project page also appears on the guidebook webpage.

CHAPTER 1

Introduction and Background

This guidebook was developed as part of ACRP Project 02-63, "Quantifying Airport Ground Access Vehicle Activity for Emissions Modeling." The guidebook provides a set of identified best practices for obtaining or deriving airport-related ground access vehicle (GAV) data for input into the following computer models or electronic databases:

- Motor Vehicle Emission Simulator (MOVES), from EPA;
- Emissions Factor Model (EMFAC), from the California Air Resources Board (CARB);
- Aviation Environmental Design Tool (AEDT), from FAA;
- AERMOD, from EPA; and
- CAL3QHC and CAL3QHCR line source models, also from EPA.

1.1 Purpose of the Guidebook

The objectives of this guidebook are to provide analysts (e.g., air quality, traffic, planning) with methods to obtain or derive GAV-specific data for input into the listed models. More specifically, the two principal objectives of this guidebook are:

1. To provide clarity and consistency about methods for quantifying airport GAV activity for the purposes of emissions modeling, and
2. To provide guidance that airports can use to collect and/or develop these data in ways that are accurate, cost-effective, and appropriate for the application.

Supporting objectives also important to obtaining or deriving GAV data include defining the types of airport GAV, identifying sources and methods for obtaining GAV data, determining the suitability of data, delineating boundaries for computing GAV emissions, and describing airport GAV infrastructure.

To perform emissions modeling, analysts need an understanding of the various types of GAV, factors that affect the emissions that result from operation of the vehicles, and the airport-related infrastructure on which GAV operate. These topics also are addressed in the guidebook.

The guidebook also presents a systematic, three-tiered approach analysts can follow when making decisions about the data needed for the analysis and for collaborating with others on data collection. Such a methodical, collaborative approach can yield a more cost-effective data collection/data development effort based on the specific needs and circumstances of each air quality assessment. Lastly, a tutorial has been prepared to aid the analyst through this guidebook and its application.

Two primary purposes for obtaining input data and computing GAV-related emissions are (1) airport planning (e.g., to assess the effects of airport improvements on emissions) and (2) support of required National Environmental Policy Act (NEPA) documents that involve the quantification or disclosure of GAV emissions. GAV emissions also may be computed for inclusion in State Implementation Plans (SIPs).

If air emissions modeling must be performed for a proposed airport project/action under NEPA, the air quality assessment will be one component of a much larger set of analyses that probably address surface transportation/traffic planning, airport noise, and a number of other environmental impact categories and issues.

The air quality analyst is seldom the entity responsible for the actual collection of the GAV data that are needed for emissions modeling. Most often, data collection is part of the scope of work for ground transportation analysts or traffic engineers. These transportation consultants collect the data primarily for use in traffic studies that support the design of, or change to, an airport's ground transportation system (i.e., access and circulation roads, curbsides, parking facilities, etc.).

Because the air quality analyst often derives the GAV data used in the emissions modeling from the transportation consultants' work, it is helpful if the air quality analyst has early input to the development of the transportation consultants' approach and end-points for data collection (i.e., the transportation consultant's scope of work). This input helps ensure that the resulting data also are useful for emissions modeling.

1.2 Contents of the Guidebook

The guidebook is organized in five chapters that build the content progressively. For guidebook users who wish to focus on particular topics of interest, the *Quick Lookup Guide* (see text box) provides an index to the most commonly cited subject matter.

- **Chapter 2: Computer Models** describes the types and functions of computer models commonly used for computing airport GAV emissions, including MOVES, EMFAC, and AEDT;
- **Chapter 3: Airport GAV Fleet and Operational Characteristics** identifies the various types of airport-related GAV and their operating characteristics, with the emphasis on applying these data and information to the computer models discussed in Chapter 2;

Quick Lookup Guide

Topic	Chapter
• Data collection methods	6
• Fuel types	3
• Future conditions	6
• GAV data requirements	5
• GAV types	3
• Idle times	6
• Infrastructure	4
• Models	2
• Operating speeds	6
• Purposes of modeling	5
• Regional traffic	5
• Speeds	3
• Temporal factors	5
• Tiered approaches	5
• Traffic volumes	6
• Vehicle mix	6

- **Chapter 4: Airport GAV Infrastructure** provides information pertaining to airport facilities on which GAV commonly operate and the types of GAV that occur in these areas;
- **Chapter 5: Emissions Model Data Requirements** contains information pertaining to the data requirements for conducting GAV emissions modeling according to three different approaches (i.e., Tiers I, II, and III); and
- **Chapter 6: Data Collection and Development** discusses the various and appropriate data collection and development methods for computing GAV emissions under both existing and future conditions.

A glossary, references, list of abbreviations, and frequently asked questions and answers are provided in the back matter of the guidebook. For brevity and ease of use of the guidebook, the Contractor's Final Report containing supporting information and data collected or developed during the course of the ACRP Project 02-63 research can be accessed from the project webpage at www.trb.org. Finally, an interactive PowerPoint tutorial is provided to aid in the application of the guidebook. The tutorial can be downloaded from a link on the guidebook webpage.

CHAPTER 2

Computer Models

The emissions from GAV are categorized as being *air pollutants* (i.e., emissions for which National Ambient Air Quality Standards [NAAQS] exist); air pollutant *precursors* (i.e., emissions which secondarily form into air pollutants); *hazardous* air pollutants (HAPs), and *greenhouse gases* (GHGs). This chapter presents an overview of the computer models that are used to derive airport GAV emission rates to prepare inventories of the pollutants, precursors, HAPs, and GHGs, and to prepare estimates of pollutant concentrations. More specific information pertaining to each model's applications, design features, input and output data, and other functional parameters is available in the Contractor's Final Report for ACRP Project 02-63.

2.1 Emissions Rate Models

The MOVES and EMFAC models are the requisite software for computing on-road motor vehicle emissions factors throughout the United States. MOVES can be used to estimate motor vehicle emissions for any part of the United States except California. Emission rates for vehicles in California are estimated using the EMFAC model. By definition, on-road motor vehicles are designed and equipped to travel on public roadways and generally comprise automobiles (e.g., passenger cars, vans, motorcycles, etc.), buses, and trucks.

The MOVES model provides both a total emissions inventory as well as emission rates by vehicle type, fuel type, and other factors. At publication of this guidebook, the latest version of the model is MOVES2014a (see box).

For simplified projects/assessments being performed for airports in California, commonly used EMFAC emission rates can be obtained from CARB's web database. More complex studies, which require hourly emissions or emission rates data by temperature and humidity, are obtained from the EMFAC model.

MOVES and EMFAC

- Additional information about the U.S. EPA MOVES software can be obtained at: https://www3.epa.gov/otaq/models/moves/index.htm. MOVES2014a, released in October 2014, became the required model as of October 7, 2016 (79 FR 60343).
- Additional information about the CARB EMFAC software/web database can be obtained at: https://www.arb.ca.gov/msei/msei.htm. The EMFAC2014 model and web-based database (current version 1.0.7), were approved for regulatory planning inventories by the EPA in December 2015 (79 FR 60343).

Both MOVES and EMFAC are applied in the "project-level" mode to derive an emission inventory for an airport. In project-level mode, the models produce emission rates (i.e., mass emissions per unit activity). These emission rates are combined with corresponding activity data to produce emission inventory totals.

2.2 Dispersion Models

FAA's AEDT is the required model for performing air quality analyses for airport-related emission sources, including GAV operating on airport roadways, curbsides, parking facilities, and so forth (see box). For the purpose of modeling dispersing pollutants, the AEDT contains the AERMOD model. AERMOD is the EPA-preferred atmospheric dispersion model for assessing a wide assortment and combinations of stationary and mobile sources of emissions.

The current AEDT release does not include GAV-related sources (e.g., roadways and parking lots). For these sources, emissions are evaluated externally through MOVES and then imported into AEDT. As such, the data requirements for AEDT to prepare an emissions inventory are the same as the requirements described above for MOVES and EMFAC. It is FAA's intent that future releases of the AEDT model will include a roadway network design feature that will allow analysts to geographically define roadway links, parking lots and construction areas on airport property. Analysts will then export the roadway network information, model the emissions with MOVES for the sources that are defined using AEDT, and then import the emissions into AEDT (i.e., GAV emissions will still be evaluated externally through MOVES).

AEDT

- The current version, AEDT2c, was released September 12, 2016.
- Additional information about the AEDT can be obtained at: https://aedt.faa.gov/.

2.3 Hot-spot Models

Assessment of some airport improvement projects that involve GAV may require air pollutant "hot-spot" analysis. (Hot-spots are localized areas of elevated pollutants such as roadway intersections, terminal curbsides, parking garages, etc.) Two EPA-developed computer models can be used for this purpose: CAL3QHC and CAL3QHCR. The CAL3QHC model was developed to predict pollutant concentrations of carbon monoxide (CO) and other inert pollutants from motor vehicles approaching and departing roadway intersections. CAL3QHCR, a more refined version of this model, requires local meteorological data and may be considered on a case-by-case basis. In July 2015, EPA proposed to replace CAL3QHC and CAL3QHCR with AERMOD as the preferred dispersion model for all mobile source modeling of inert pollutants (see box).

AERMOD and CAL3QHC/CAL3QHCR

- Additional information on the AERMOD model is available at: https://www3.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod.
- Additional information about the CAL3QHC/CAL3QHCR software can be obtained at: https://www3.epa.gov/ttn/scram/dispersion_prefrec.htm#cal3qhc.

CHAPTER 3

Airport GAV Fleet and Operational Characteristics

GAV are located on the landside of an airport. GAV users include airline passengers; the entities transporting passengers to, from, and sometimes within the airport; airport employees; airline or airport tenants; and users of airport support vehicles (e.g., vehicles delivering supplies). These airport users travel to, from, and on the access/egress roadway system of the airport in one or more of the following types of GAV:

- Private vehicles;
- Rental cars;
- On-demand taxicabs;
- Pre-reserved taxicabs;
- Pre-arranged limousines;
- On-demand limousines/town cars;
- Door-to-door vans;
- Courtesy vehicles;
- Security vehicles;
- Charter buses;
- Scheduled buses;
- Service and delivery vehicles;
- Transportation Network Company (TNC) vehicles (e.g., Uber, Lyft); or
- Air cargo vehicles.

FAA categorizes airports as being commercial service, cargo service, reliever, and/or general aviation airports. Commercial service airports are further categorized by the number of annual passenger enplanements (i.e., boardings). Whether one, two, or all of the GAV types listed operate at a given airport will depend on the type of airport. For example, a small general aviation airport is unlikely to be on a scheduled bus route, but a large metropolitan airport would most certainly have this service.

