Improving Ground Support Equipment Operational Data for Airport Emissions Modeling

DETAILS

152 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-37493-4 | DOI 10.17226/22084

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 149

Improving Ground Support Equipment Operational Data for Airport Emissions Modeling

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Saint Petersburg, FL

Subscriber Categories
Aviation • Environment • Vehicles and Equipment

Research sponsored by the Federal Aviation Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2015
www.TRB.org

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

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ACRP REPORT 149

Project 02-46
ISSN 1935-9802
ISBN 978-0-309-37493-4
Library of Congress Control Number 2015957200

Cover photo: Airbus A-380 and Tow Tug; photo by M. Kenney, KBE 2014.

Published reports of the

AIRPORT COOPERATIVE RESEARCH PROGRAM

are available from

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet by going to

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Printed in the United States of America

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FOREWORD

By Theresia H. Schatz
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ACRP Report 149: Improving Ground Support Equipment Operational Data for Airport Emissions Modeling is a guidance document that provides a potential update to the current set of default ground support equipment (GSE) fleet and activity data used for passenger and cargo aircraft and a protocol to improve the accuracy and consistency of data collection for airport GSE activity compatible with Emissions and Dispersion Modeling System (EDMS), and the Aviation Environmental Design Tool (AEDT). This guidance document can be used by airport operations, environmental and planning personnel, and other stakeholders for the purpose of understanding and improving local air quality.

The updated set of default GSE fleet and activity values address the number and type of vehicles by aircraft code (e.g., A, B, C, D, etc.); difference between type of operations (i.e., dedicated cargo vs. passenger operations); time in operational mode (including idling); and gate deicing vehicles. The airport-specific data-gathering protocol includes the parameters (i.e., time in operational mode, climatic conditions) to be collected; recommendation of statistically valid sample sizes; operational considerations for start-up and mobilization of equipment (i.e., when is the equipment actually in use for the aircraft or in transit); coordination with airlines; and safety considerations. The guidance is tailored to airports of different sizes (small, medium, large/international); airports of different climates; limitations of the current default GSE fleet; various fueling methods (e.g., hydrant system vs. fuel trucks); availability and utilization of aircraft parking position utilities (availability of ground power and pre-conditioned air); and is applicable to newer aircraft (i.e., A380, B787).

Estimating an airport's contribution to a region's overall air quality is often required for State Implementation Plans (SIPs), Health Risk Assessments (HRAs), National Environmental Policy Act (NEPA) analyses, other emission inventory programs, and for grant applications, such as FAA's Voluntary Airport Low Emissions (VALE) program. Although airport GSE can provide significant contributions to an airport's overall emissions, little guidance is available to help airports accurately capture actual GSE activity at their facilities in a manner suitable for the FAA's approved emissions models, EDMS and the AEDT. This can result in inaccurate predictions of air quality impacts because staff may use insufficient or inconsistent data collection, analysis, and reporting methods (e.g., when GSE are considered to be within an aircraft's activity zone). Conversely, airports often choose not to collect specific GSE activity data and instead use default values established in EDMS and AEDT, often due to resource constraints and the lack of guidance on how to gather GSE activity data. However, these default values are widely acknowledged to be conservative and may overestimate an airport's air quality impacts.

Under ACRP Project 2-46, research was conducted by KB Environmental Sciences, Inc. in association with CDM Smith, Mosaic, ATAC, and Jim Gebhardt. A total of 65 airlines, ground handling companies, and equipment manufacturers were contacted to gain insight on their fleet, operations, environmental initiatives, and willingness/ability to share information and participation in the project.

CONTENTS

SUMMARY

Improving Ground Support Equipment Operational Data for Airport Emissions Modeling

The principal objective of ACRP Project 02-46 and guidebook is to provide an improved-upon and consistent approach on how airport ground support equipment (GSE) emission inventories are prepared. This goal is achieved by developing a practical guide on how to conduct the emissions inventory, which includes a methodology on how airport-specific GSE population and operational data can be obtained and developed. The guide also contains recommended default data when these airport-specific GSE data are not obtainable or collected.