For each type of GAV, three factors determine the level of emissions for an individual vehicle within that type of GAV: (1) the fuel used to power the vehicle's engine, (2) the operating speed of the vehicle, and (3) the amount of time the vehicle's engine is running at idle.

An important distinction between the MOVES and EMFAC models is the difference in their vehicle classification schemes. MOVES defines the "source type" as the primary vehicle classification for model input and output. EMFAC2014 uses multiple classification schemes that are named according to the model version that introduced them (e.g., EMFAC2007 and EMFAC2011 vehicle classifications). Table 3-1 describes the types of GAV, gives examples of the vehicles for each type, and lists equivalent vehicle classifications for the MOVES and EMFAC models.

Table 3-1. Mapping of GAV types to MOVES and EMFAC vehicle classifications.

GAV Type [a]	Description	Vehicles in Group [a]	Example Vehicle(s)	MOVES Equivalents [b]		EMFAC Equivalents [c]	
				Vehicle Type	Fuel Type(s)	Vehicle Type	Fuel Type(s) [c]
Private vehicles (PV)	Privately owned and operated vehicles	Automobiles	Chevrolet Malibu	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
		Vans/SUVs	GMC Savana	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501-10,000 lbs.)	Gas, diesel
		Pickup Trucks	Ford F-150	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501-10,000 lbs.)	Gas, diesel
		Motorcycles	Victory Gunner	Motorcycle	Gas	Motorcycle	Gas
Rental cars (RC)	From companies on or near airport	Automobiles	Chevrolet Malibu	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
		Vans/SUVs	GMC Savana	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501-10,000 lbs.)	Gas, diesel
		Pickup Trucks	Ford F-150	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501-10,000 lbs.)	Gas, diesel
On-Demand Taxicabs (ODTs)	Typically vehicles capable of transporting five passengers	Automobiles	Ford Crown Victoria	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
		Vans/SUVs	GMC Savana	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501–10,000 lbs.)	Gas, diesel
Pre-Reserved Taxicabs (PRTs)	Typically vehicles capable of transporting five passengers	Automobiles	Ford Crown Victoria	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
		Vans/SUVs	GMC Savana	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501–10,000 lbs.)	Gas, diesel
Vehicles Owned by a Transportation Network Company (TNC) such as Uber or Lyft	Privately owned and operated vehicles	Automobiles	Chevrolet Malibu	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
		Vans/SUVs	GMC Savana	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501–10,000 lbs.)	Gas, diesel
		Pickup trucks	Ford F-150	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501–10,000 lbs.)	Gas, diesel
Pre-Arranged Limousines (PALs)	Typically vehicles capable of transporting five passengers (more for stretch)	Automobiles	Lincoln Town Car	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
On-Demand Limousines or Town Cars (ODLTCs)	Typically vehicles capable of transporting five passengers	Automobiles (Town Car)	Lincoln Town Car	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel

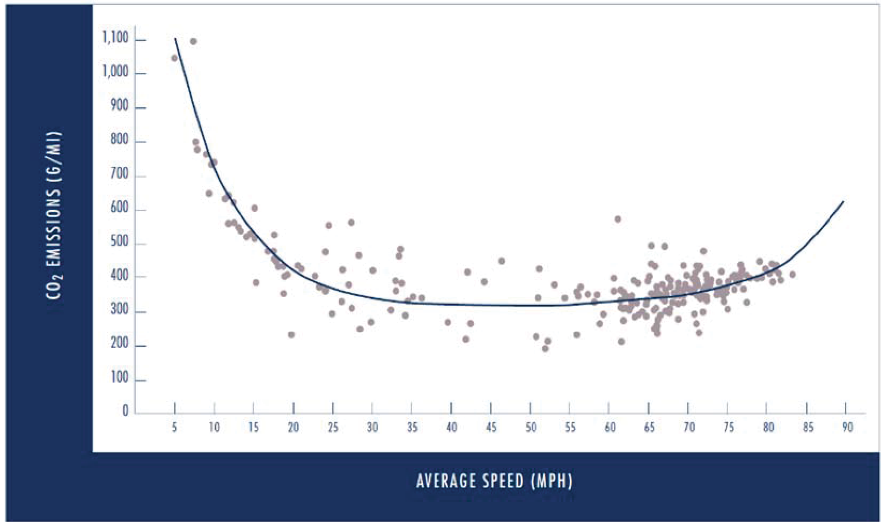
Table 3-1. (Continued).

GAV Type [a]	Description	Vehicles in Group [a]	Example Vehicle(s)	MOVES Equivalents [b]		EMFAC Equivalents [c]	
				Vehicle Type	Fuel Type(s)	Vehicle Type	Fuel Type(s) [c]
Door-to-Door/ Shared Ride Vans (D2D/SRVs)	Typically vehicles capable of transporting eight to ten passengers	Vans	Ford E150	Light commercial truck	Gas, diesel, E-85, electric	Light heavy-duty truck (up to 8,501 lbs.), light heavy-duty truck (8,501-10,000 lbs.)	Gas, diesel
Courtesy Vehicles (CVs)	Shared-ride transportation by hotels, motels, rental car company, parking lot operators. Typically eight to twelve-passenger vans, minibuses and full size buses	Vans	Ford E150	Light commercial truck	Gas, diesel, E-85, electric	Light heavy-duty truck (up to 8,501 lbs.), light heavy-duty truck (8,501-10,000 lbs.)	Gas, diesel
		Minibuses	Turtle Top Odyssey	Short-haul single-unit truck	Gas, diesel	Light heavy-duty truck (10,001-14,000 lbs.)	Gas, diesel
		Buses	Motor Coach Industries 102-DW3SS	Transit bus	Gas, diesel, CNG	Urban bus	Diesel, gas, natural gas
Buses (scheduled or charter)	--	Buses	Motor Coach Industries 102-DW3SS	Transit bus	Gas, diesel, CNG	Urban bus	Diesel, gas, natural gas
Service and Delivery Vehicles (S/DV)	Transport goods, air cargo, mail, contractors, refuse, etc.	Trucks	Kenworth T170	Short-haul single-unit truck	Gas, diesel	Medium-heavy-duty diesel truck (10,001-26,000 lbs.)	Diesel
			Kenworth T270	Refuse truck	Gas, diesel	Heavy heavy-duty diesel solid waste collection truck	Diesel, natural gas
		Vans	GMC Savana	Light commercial truck	Gas, diesel, E-85, electric	Light heavy-duty truck (8,501-10,000 lbs.)	Diesel, gas
		Semi-trailers	Kenworth T800	Short-haul combination truck	Gas, diesel	Heavy heavy-duty diesel tractor	Diesel
	Small package delivery service	Light trucks	Freightliner P1000	Short-haul single-unit truck	Gas, diesel	Light heavy-duty truck (10,001–14,000 lbs.), medium heavy-duty diesel truck (14,001–26,000 lbs.)	Gas, diesel
		Vans	GMC Savana	Light commercial truck	Gas, diesel, E-85, electric	Light heavy-duty truck (8,501–10,000 lbs.)	Diesel, gas
Airport Vehicles (AVs) and Security Vehicles	Vehicles owned/operated by airport/airline staff and by airport security personnel	Automobiles	Chevrolet Malibu	Passenger car	Gas, diesel, E-85, electric	Passenger car	Gas, diesel
		Vans and sport utility vehicles (SUVs)	GMC Savana	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501–10,000 lbs.)	Gas, diesel
		Pickup trucks	Ford F-150	Passenger truck	Gas, diesel, E-85, electric	Light-duty truck (1 and 2), medium-duty truck, light heavy-duty truck (8,501–10,000 lbs.)	Gas, diesel

[a] *ACRP Report 40*: *Airport Curbside and Terminal Area Roadway Operations* (LeighFisher 2010)

[b] Table 2-6 from *Population and Activity of On-road Vehicles in MOVES2014a* (EPA 2015b)

[c] Table 6-1A from *EMFAC2014 Volume III – Technical Documentation* (CARB 2014)



Source: Barth and Boriboonsomsin (2016).

Figure 3-1. Emissions–speed plot of individual trips or trip segments.

3.1 Fuel Type

The most significant factor that determines the level of emissions from a vehicle is the fuel that powers the vehicle's engine. The engines and fuel types associated with airport-related GAV vary somewhat, but the majority of engines are fueled by gasoline. Other fuels include, but are not limited to, the following:

- Diesel,
- Compressed natural gas (CNG),
- Liquefied petroleum gas (LPG),
- Ethanol (E-85), and
- Electric.

For each type of GAV, the fuel types listed in each of the emissions models also are shown in Table 3-1.

3.2 Operating Speed

A vehicle's operating speed is another factor that determines the level of emissions. For example, emissions of carbon dioxide (CO_2), a significant GHG, are greatest at motor vehicle speeds less than 10 miles per hour (mph) and decrease substantially as the speed of a vehicle increases (see Figure 3-1). Within any given area of an airport, the range of vehicle speeds will vary depending on location (e.g., an access roadway versus an airport curbside), the GAV driver's familiarity with the airport or area of the airport, and the posted speed limits.

3.3 Idle/dwell Time and Delay Time

For a GAV air quality assessment, *idle/dwell time* refers to periods of continuous engine operation while the vehicle is stopped curbside at an airport's terminal (i.e., at the enplane and deplane areas). *Delay* refers to periods of engine-on time while a vehicle is stopped at an intersection.

CHAPTER 4

Airport GAV Infrastructure

The airside areas of an airport are restricted; they are accessible only to aircraft and airport/airline employees and to already-screened and ticketed passengers (who follow controlled pathways to board their designated aircraft). The landside areas of an airport are fully accessible to the public. On an airport's landside, GAV operate in the following general areas:

- Roadways,
- Parking facilities, and
- Hold areas (i.e., vehicle staging/queuing areas).

If an airport has service areas such as transit bus stops and "kiss-n-fly" passenger drop off locations, GAV may also operate in these additional areas.

Table 4-1 lists the general and specific airport GAV infrastructure for which data collection methods are presented in this guidebook, as well as the types of GAV expected to operate in each of these areas. In practice, the existence of these areas (and the types of vehicles operating in an area) will be airport-specific.

Table 4-1. GAV infrastructure.

GAV Infrastructure		GAV Operating in Each Area										
General	Specific	PV	RC	ODT	PRT	TNC	PAL	ODLTC	D2D/ SRV	CV	Bus	S/DV
Roadways	Access	X	X	X	X	X	X	X	X	X	X	X
	Curbside	X	X	X	X	X	X	X	X			
	Circulation	X	X	X	X	X	X	X	X	X	X	X
	Service											X
	Cargo	X										X
	Airfield											X
Parking Facilities	Surface	X										
	Multi-level	X										
	Employee	X										
	Cell phone	X										
	Hotel	X										
	Rental car		X									
	Off-airport	X										
Vehicle Staging/ Queuing Areas	On-demand taxi/limousine			X				X				
	Limousine						X	X				
	Door-to-door/shared ride								X			
	Hotel/motel shuttles									X		
	Parking shuttles (on airport)									X		
	Parking shuttles (off airport)									X		
	TNC	X										
Other	Kiss-n-Fly	X										
	Transit stop										X	
	Pre-arranged taxi/Limousine				X		X					
	Charter bus										X	
	Cargo facilities	X										X

PV = Private vehicle
RC = Rental car
ODT = On-demand taxi
PRT = Pre-reserved taxi
TNC = Transportation network company
PAL = Pre-arranged limousine
ODLTC = On-demand limousine/town car
D2D/SRV = Door-to-door/shared ride van
CV = Courtesy vehicle
Bus = Scheduled bus
S/DV = Service/delivery vehicle

CHAPTER 5

Emissions Model Data Requirements

This guidebook is primarily intended to help air quality analysts identify, collect, and/or develop the data and information necessary to compute GAV emissions. It also is intended to assist specialists (e.g., traffic engineers or planners, airport planners, and others) who may be responsible for the actual collection (or development) of the GAV data.

Fortunately, much of the GAV-related data developed by a traffic specialist can also be used by the air quality analyst for emissions modeling. Because the traffic specialist's work can be the air quality analyst's main source of GAV data, it is desirable that the air quality analyst and the traffic specialist coordinate at the outset of a data collection phase. Early coordination can ensure that the traffic specialist's data collection efforts will also satisfy the needs of the air quality analyst.

5.1 Emissions Model General GAV Data Requirements

This section of the guidebook is designed to assist the air quality analyst in determining the types of data and specific information needed to conduct GAV emissions modeling. Using this guidance, the air quality analyst can find descriptions of the specific GAV data they will need to prepare emissions inventories or perform dispersion analysis for airport projects of various types, sizes, and complexities.

5.1.1 Purposes for Emissions Modeling at Airports

Airport GAV emissions modeling may be conducted for various purposes or applications, each of which has an appropriate approach.

One purpose of emissions modeling at airports is compliance with federal environmental rules and regulations. Most federally funded improvements or modifications at airports will require disclosure of a project's potential environmental impacts as part of compliance with NEPA. Air quality studies (including emissions modeling) are among several environmental impact categories evaluated in NEPA studies. The documentation required for NEPA compliance differs with the significance and anticipated impacts of the project. Documents that may be required for NEPA compliance are:

- **Categorical Exclusion (CATEX).** A project's impact may be documented in a CATEX if the extent of the impact is relatively small or insignificant.
- **Environmental Assessment (EA).** An EA is prepared when it is unclear whether the federally funded project will have a significant effect on the environment.
- **Environmental Impact Statement (EIS).** If, through existing knowledge or the results of an EA, a federally funded project is determined to have a potential significant impact on the environment, an EIS is prepared. Projects for which an EIS is prepared typically have more opportunities for public review and comment.

The General Conformity Rule of the Clean Air Act (CAA) also may apply to an airport project if the project is located in an area designated as being either "non-attainment" or "maintenance" for any of the NAAQS (40 CFR 93). The status of the air quality within an area with respect to the NAAQS can be obtained from EPA's online Green Book, available at https://www.epa.gov/green-book. The severity of an area's non-attainment status for an individual pollutant may also dictate the level of air quality analysis that is required (levels of non-attainment for a pollutant may be designated as extreme, severe, serious, moderate, or marginal).

Two major objectives of this guidebook are to provide a consistent approach to categorizing the different types of projects for which emissions modeling is required and to define specifically the GAV data collection that is appropriate for each category of project. By following the guidelines, air quality analysts can more efficiently determine GAV data input needs and achieve consistency among emissions modeling studies.

5.1.2 Summary of General GAV Data Required for Emissions Modeling

Regardless of the purpose or requirement for the emissions modeling, the collection or development of certain model input data will be required. While emissions models differ in their purpose and design, the input data required to compute GAV-related emissions are typically similar and somewhat consistent. Generally, these data are:

- Traffic volume,
- Vehicle mix,
- Operating speed, and
- Idle/dwell time.

The configuration/geometries of the airport GAV infrastructure upon which GAV travel to, from, and around the airport (e.g., roadways, parking facilities) also are required to compute emissions. The basic GAV data must be collected relative to the airport GAV infrastructure, as summarized in Table 5-1.

The time periods for which representative GAV data are collected or derived are the same regardless of GAV area. To prepare an inventory of total emissions that occur during a calendar year, an air quality analyst only requires data for an average annual daily condition.

When performing dispersion analysis, an air quality analyst requires data that can be used to derive activity at an airport for every hour of a year. For example, if the traffic specialist/engineer has collected or derived GAV data for the peak hour of an average day, factors to derive the activity occurring every other hour of the day will be required (24 factors with the peak hour assigned a value of one). The air quality analyst also will require factors to derive weekly emissions (seven factors) and factors to derive monthly emissions (12 factors).

Figure 5-1 illustrates hourly, daily, and monthly temporal factors for an airport at which the maximum GAV volume is observed/recorded from 4 p.m. to 5 p.m. on a Friday in August. The temporal factors are listed above the bars in each chart (hourly, daily, and monthly).

5.2 Determining Specific GAV Data Needs (Project-by-Project)

The emissions models discussed will always require input data within the general categories described above. It is important to note, however, that *varying levels* of data are appropriate, depending on some basic study factors. The quantity, depth, complexity, and precision

Table 5-1. General GAV activity data requirements for emissions modeling.

GAV Infrastructure		Required Data				
		Volume				
General	Specific	Entering	Exiting	Vehicle Mix [a]	Average Speed [b]	Idle/Dwell Time
Roadways	Access	X		X	X	
	Curbside	X		X		X
	Circulation	X		X	X	
	Service	X		X	X	
	Cargo	X		X	X	X
	Airfield	X		X		
Parking Facilities	Surface	X	X			
	Multi-level	X	X			
	Employee	X	X			
	Cell phone	X	X			X
	Hotel	X	X			
Vehicle Staging/ Queuing Areas	On-demand Taxi/limousine	X	X			X
	Limousine	X	X			X
	Door-to-door/shared ride	X	X			X
	Hotel/motel shuttles	X	X			X
	Parking shuttles (on airport)	X	X			X
	Parking shuttles (off airport)	X	X			X
	TNC	X				X
Other	Kiss-n-Fly	X				X
	Transit stop	X				X
	Pre-arranged Taxi/limousine	X				X
	Charter bus	X				X
	Cargo facilities	X		X		X

[a] For the purpose of an air quality analysis, a GAV fleet mix is not required in areas where only one type of GAV is operating (i.e., notwithstanding the fact that private vehicles comprise various types of vehicles, it can be assumed that only private vehicles would operate in an airport parking facility).

[b] Average speed means average operating speed. For the purpose of an air quality analysis, an average speed of 20 mph or less can be assumed for all parking facilities, vehicle staging/queuing areas, and other airport areas.

of GAV data appropriate for one project can differ substantially from what is needed for another project.

In the "Traffic Volume" category, for example, a major airport reconstruction or expansion effort may need to incorporate data from existing traffic counts and future forecasts for a substantial number of roadway segments. On the other hand, a minor project at a smaller airport may not require counts at all, but rather can estimate traffic volumes based on aviation activity (e.g., number of passengers, number of flights). The appropriate level of GAV data should be collected and developed for each type/size/purpose of study. To facilitate this, the guidebook establishes three "tiers" into which projects may be categorized according to type, size, complexity, and other parameters. The tier approach is discussed in the next section.

5.2.1 Categorizing Projects for Emissions Modeling (the Tier Approach)

For categorizing airport projects to determine the appropriate types and levels of emissions data needed for each, this guidebook uses three tiers: Tier I: Basic, Tier II: Intermediate, and Tier III: Advanced.

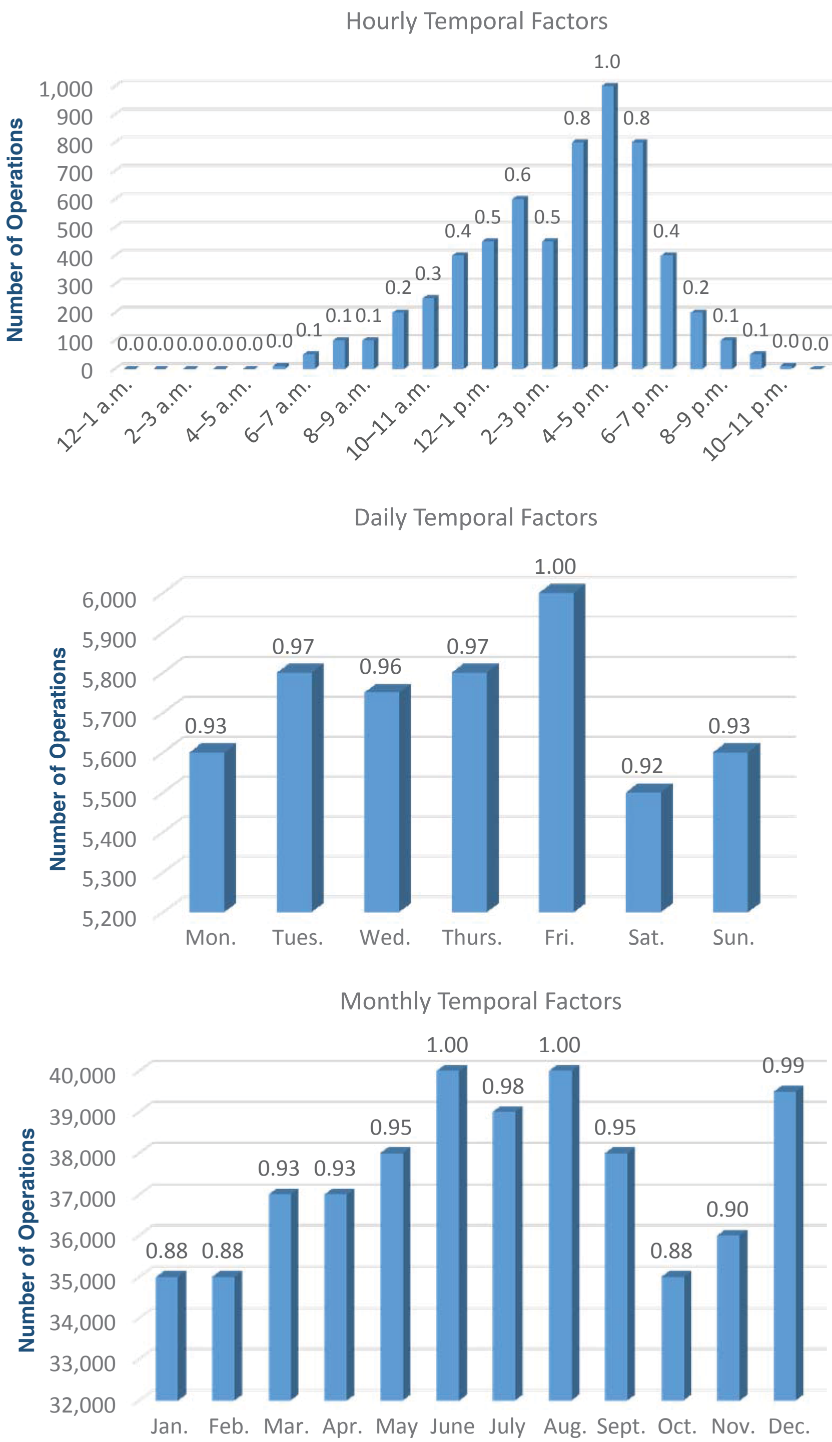


Figure 5-1. Temporal factors.

	Tier I (Basic)	Tier II (Intermediate)	Tier III (Advanced)
Document Type	CATEX	EA	EIS
Attainment Status	Attainment	Maintenance/ Nonattainment	Serious to Extreme Nonattainment
Public Interest	Limited	Moderate	Ample

Figure 5-2. Tiered approach to quantifying airport GAVs for emissions modeling.

Figure 5-2 depicts the three tiers, along with the appropriate project characteristics for determining to which tier a given project should be categorized for purposes of computing GAV-related emissions. Factors are listed on the left side of the matrix (i.e., federal document type, attainment status, and public interest). Table 5-2 provides expanded descriptions of the project factors and characteristics for each of the tiers.

Virtually any airport project requiring emissions modeling will have a “best fit” with one of the three tiers. For example, Table 5-3 lists the air quality assessment examples in Figure 4-5 of FAA’s *Air Quality Handbook* and shows how the projects would be categorized based on a need to model GAV emissions (if applicable to the project), using the tier approach. When determining the appropriate level, or tier, for any given project, the air quality analyst should involve the project sponsor (e.g., the airport owner/operator) and the appropriate regulatory agencies (e.g., FAA, state/local air quality board) in the decision.

5.2.2 GAV Data Needs by Tier

Once the air quality analyst has determined into which tier a project will fit, the next challenge is to know what level of GAV data needs to be collected or developed to support the emissions modeling. Using the tiered approach provides the air quality analyst with specific guidance so that future emissions modeling for similar project types can use the same, or a similar, approach.

The Tier I, II, and III data requirements presented in this section are necessary to prepare an air emissions assessment for existing conditions at an airport and, if the assessment will be used to evaluate proposed improvements, to project future conditions with and without the improvements (reflecting “build” and “no-build” alternatives).

5.2.2.1 Tier I Data Requirements

Table 5-4 presents the GAV data needed for Tier I analyses. In the absence of airport-specific data, or for a minor project with limited GAV activity associated with an airport improvement, the minimum amount of airport-specific data required for GAV emissions modeling would be the number of average daily trips (i.e., the volume of traffic) entering an airport. The average daily number of GAV entering one of the specific GAV infrastructure areas also may be required if the area is of interest in the evaluation (e.g., if an airport improvement project involves adding a new multi-level parking lot). For the remaining emissions modeling data

Table 5-2. Description of tier factors.

Factor	Tier I (Basic)		Tier II (Intermediate)		Tier III (Advanced)	
	Data Level	Description	Data Level	Description	Data Level	Description
Document Type [a]	CATEX	A category of actions that do not, individually or cumulatively, have a significant effect on the human environment, with the result that neither an EA nor an EIS is required.	EA	Prepared when a proposed action does not fall within the scope of a CATEX and does not require an EIS.	EIS	One or more environmental impacts (of the project or action) would be significant, and mitigation measures cannot reduce the impact(s) below significant levels.
Attainment Status [b]	Attainment	Applies to areas where air pollution levels do not exceed the NAAQS. [c]	Maintenance/ marginal to moderate non-attainment	Applies to areas where air pollution levels did/do exceed the NAAQS. [c]	Serious to extreme non-attainment	Applies to areas where air pollution substantially exceeds the NAAQS. [c]
Public Interest	Limited	The airport and/or the proposed action are not controversial.	Moderate	The airport and/or the proposed action may be controversial.	Ample	The airport and/or a proposed project are controversial.

[a] FAA Order 1050.1F (July 16, 2015a).

[b] EPA Green Book (www3.epa.gov/airquality/greenbook).

[c] Refers to project-related emissions. If dispersion modeling is to be performed, an expectation that an exceedance of the NAAQS would be predicted should also be considered when selecting a tier level.

Table 5-3. Airport project/tier assignment.

Project/Action Category	Model GAV [a]	Tier I	Tier II	Tier III
Project Type				
New Airport	H			X
New Runway	M		X	
Major Runway Extension	M		X	
New or Expanded Terminal	H			X
Relocated Terminal	H			X
Roadway Modifications	H			X
New or Expanded Cargo or Fixed-Base Operator (FBO) Facility	M		X	
New or Expanded Parking	H			X
New or Expanded Utility Plant	L	X		
New Fuel Storage System	L	X		
New or Modified Taxiway	L	X		
Runway Safety Area	L	X		
Runway Rehabilitation	L	X		
Obstruction Removal	L	X		
Air Traffic Control Tower	L	X		
Action Type				
Increase in Aircraft Operations	H			X
Change in Runway Utilization	L		X	
Change in Vehicle Mix	M		X	
Increase Taxi Time/Delay	L	X		
Increase in Motor Vehicle Trips	H			X
Air Traffic Procedures < 3,000 ft.	M		X	
Air Traffic Procedures > 3,000 ft.	L	X		
Land Acquisition	L	X		
Navigational System	L	X		
Policy Type				
Change in Parking Fees	L	X		
Change in Length-of-Stay	L	X		
Change in Mass Transit Fares	L	X		
Parking Facility Planning	M	X		

[a] Indicates likelihood that GAV emissions will be modeled: H = High, M = Medium, L = Low

categories (e.g., vehicle mix, vehicle speed[s], and idle/dwell time), the conservative assumptions listed in Table 5-4 can be made.

5.2.2.2 Tier II Data Requirements

Reflecting the anticipated greater potential impacts on air emissions of airport projects that fit in the Tier II category, the emissions modeling will be somewhat more analytical and precise. The GAV data required for input to the emissions modeling will be more detailed. Table 5-5 provides a comprehensive listing of the GAV data needs for Tier II.

Table 5-5 is intended to be used as a checklist. Working with the traffic engineer/specialist who will be responsible for actual collection/development of the data, the air quality analyst can use this table to ensure that a consistent and standard level of analysis is performed for any Tier II project.

With the exception of roadways, the data required for a Tier II analysis is the same as that required for a Tier I analysis (Tier I and II requirements that are the same are shaded in gray in Table 5-5). For roadways, average daily vehicle trips by GAV are required for each specific infrastructure area (i.e., access roadway, curbside, circulation roadways, etc.).

Table 5-4. Required GAV data—Tier I.

GAV Infrastructure		Required Data			
General	**Specific**	**Volume**	**Vehicle Mix** [a]	**Speed**	**Idle/Dwell Time**
Roadways	Access	Average daily trips entering airport.	Assume a 50-50 split of passenger cars/trucks and composite fuel.	Assume 20 mph.	Not considered in analysis.
	Curbside				
	Circulation				
	Service				
	Cargo				
Parking Facilities	Surface	If project involves parking, average daily trips to parking facility of interest.	Assume a 50-50 split of passenger cars/trucks and composite fuel.	Assume 10 mph.	Not applicable.
	Multi-level				
	Employee				
	Cell phone				
	Hotel				
	Rental car				
	Off airport				
Vehicle Staging/ Queuing Area(s)	On-demand taxi/ limousine	If project involves staging area(s), average daily trips to area of interest.	For taxi/limousine areas, assume a 50-50 split of passenger cars/trucks and composite fuel. For shared ride and shuttle areas, assume a 50-50 split of light commercial trucks and short-haul single-unit trucks and composite fuel.	Assume 10 mph.	Assume dwell times shown in Table 6-3.
	Limousine				
	Door-to-door/shared ride				
	Hotel/motel shuttles				
	Parking shuttles (on airport)				
	Parking shuttles (off airport)				
	TNC				
Other GAV Area(s)	Kiss-n-Fly	If project involves one of the "other" GAV areas, average daily trips to the area.	For Kiss-n-Fly and taxi/limousine areas, assume a 50-50 split of passenger cars/trucks and composite fuel. For transit stop and charter bus areas, assume buses and composite fuel. For cargo facilities, assume short-haul single-unit trucks and composite fuel.	Assume 10 mph.	Assume dwell times shown in Table 6-3.
	Transit stop				
	Pre-arranged taxi/limousine				
	Charter bus				
	Cargo facilities				

[a] Vehicle types are discussed in Chapter 3 (see Table 3-1. Mapping of GAV types to MOVES and EMFAC vehicle classifications).

Table 5-5. Required GAV data—Tier II.

GAV Infrastructure		Required Data			
General	**Specific**	**Volume**	**Vehicle Mix [a]**	**Speed**	**Idle/Dwell Time**
Roadways	Access	Average daily trips for each specific area.	Assume vehicle mix percentages for GAV for each area in Table 3-1.	Use posted speeds for access, circulation and service areas. For curbside and cargo assume 20 mph.	Not considered.
	Curbside				
	Circulation				
	Service				
	Cargo				
Parking Facilities	Surface	If project involves parking, average daily trips to lot.	Assume a 50-50 split of passenger cars/trucks and composite fuel.	Assume 10 mph.	Not applicable.
	Multi-level				
	Employee				
	Cell phone				
	Hotel				
	Rental car				
	Off airport				
Vehicle Staging/ Queuing Area(s)	On-demand taxi/limousine	If project involves staging area(s), average daily trips to area of interest.	For taxi/limousine and TNC areas, assume a 50-50 split of passenger cars/trucks and composite fuel. For shared ride and shuttle areas, assume a 50-50 split of light commercial trucks and short-haul single-unit trucks and composite fuel.	Assume 10 mph.	Assume dwell times shown in Table 6-3.
	Limousine				
	Door-to-door/shared ride				
	Hotel/motel shuttles				
	Parking shuttles (on airport)				
	Parking shuttles (off airport)				
	TNC				
Other GAV Area(s)	Kiss-n-Fly	If project involves one of the "other" categories, average daily trips to area.	For Kiss-n-Fly and taxi/limousine areas, assume a 50-50 split of passenger cars/trucks and composite fuel. For transit stop and charter buses areas, assume buses and composite fuel. For cargo facilities, assume short-haul single-unit trucks and composite fuel.	Assume 10 mph.	Assume dwell times shown in Table 6-3.
	Transit stop				
	Pre-arranged taxi/limousine				
	Charter bus				
	Cargo facilities				

Note: Shaded areas denote GAV data needs that are the same for Tier I and Tier II.

[a] Vehicle types are discussed in Chapter 3 (see Table 3-1. Mapping of GAV types to MOVES and EMFAC vehicle classifications).

5.2.2.3 Tier III GAV Data Requirements

For those airport projects that require a Tier III analysis (the highest level of analysis using the most precise and customized data), the collection effort is the most comprehensive, time-consuming, and resource-intensive. Table 5-6 can be used as a checklist for identifying and applying standardized, consistent data needs for Tier III projects.

For a Tier III analysis, airport- and study-specific GAV volumes are required for all general and specific infrastructure areas of the airport, for airport- and study-specific vehicle mix data for the airport's roadways, and for shared ride and shuttle areas. For roadways, vehicle-speed assumptions may still be used in cargo areas and at the airport's enplane and deplane curbsides. However, airport-specific vehicular speed data should be collected for access, circulation, and service area roadways, as well as for idle/dwell times of the vehicles at curbside.

Table 5-6. Required GAV data—Tier III.

GAV Infrastructure		Required Data			
General	**Specific**	**Volume**	**Vehicle Mix [a]**	**Speed**	**Idle/Dwell Time**
Roadways	Access Curbside Circulation Service Cargo	Peak-hour data and temporal factors (peak hour to average day, week, and month).	Vehicle mix for each area.	Use observed, measured actual or derived speeds for access, circulation and service areas. For curbside and cargo, assume 20 mph.	Use airport-specific idle/dwell times for curbside.
Parking Facilities	Surface Multi-level Employee Cell phone Hotel Rental car Off airport	Peak-hour data and temporal factors (peak hour to average day, week, and month).	Assume a 50-50 split of passenger cars/trucks using a composite fuel.	Assume 10 mph.	Not applicable.
Vehicle Staging/ Queuing Areas	On-demand taxi/limousine Limousine Door-to-door/shared ride Hotel/motel shuttles Parking shuttles (on airport) Parking shuttles (off airport) TNC	Peak-hour data and temporal factors (peak hour to average day, week, and month).	For taxi/limousine and TNC areas, assume a 50-50 split of passenger cars/trucks and composite fuel. For shared ride and shuttle areas, use airport-specific vehicle mix and composite fuel.	Assume 10 mph.	Assume dwell times shown in Table 6-3.
Other GAV Area(s)	Kiss-n-Fly Transit stop Pre-arranged taxi/ Limousine Charter bus Cargo facilities	Peak-hour data and temporal factors (peak hour to average day, week, and month).	For Kiss-n-Fly and taxi/limousine areas, assume a 50-50 split of passenger cars/trucks and composite fuel. For transit stop and charter bus areas, assume buses and composite fuel. For cargo facilities, assume short-haul single-unit trucks and composite fuel.	Assume 10 mph.	Assume dwell times shown in Table 6-3.

Note: Shaded areas denote GAV data needs that are the same for Tier I and Tier II.

[a] Vehicle types are discussed in Chapter 3 (see Table 3-1. Mapping of GAV types to MOVES and EMFAC vehicle classifications).

CHAPTER 6

Data Collection and Development

The air quality analyst typically makes decisions about the appropriate level, quantity, and precision of GAV data in consultation with the regulatory agency requiring the study. This chapter focuses on the techniques used to collect the GAV data. Typically, decisions about the appropriate collection techniques are made by the traffic engineer/specialist who will be responsible for the actual collection of the data.

Collection techniques range from the very simple (e.g., manual traffic counts) to the highly-technical (e.g., collection of global positioning system [GPS] data, use of ultrasonic sensors). Any technique—or, more commonly, a combination of these techniques—may be used for any GAV data collection effort, regardless of which tier the project may fall under.

6.1 GAV Data Collection—Existing Conditions

Table 6-1 lists many of the options available to collect basic GAV data on existing traffic volumes, vehicle speeds, and vehicle types. The options are categorized as being simple, automated, or intelligent based on the need to use specialized technology (e.g., automated traffic recorders [ATRs] or an intelligent transportation system [ITS]). The table also indicates the applicability to emissions modeling of the data obtained using each technique in relation to volume, vehicle class, and speed, and notes whether the option involves temporary and/or permanent arrangements or installations. The text in this section addresses the data collection options in relation to specific parameters (e.g., traffic volume, vehicle mix, operating speed, and idle/dwell time) that are needed for emissions modeling.

6.1.1 Traffic Volume

Regardless of the airport infrastructure for which GAV traffic volumes are desired, the simplest method of collecting GAV-related traffic volumes is for individuals equipped with hand-held counters and/or electronic or paper forms to record the data manually. Depending on the traffic volumes, the number of locations for which volumes are desired, or the duration of the survey, this method can be cost-effective for small or uncomplicated applications. This method can be labor intensive, however, and it can become costly as the complexity of the data collection increases.

A more advanced Tier II approach to collecting traffic volume data involves technologies such as ATRs. ATRs can be permanently embedded into the roadway in strategic locations or (as is typically done with pneumatic road tubes) temporarily set for a time period and then removed at the completion of the data collection period.

Higher-level traffic management systems are among those categorized as ITSs. These systems monitor traffic flow and other parameters, providing data on “real-time” conditions. Other ITSs

Table 6-1. GAV data collection techniques.

Simple [1]	Automated [1]	Intelligent [1]
Use no special technology [2]	Use automated traffic recorders (ATRs) [2]	Use intelligent transportation systems (ITSs) [2]
• Manual traffic counts (V, C, T)	• Pneumatic road tubes (V, C, S, T) • Video image processors and recording data collection (V, C, S, P/T)	• Inductive loop detectors (V, C, S, P) • Magnetic sensors (V, S, P) • Microwave radar sensors (V, C, S, P) • Active infrared sensors (V, C, S, P) • Passive infrared sensors (V, S, P) • Laser radar sensors (V, C, S, P) • Acoustic array sensors (V, S, P) • Pulse/Doppler ultrasonic sensors (V, S, P) • Piezo-electric sensors (V, C, S, P) • Bending plates (V, C, P) • Sub-pavement magnetometers (micro-loops) (V, S, P) • Weigh-in-motion sensors (V, C, P) • GPS cell phone data collection (V, C, T)

[1] Applications: V = Volume, C = Vehicle Classification, S = Speed
[2] Arrangement/Installation: P = Permanent, T = Temporary, P/T = Permanent or Temporary

include infrared, radar, video, and acoustic technologies that can involve either permanent installations or temporary arrangements based on the purpose of the analysis.

6.1.2 Vehicle Mix

Given the range of GAV that travel on airport roadways, particularly large international airports, determining the mix of vehicles often is a challenge. Large airports with complex roadway networks can have multiple access/egress gateways and roadways that are relegated to patron, cargo, and other special purposes. Thus, the vehicle mix can differ substantially by roadway type and/or segment.

The simplest method to use is to record vehicle types manually. This method also allows for the collection of more specific fleet data (e.g., visually, a passenger car can be readily distinguished from a commercial taxi). As with data collection for traffic volumes, the size and type of airport and the duration of the data collection period can have a significant impact on the accuracy and cost of this data collection method. In the absence of actual measured or observed airport-specific data, the fleet information provided in Table 3-1 of this guidebook could be used to develop a vehicle mix for each GAV area of interest, assuming a fleet that would result in a conservative estimate of emissions.

Among the more advanced methods for determining vehicle mix is the use of ATRs that are capable of providing vehicle classifications as well as volume data. The technologies listed in Table 6-1 can also provide data on vehicle mix. Although the higher-level automated techniques often can measure the number of axles (which would segregate passenger cars from some service trucks/buses), these techniques cannot distinguish among the categories of airport-related vehicles that use similar vehicle types (e.g., private passenger cars versus taxis). If a refined vehicle mix is desired (e.g., for a Tier II or III assessment), an estimate can be developed from data on travel mode choices (see Table 6-2). Data about travel mode choice typically will be captured through air passenger surveys.

6.1.3 Operating Speed

The simplest method of collecting operating speed data is to assume the posted speed limit or the design speed for a roadway. Speed data may also be collected using radar detectors similar to those used by law enforcement, measuring the time it takes a vehicle to traverse a roadway

Table 6-2. Travel mode choice data collection methods and sources for traffic count programs.

GAV Infrastructure		Collected Data	Source
General	Vehicles		
Roadway	Curbside cars, vans, buses, etc.	Vehicle volume and mix	Curbside observations/counts
Parking Facilities (Surface and Multi-Level)	On-airport cars and trucks	Vehicle entries and exits	Transaction/gate data or driveway counts
	Off-airport cars, vans, buses, etc.	Vehicle entries and exits	Parking transaction/gate data, driveway counts, or courtesy shuttle boarding counts
	Rental vehicles (cars)	Vehicle entries and exits	Rental transaction data, driveway counts, or courtesy shuttle boarding counts
Vehicle Staging/ Queuing Areas	On-demand Taxis/Limousines	Vehicle volume	Curbside observations/counts, taxi dispatch data, or taxi pool driveway counts
	Door-to-door/shared ride cars and vans	Vehicle volume or the number of air passengers per shuttle	Curbside observations/counts, shuttle boarding counts, or reservation data
	Hotel/motel shuttles	Vehicle volume or the number of air passengers per shuttle	Curbside observations/counts, shuttle boarding counts, or shuttle schedule
	Parking shuttles (on and off airport)	Vehicle volume or the number of air passengers per shuttle	Curbside observations/counts, shuttle boarding counts
Other	Public transit buses and vans	Vehicle volume or the number of air passengers per shuttle	Curbside observations/counts, vehicle boarding counts, station gate counts, or transit schedule/frequency
	Charter buses	Vehicle volume or the number of air passengers per bus	Curbside observations/counts, bus boarding counts

segment with a known length and dividing by the length, or by travel-time runs (i.e., speeds taken by a driver or passenger in a car). If more refined data are necessary or required, ATRs and Advanced Traffic Management System (ATMS) or other advanced data collection technologies can be used to measure vehicular speeds in addition to volumes and vehicle mix.

6.1.4 Idle/dwell Time

Idle and dwell time, or the time a vehicle spends parked at the terminal curb, is defined as the time from when a driver parks a vehicle until the time the vehicle departs the curbside area. An analysis that uses the Tier I approach—which minimizes or avoids extensive field work in the GAV data collection effort—can use the average curbside dwell times presented in *ACRP Report 40: Airport Curbside and Terminal Area Roadway Operations* (LeighFisher 2010) (see Table 6-3). The times presented in the table are based on measured dwell times at airports in Memphis (medium hub), Oakland (medium hub), Portland (medium hub), San Francisco (large hub), and Washington, D.C. (large hub).

For a Tier II analysis, manual recordings and observations can also be made to determine average dwell time, but it should be noted that this technique can be labor intensive depending on the length of curbside and the resources available.

To collect more refined idle/dwell times (e.g., for a Tier III analysis), use of advanced data collection technologies (e.g., video analytics) should be considered.

Table 6-3. Curbside dwell times.

Vehicle Type	Average Dwell Time (minutes)	
	Enplane Level	Deplane Level
Private Vehicle	3	5.2
Taxicab	2	--
Limousine	2.5	5.2
Door-to-Door Van	3	--
Courtesy Van	4	1
Scheduled Bus	5	--

Source: ACRP Report 40 (LeighFisher 2010)

6.1.5 Existing Data Collection Considerations

Table 6-4 summarizes the optional approaches to collecting and/or developing data about the existing traffic volume, vehicle mix, average travel speed, and idle/dwell times of GAV operating at an airport. Any combination of these techniques may be used for GAV data collection for any emissions inventory; however, the more advanced and automated techniques will generally be appropriate for Tier II or Tier III analyses.

Whether the analyst chooses a Tier I, Tier II, or Tier III approach, several factors—including time of day, day of the week, and time of year—are important considerations when collecting GAV data. These factors are:

- **Time of day/duration.** Airport vehicle activity can vary significantly by time of day. GAV emissions analysis sometimes dictates the use of the roadway peak hour, so it is important to determine when the airport roadway peak hour occurs. The roadway peak hour does not necessarily, or even typically, coincide with the airport flight schedule. An airport's departures-level roadways are typically busiest an hour or more prior to the peak flight departure time of the day. The arrivals-level roadways are typically busiest an hour or more after the peak number of arriving flights.
- **Day of the week.** Depending on the airport, activity can vary significantly by day of the week. At commercial airports, the busiest days typically are Mondays through Fridays. At a general aviation airport, the busiest day may occur on the weekend.
- **Time of year/seasonality.** Airport activity also varies depending on the time of year. When developing a count program, it is important to understand this nuance. Care should be taken when extrapolating hourly or daily counts to annual average daily or annual counts. The season during which a count is obtained may need to be considered, along with special events (e.g., air shows) that may sometimes occur at an airport. Data collected during peak seasonality will represent a conservative assessment of landside conditions.

Table 6-4. Data recording methods for existing conditions.

Vehicle Parameter	Simplest Methods	Methods Using Some Automation	Methods Using Highest Levels of Automation
Traffic Volume	Manual counts	ATRs (temporary)	ATMS and advanced collection technologies
Vehicle Mix	Manual counts Fleet (see Table 3-1)	Vehicle classification ATRs	Advanced collection technologies
Average Speed	Manual recording Posted speeds Roadway design speeds	Speed ATRs	ATMS and advanced collection technologies
Idle/dwell Time	*ACRP Report 40* dwell times	Manual recording/ observations	Video analytics

- **Lead and lag times.** Air passengers arrive via GAV prior to their scheduled departure (lead time) and depart via GAV after their scheduled arrival (lag time). Lead and lag times can vary significantly based on several factors, including passenger characteristics and airport operational characteristics. For example, air passengers arriving via international flights require longer lag times because of immigration and customs processing. Lead and lag time data are typically obtained through air passenger surveys or using data from peer airports with similar air passenger and operational characteristics.
- **Cold versus warm starts.** The GAV data for parking facilities may also include the operating conditions of the parked vehicles. As a rule, cold-starting motor vehicle engines emit more emissions than warm-starting vehicles. For this reason, GAV that have been parked for several hours or days are characterized by "cold" engine emissions, whereas those parked for shorter periods (up to a few hours) are treated as "warm starts." To simulate these differing engine operating modes, MOVES provides emission factors that are representative of each condition.
- **Other input factors.** This guidebook focuses on collecting the appropriate traffic data for conducting emissions modeling of airport GAV. MOVES files obtained from state and local agencies will include other, area-specific input factors.

6.2 GAV Data Development—Future Conditions

To perform emissions modeling of future conditions at an airport, data about GAV volumes, vehicle mix, average speed, and idle/dwell time also are required. Typically, these forecasts are based on the results of the data collection effort for existing conditions (see box). Anticipated future projects (e.g., a new airport roadway, relocated parking structure, or new terminal) that would alter travel patterns and paths also have to be included in the analysis. This section of the guidebook presents methods and data collection techniques that can be used to derive data representative of predicted future conditions.

Estimating Future Conditions

Preparing the data necessary for computing future GAV emissions presents unique challenges. Forecasting methods necessarily involve uncertainties. Generally, however, the more accurate and refined the data are for inputting critical parameters, the more accurate and reliable will be the outputs.

6.2.1 Traffic Volume

Growth in GAV traffic volume on airport roadways typically results from changes in the numbers of airline passengers, airport employees, employees of supporting concession and other airport tenants, employees who service cargo and airmail facilities, and airport service and delivery functions. As with estimating existing conditions, the effort required to estimate future traffic volume can vary based on the purpose of the emissions calculation. For example, the development of a GHG emissions inventory for planning purposes is a relatively simple project. In this case, the analyst may choose to simply multiply the traffic volume of existing GAV in each area of an airport's landside by a simple growth factor. On the other hand, the NEPA process may require greater effort to estimate GAV emissions for future airport activity and traffic volumes resulting from new airport projects.

ACRP Report 40 (LeighFisher 2010) introduced the following four-step transportation modeling approach to estimate future airport roadway traffic volumes:

- Step 1. Estimate traffic volume for each on-airport land use (i.e., trip generation).
- Step 2. Determine trip distribution.
- Step 3. Analyze the travel mode choice.
- Step 4. Distribute the estimated traffic volumes to the airport roadways.

Mode choice analysis (Step 3) requires a sophisticated travel demand forecasting model. In an airport setting, Step 3 typically is not required unless a new travel access mode (e.g., rail service to the airport) is introduced into the transportation system. Notably, the other three steps require their own set of collected data and analysis processes. The next section provides an overview of the data inputs necessary to complete Step 1, the estimation of traffic volume for each on-airport land use.

6.2.1.1 Airline Passengers

This section of this guidebook presents the tiered approaches to estimating the growth in airline passengers at an airport. Among other factors, it discusses how changes in the number of passengers who begin or end their flights at an airport might affect this growth, how these changes might influence other travel choices made by passengers (e.g., using private versus shared rides), and when the peak volumes of GAV traffic would be expected compared to the peak aircraft arrival and departure times.

6.2.1.1.1 Growth in passenger numbers. Future air passenger numbers are a function of future flight schedules, aircraft size (number of seats), and anticipated percentage load factor. This information can generally be found in recent airport master plans, the FAA Terminal Area Forecast (TAF), and other sources. It is important to understand whether the projected growth is evenly distributed throughout the day or if it is tied to specific time periods (i.e., during specific peak periods or at midday), as the pattern of increased numbers has a direct impact on peak-hour GAV volumes.

6.2.1.1.2 Originating and destination (O-D) passengers. O-D passengers are those whose flight itinerary begins or ends at the airport in question, as opposed to those whose flights connect within the airport. Because air passengers who arrive and connect to flights within the airport do not exit the airport terminals, changes in their numbers do not influence GAV volumes. It is important, however, to consider changes in the mix of O-D air passengers. If an airport's anticipated growth is largely due to its activity as an airline hub, GAV volumes may not increase at the same rate as other airport metrics. Existing originating and terminating air passenger data can be found online in the Airline Origin and Destination Survey (DB1B), available at https://www.transtats.bts.gov/DatabaseInfo.asp?DB_ID=125 (U.S.DOT n.d.). The database is based on a 10% sample of airline tickets collected by U.S. airlines. The future O-D passenger mix should be determined based on airport estimates from recent master plans, traffic studies, and/or anticipated changes in airline operations.

6.2.1.1.3 Passenger characteristics. Air passenger GAV travel patterns are a direct function of several passenger characteristics, such as trip purpose (business/non-business), place of residence (local resident/non-resident), and type of flight (short-haul domestic, long-haul, transborder, overseas, or other). For example, local residents traveling for business are more likely to use private vehicles and on-airport parking than are visiting non-residents. For modeling purposes, data regarding passenger characteristics typically are obtained through air passenger surveys commissioned by the airport or by governing authorities.

6.2.1.1.4 Lead and lag times. In general, lead and lag times will stay constant from existing to future conditions unless significant changes are made to air passenger processing time (e.g., customs immigration throughput, security procedures).

6.2.1.1.5 Vehicle occupancy. In addition to travel mode choice, vehicle occupancy (i.e., the number of passengers per vehicle) also factors into conversion of air passenger volumes to vehicle volumes. Vehicle occupancy data can be acquired through air passenger surveys or through curbside observations, particularly for multi-party vehicles. Vehicle occupancy data also can be obtained from peer airports; however, caution must be observed when applying this data to other airports. Table 6-5 provides typical vehicle occupancy rates at airports.

6.2.1.1.6 Traffic circulation patterns. GAV activity often is not as simple as an arrival or departure of a vehicle. Vehicles might take many different travel paths, depending on the travel mode choice and the configuration of the roadway network. Some passenger trips may include use of several travel modes. For example, passengers who arrive at a transit station at the airport may also use an airport circulator shuttle on trips of varying length to access specific terminals. Airport passengers who are traveling in a group also may choose to drive together to the airport, drop off one or more other passengers at an airport curbside check-in prior to parking their vehicles, and then have the driver(s) rejoin their travel party. It is important for the analyst to understand the nuances of their airport's transportation system and GAV behavior and adjust their analyses accordingly. Data regarding circulation patterns may be captured in air passenger surveys or using existing precedents. In general, future vehicle circulation patterns can be assumed to follow existing patterns unless significant changes are made to the airport's roadway network. Table 6-6 provides the typical vehicle circulation patterns of originating airline passengers.

6.2.1.1.7 Summary—passengers. Based on the discussion in this section, the various options for methods to estimate future passenger-related GAV activity can be generally matched to the tiered approaches as shown in Table 6-7.

6.2.1.2 Visitors

Airport passengers are sometimes accompanied by non-traveling members of the public prior to their departing flight and/or greeted upon their arrival (i.e., "meeters" and "greeters"). The number of these airport visitors typically is a function of the passengers' trip purpose and destination, with higher numbers of airport visitors associated with international and leisure air

Table 6-5. Typical vehicle occupancy at airports.

Mode	Typical Vehicle Occupancy
Curbside	1.2
Short-term parking	1.3
Long-term parking	1.3
Off-airport parking	1.3
Rental car	1.4
Taxicab	1.5
Limousine	1.5
Door-to-door shuttle	4.0
Hotel/motel courtesy vehicle	2.6
Public transit	5.0
Charter/other bus	15.0

Source: ACRP Report 40 (LeighFisher 2010)

Table 6-6. Typical vehicle circulation patterns—originating passengers.

Travel Mode	Circulation Pattern	Percentage
Private Vehicle(s)	Drop off at curb, then exit	31
	Drop off at curb, then park – Hourly, remain	9
	Drop off at curb, then park – Hourly, then exit	4
	Drop off at curb, then park – Daily parking	7
	Drop off at curb, then park – Economy parking	4
	Direct to park – Hourly, remain for duration	4
	Direct to park – Hourly, exit immediately	14
	Direct to park – Daily	14
	Direct to park – Economy	9
	Direct to off-airport location	4
	Total	100
Rental Cars	Direct to rental car return	73
	Drop off at curb, then rental car return	23
	Direct to off-airport location	4
	Total	100
Taxicabs	Drop off, then exit	83
	Drop off, then hold area	17
	Total	100

Source: LeighFisher (July 2009), based on data gathered at Los Angeles International, Salt Lake City International, Tampa International, and other airports

Table 6-7. Tier methods—future passenger-related GAV activity.

Factor	Tier I (Basic)	Tier II (Intermediate)	Tier III (Advanced)
Future Air Passenger Growth	Use FAA TAF, airport master plan or documented regional or economic growth forecast		Analysis based on airport-specific future flight schedule, aircraft size, and load factor
Shifts in O-D Air Passengers	Use existing FAA airport O-D data and assume no shift in O-D mix	Estimates from recent master plans and/or analysis based on airport-specific future flight schedules and airline hub activity	
Passenger Characteristics	Air passenger survey		
Lead and Lag Times	Air passenger survey or data from peer airports		
Travel Mode Choices	Air passenger survey or comprehensive count program		
Vehicle Occupancy	Data from peer airports	Curbside observations	Air passenger survey
Traffic Circulation Patterns	Data from peer airports	Air passenger survey	Origin-destination license plate survey or microsimulation

passenger trips. Based on the airport's operations and facilities (e.g., the availability and cost of short-term parking or availability of a cell phone lot), visitors will have unique on-airport trip patterns. Data on visitor-generated traffic can be obtained through air passenger surveys or through a combination of curbside observations and short-term parking transaction data.

6.2.1.3 Employees

GAV employee-generated traffic characteristics are largely a function of the number of employees, their travel mode choice, the on-airport driving patterns, and work schedules. A partial list of on-airport employers with staff includes:

- Airport operator and third-party contractors such as janitorial, parking operators, and bus operators;
- Airlines, including flight crews, maintenance staff, and terminal employees;
- Concessionaires and other airport tenants such as rental car companies, food service companies, and retail establishments;
- Government agencies, including TSA, FAA, U.S. Customs and Border Protection (CBP) and DHS, and the U.S. Postal Service;
- Air cargo shippers;
- Fixed-base operators (FBOs); and
- Construction contractors.

The data needed to calculate traffic volumes generated by employees working at airports includes:

- Employee population,
- Employee travel mode choices,
- Employee circulation patterns, and
- Employee work schedules.

Given the varying staff and work hours, establishing a representative GAV count is sometimes difficult. For example, non-standard work hours could affect the traditional "peak" hour or "peak day" volumes. Further, many of the airport employees are not directly managed by the airport operator, which adds to the challenges of collecting these data.

ACRP Report 40 provides estimated average daily number of employees for large and medium hub airports and reveals a wide range in each employee category (LeighFisher 2010). Employee surveys based on travel mode choices, work schedules, and travel patterns are among the most common methods for collecting these data. Alternatively, employee GAV data can be estimated based on entry and exit counts at employee parking areas.

Non-Passenger GAV Trips

Quantifying motor vehicle trips associated with airport employees, delivery vehicles, and non-aviation activities is possible, but may not warrant extensive efforts given their comparatively small contribution to airport-wide emissions.

6.2.1.4 Air Cargo

GAV trips generated by air cargo (including airmail) include vehicles transporting the cargo, cargo facility employees' private vehicles, and cargo customers' vehicles. According to *ACRP*

Report 40, the volume of GAV trips generated by air cargo should be estimated separately from that generated by airport employees (LeighFisher 2010). Also, trip generation rates for air cargo are unique to individual airports. The two most available dependent variables related to air cargo (cargo tonnage and air cargo facility size) typically are not reliable indicators for GAV activity.

For Tier I air quality assessments, if cargo-related GAV should be considered in the assessment, the trips can be assumed to be included in the background traffic at the airport. For Tier II or Tier III assessments, trip generation rates can be calculated using the arrival or departure of cargo tonnage over a defined time period or periods.

6.2.1.5 Service and Delivery Vehicles

Service and delivery vehicles include those vehicles providing goods and materials to/from the terminal building loading docks, transporting individuals performing maintenance and construction, vehicles being used by emergency response (police, fire, emergency medical service), and other vehicles making trips not directly generated by airport passengers, employees, or air cargo (LeighFisher 2010). Often, data on these vehicles are not readily available. Moreover, the data collected at selected airports are not easily transferrable to other airports. Additional research on this GAV category is necessary if these vehicles are to be specifically identified in the emissions assessment. Otherwise, they should be assumed to be included in an airport's background traffic.

6.2.1.6 Other Airport Land Uses

Other airport land uses may generate GAV trips and contribute to the GAV volumes on airport roadways. In general, GAV trips related to such other uses are difficult to quantify and, given their relatively low numbers compared to total airport volumes, they should be considered as background traffic. For a particular assessment, if other airport-related land uses are estimated to be significant, standard trip generation rates can be used to estimate vehicular volumes.

6.2.1.7 Non-Airport Vehicles Using Airport Roadways

Some on-airport roadways may be used by vehicles that do not originate on or travel to the airport, and that are not otherwise associated with the airport. These vehicles' "cut-through" trips can affect airport GAV activity levels. Determining the volume (or proportion) of cut-through trips on airport roadways requires information on such vehicles' entry and exit points as well as the shared roadway segments. License plate surveys (tracking the entry and exit point of a vehicle by capturing its license plate information) or data from tolling tags can be used to determine the proportion of non-airport vehicles. The analyst also should be aware of any major roadway infrastructure or land use changes within the region that may shift travel patterns and increase or decrease cut-through trips along on-airport roadways.

If available, a regional travel demand model can be used to determine the proportion of non-airport vehicles traveling on a roadway link and the implications of future transportation infrastructure or land use changes on cut-through trips on airport roadways.

6.2.1.8 Summary—Future Traffic Volumes

This section has presented approaches to developing future-year GAV for airport visitors, employees, vehicles related to air cargo, and service and delivery vehicles (i.e., non-passenger traffic volumes). Considerations for other airport land uses and non-airport vehicles that use airport roadways were introduced. From this discussion, it is possible to generally align the estimation techniques discussed with the tier-levels identified for emission inventory studies, as shown in Table 6-8.

Table 6-8. Tier methods—future non-passenger-related traffic volumes.

Factor	Tier I (Basic)	Tier II (Intermediate)	Tier III (Advanced)
Visitors	Data from peer airports	Air passenger survey	Origin-destination license plate survey or microsimulation
Employees	Assume as part of background volumes	Development of employee trip generation rates based on entry and exit counts at employee parking areas (if no additional modal options exist) and total number of employees	Development of employee trip generation rates based on data from employee transportation survey and total number of employees
Air Cargo	Assume as part of background traffic	Development of air cargo trip generation rates based on entry and exit counts at air cargo area(s) and total tonnage of cargo over time	
Other Airport Land Use	Assume as part of background traffic	Use of ITE trip generation rates (if applicable for land use type)	
Non-Airport Vehicles Using Airport Roadways	Assume proportion of vehicle volume cut-through traffic	License plate survey or regional travel demand model	

6.2.2 Distributing Future Roadway Traffic

Step 2 for estimating future-year GAV is determining the volume distribution from the airport entry and exit point(s) and on the airport's roadways. Some airports have a single entry and exit gateway while other airports have several. In some cases the entry and exit point is a single intersection; in others, it is as complex as a regional highway interchange. In all cases, the analysts should determine which roadways are within the scope of the air emissions assessment and, if it is possible, develop cordons that isolate airport traffic from non-airport traffic.

Existing distributions of airport trips may be used to project the distribution of future GAV volumes. This approach is applicable for Tier I and II assessments. Some caution should be taken, however, as regional land uses and transportation infrastructures may change over time, shifting the overall trip distribution at the entry and exit point(s).

For a Tier III analysis, a regional travel demand model can be used to determine the trip distribution at the airport's entry and exit points. Regional travel demand models typically reflect changes in regional land use and transportation infrastructure, particularly over longer time horizons.

Mode choice analysis—Step 3 of the four-step approach—requires a sophisticated travel demand forecasting model and is typically not required in an airport setting unless a new travel access mode to the airport is introduced into the transportation system.

In Step 4, future volumes on airport roadways are assigned. At this point, the traffic engineer should already have determined (1) the overall increase in GAV volume, by user and mode if applicable; (2) the locations where these new GAV trips will enter and/or exit the airport; and (3) the origin and destination points within the airport.

To assign volumes to on-airport roadways, GAV travel paths are first defined. Typically, GAV travel paths are chosen based on circulation patterns and on paths that reflect the shortest travel times. Unlike city streets, internal airport roadways limit the number of path options, which simplifies this analysis. Private vehicle GAV will typically follow wayfinding signs that guide them through the airport to major airport destinations. Service vehicles, taxis, and other GAV operated by drivers familiar with the airport roadways typically find and follow the quickest paths.

Changes in traffic volumes, particularly increases, can affect airport roadway congestion and also affect travel time. A microscopic transportation model (e.g., VISSIM or Transmodeler) can account for changes in travel time and balance the volumes assigned to multiple travel paths. However, GAV operators will typically not deviate to different routes unless they are guided to do so or are familiar with the roadway network. Finally, some vehicular volumes may need to be reassigned if the airport road network changes or if significant changes occur in on-airport land use.

6.2.3 Vehicle Mix, Operating Speed, and Idle/Dwell Time

Determination of the future airport-related GAV fleet mix largely depends on the purpose and time horizon of the analysis. For example, if the analysis involves a short-term time horizon, the analyst can generally assume a vehicle mix similar to existing conditions. If the time horizon is several years or more, however, a number of important questions should be considered:

- What are the macroscopic changes to the transportation system?
- What are the anticipated changes to travel options?
- What airport policies affect or address these changes?
- What fuel and technology will be employed?

Future-year vehicle speeds also should be considered. Such speeds often are functions of roadway geometry, vehicular volumes, driver behavior, and future technology. Increases in vehicular volume may further constrain congested roadway conditions, decreasing vehicular speeds. The analyst can choose to assume that vehicle speeds remain constant over time or conduct simulation analyses that take into account these variables.

A variety of factors could affect the length of time during which vehicles idle/dwell at airport terminal curbsides (i.e., departure/arrival curbs and other airport vehicle staging areas). For Tier I assessments, this data can be assumed to be included as a component of the GAV vehicles operating near the terminal area. For Tier II, an idle/dwell time based on existing conditions may be used, with adjustments, if necessary. For Tier III, obtaining specific terminal area traffic data is the most desirable approach.

The Tier I, Tier II, and Tier III assumptions and methods for future vehicle mix, operating speed, and idle/dwell time are summarized in Table 6-9.

Table 6-9. Tier methods—future vehicle mix, operating speed, and idle/dwell time.

Factor	Tier I (Basic)	Tier II (Intermediate)	Tier III (Advanced)
Future Vehicle Mix	Same as for existing condition		Special considerations
Average Speed	Same as for existing condition		Microsimulation analysis
Idle/Dwell Time	Same as for existing condition		

6.2.4 Regional (Off-Airport) GAV Data

When preparing an airport air quality assessment, the most common convention is to include only the GAV that operate within the airport's property line because doing so is consistent with two common tenets of airport emissions modeling:

- **SIP surface transportation emissions.** All motor vehicles operating on the regional roadway network (i.e., off-airport property) are understood to be accounted for in this category of emission sources. If they are included in an allocation for an airport, the emissions would be "double-counted."
- **"Foreseeable and practicably controllable."** This phrase from the federal CAA General Conformity Rule applies to emissions sources over which the sponsoring agency (i.e., FAA or the airport authority) has jurisdiction. In the case of airport GAV, it is often successfully argued that when the GAV are off the airport property, the agency has little to no control over their movements or operating conditions.

Occasions and reasons exist for preparing emissions associated with GAV that occur outside the airport's boundaries. For example, if a proposed project is forecast to increase the number of commercial aircraft operations at an airport, an estimate would be computed of the emissions attributable to the increase in passengers traveling to and from the airport.

Emissions that occur outside an airport's boundary are a function of travel distances, speeds, and roadway conditions. Commonly represented as vehicle-miles traveled (VMT), the associated data can be assumed or derived using a variety of methods, although none of the methods are considered to be "standard" or airport-specific.

For illustrative purposes, Figure 6-1 demonstrates the "gravity" model, an often-used approach to estimating off-airport GAV VMT. The example assumes an airport (in this example, a non-hub airport) surrounded by three municipalities of varying sizes (i.e., varying populations). The towns also are located at varying distances from the airport. The population and distance from the airport to each town are presented in Table 6-10. Using these data, a weighted VMT (per vehicle) is calculated as follows:

$$\begin{aligned}\text{Weighted travel distance} = &(\text{Distance to Town A} \times \text{percentage of total area population})\\ &+(\text{Distance to Town B} \times \text{percentage of total area population})\\ &+(\text{Distance to Town C} \times \text{percentage of total area population}).\end{aligned}$$

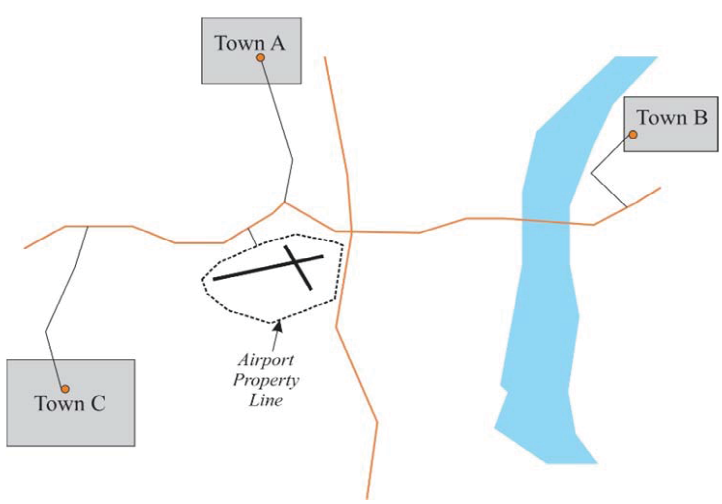


Figure 6-1. Example, off-site GAV trip distances (gravity model).

Table 6-10. Regional (off-airport) GAV travel distance (gravity model method).

Town	Distance from Airport (miles)	Population	Percentage of Total Area Population	Weighted Distance (in miles) to/from Airport (one-way)
A	4.5	20,000	27.78	1.25
B	10.0	12,000	16.67	1.67
C	8.5	40,000	55.56	4.72
Total	**--**	**72,000**	**100.00**	**7.64**

The gravity model method may be appropriate if the analyst is developing a regional (off-airport) GAV forecast for an uncomplicated project emission inventory (e.g., Tier I). When the analyst is performing a Tier II or Tier III air quality assessment, the estimation of regional airport GAV traffic requires that a large amount of data be obtained and analyzed (typically through air passenger surveys). This data is then used in a mathematical spreadsheet model to develop a "moderate" estimate of regional GAV data (Tier II) or fed into a regional travel demand model (Tier III).

The survey data needed to estimate regional airport GAV traffic data include:

- Travel mode share,
- Mode share vehicle occupancy rate,
- Regional origin (e.g., zip code), and
- Distance from regional origin to airport.

The air quality analyst or traffic engineer will also need to assume or develop GAV fleet mixes and travel speeds. For a Tier I analysis, the national default MOVES/EMFAC fleets can be used. For a Tier II analysis, a coarse assessment can be prepared using data from air passenger surveys. Finally, if a Tier III analysis is necessary, a regional travel demand model should be used to develop the required data.

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Abbreviations

AEDT	Aviation Environmental Design Tool
ATR	Automated traffic recorders
CAA	Clean Air Act
CARB	California Air Resources Board
CATEX	Categorical Exclusion
CFR	Code of Federal Regulations
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
E-85	Ethanol
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMFAC	Emissions Factor Model
FBO	Fixed-base operator
GAV	Ground access vehicles
GHG	Greenhouse gas
GPS	Global positioning system
HAPs	Hazardous air pollutants
ITS	Intelligent transportation system
LPG	Liquid petroleum gas
MOVES	Motor Vehicle Emission Simulator
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
O-D	Originating and destination
SIP	State Implementation Plan
TAF	Terminal area forecast
TNC	Transportation network company

Glossary

California Air Resources Board (CARB)—A clean air agency established by the government of California in 1967. One of CARB's responsibilities is the setting/refinement of emissions standards for the motor vehicles sold/registered to operate within the state.

Clean Air Act (CAA)—A federal law established in 1970 to regulate air emissions from stationary and mobile sources. The CAA was amended in 1977 and 1990, at which time new timelines were established for areas of the United States to achieve attainment of the NAAQS.

Dispersion modeling—The mathematical simulation of the dispersement of air pollutants in the ambient (i.e., outdoor) air.

Emissions modeling—Preparation of data for input to a computer model that provides estimates of air pollutants, pollutant precursors, hazardous air pollutants (HAPs), and/or greenhouse gases (GHG). Estimates of the individual pollutant, precursor, or gas typically are expressed in tons per year.

General Conformity Rule—Under the CAA's General Conformity Rule, federal non-highway and transit agencies must work with state, tribal, and local governments in an air quality non-attainment or maintenance area to ensure that actions by the agencies conform to plans to reduce or maintain levels of air pollutants to comply with the NAAQS.

Ground access vehicles (GAV)—Motor vehicles that travel to, from, and on the airport's access/egress roadways and other landside facilities (e.g., parking areas).

Hot-spot analysis—An air quality assessment for a location where emissions from one or more specific sources may expose the public to elevated pollutant concentrations.

Hub airport—An airport at which passengers arrive from multiple cities and countries and shortly thereafter depart to a different airport. FAA categorizes hub airports as being small (processing from 0.05% to 0.25% of all passenger boardings/enplanements within the United States), medium (processing 0.25% to 1% of the boardings), and large (processing more than 1% of the boardings).

Originating and destination (O-D) passengers—Passengers whose flight itinerary begins or ends at an airport (as opposed to those whose flights connect within the airport).

Transportation Conformity Rule—A requirement of the CAA, this rule ensures that federal funding and approval are given to highway and transit projects that are consistent with the air quality goals established by individual states to reduce and/or maintain levels of air pollutants to comply with the NAAQS.

Trip generation models—Computer models that estimate the number of home-based motor vehicle trips to and from zones where "trip makers" (i.e., destinations) are located.

Vehicle-miles traveled (VMT)—A measurement of the total number of miles traveled by all vehicles within a specified region, area, or roadway over a specified period of time.

Frequently Asked Questions

Questions that an air quality or traffic analyst/planner may have when collecting or developing GAV data for an airport air quality analysis include:

Q1. *The emission rate output from MOVES is provided by speed bin. How do I calculate emission rates for a particular speed?*

A. A linear interpolation can be done to calculate intermediate speeds (EPA).

Q2. *Do the GAV data requirements described in this guidebook apply only to airport-related projects?*

A. No. Regardless of whether the motor vehicles involved are airport related or non-airport related, the same general data requirements apply (i.e., volume, fleet, speed, and idle/dwell time).

Q3. *Do any of the air quality models or methodologies provide default values for the GAV-related data that is required input for the computer models?*

A. An air quality analyst could choose to run the MOVES model in "national scale"; however, this approach is not encouraged by the EPA. Doing so causes the model to assume default data for inputs such as the GAV fleet mix, and significantly reduces the precision of the results of an airport assessment.

Q4. *What is the cost/price of applying the automated and intelligent data collection techniques listed in Table 6-1 of this guidebook?*

A. The cost of applying these techniques varies depending on the number of locations at which the equipment/sensor would be installed and from which manufacturer/vendor the equipment is purchased. For this reason, specific costs are not provided in this guidebook.

Q5. *What is the useful life of the techniques listed in Table 6-1 of this guidebook?*

A. The useful life of the equipment/sensors varies depending on the manufacturer/vendor of the equipment/sensor. For this reason, the useful life of the techniques is not provided in this guidebook.

Q6. *During what phase of a project's environmental impact assessment should a ground transportation/traffic engineer and an air quality analyst discuss the GAV data that would be required for the air quality models necessary to evaluate the project?*

A. It is helpful if an air quality analyst has early input to the development of a transportation consultant's approach and end-points for data collection (i.e., the scope of work), to ensure that the resulting data can be used for the emissions modeling.

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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