This guidebook was specifically prepared for use by the array of stakeholders involved in preparing airport emissions inventories that may include, or be focused on, GSE. These principal participants mainly include the following:

- **Airport owners and operators**—These include airport managers and staff involved in managing air emissions associated with their airports for regulatory, planning, and environmental purposes.
- **GSE owners and providers**—These include passenger airlines and air cargo carriers that utilize GSE to provide the necessary ground-based services to their aircraft and other support facilities. This group also includes GSE service providers that contract their services to airlines and cargo carriers.
- **Governmental agencies**—These include federal, state, and local agencies involved in managing air quality.

The contents of the guidebook are organized around five topics that build upon one another in a progressive fashion towards the end of preparing an airport GSE emissions inventory. These topics comprise the following:

- **GSE functions and characteristics**—including the types and functions of airport GSE, their emissions characteristics, and how they are computed using available emissions models and tools.
- **GSE inventory types and strategies**—including the types of GSE emissions inventories that one might prepare, how to structure a GSE inventory based on inventory purpose, and the input data requirements.
- **GSE data collection protocol**—providing a consistent and systematic methodology to collect GSE operational and inventory data to satisfy emissions inventory input requirements discussed in the guidebook.
- **Best practices for using and modifying emissions model defaults**—specifying suggested default data to be used for the purposes of emissions calculation in the event that airport-specific data is not available or cannot be collected.

- **Coordination best practices—**covering series of coordination steps useful in securing GSE equipment inventory data from various stakeholders involved in the preparation and use of airport GSE emission inventories.

How the guidebook is used will depend in large part on the expertise of the users, the available resources to conduct the work, and the desired level of accuracy. The methods and suggestions provided in the guidebook are also designed to address these variables.

CHAPTER 1

Introduction and Background

This chapter provides an overview of the purpose of ACRP Project 02-46 as well as this resultant guidebook, including its intended audience, what this guidebook contains, and how this guidebook is suggested to be used.

1.1 What Is the Purpose of this Guidebook?

Emerging concerns over the potential effects of airport-related air emissions on human health and the environment have made the intersection between aviation and air quality a matter of increasing importance to airport operators, regulatory agencies, and the general public. As a result, a number of ACRP initiatives and publications have focused on the various sources of emissions associated with airports and the methods by which they are evaluated. The subject sources of these research efforts have included (but are not limited to) aircraft main engines,[1] auxiliary power units (APUs),[2] aircraft brakes and wheels, ground access vehicles (GAVs),[3] and construction activities.[4] Assessment methods subject to ACRP research have included air quality monitoring,[5] emission inventories,[6] and atmospheric dispersion modeling.[7]

In keeping with this ongoing and wide-ranging undertaking to advance what is known about airport-related sources of emissions and how they are assessed, this ACRP research and resultant guidebook are aimed principally at advancing how emissions associated with airport GSE are evaluated in emission inventories.

This overriding goal is achieved by formulating an improved and standardized approach for how airport-specific GSE emissions inventories are planned, organized, and conducted. Realizing that GSE emission inventories may be intended for diverse purposes; that availability of data may be different from case to case; and that manpower, time, and budget resources may be limited for some inventories—the approach must be flexible in identifying optional methods to accommodate these potential differences. In summary, this goal is achieved accomplishing the three objectives identified and delineated in the call-out box.

Guidebook Objectives

The principal objectives of this guidebook are three-fold:

1. Guide the preparation of an airport-specific GSE emissions inventory;
2. Provide a protocol by which GSE operational data can be collected for an inventory; and
3. Recommend "default" input data to use if airport-specific GSE data collection is not desired or possible.

[1] ACRP Report 6 (02-04), *Research Needs Associated with Particulate Emissions at Airports*
[2] ACRP Report 97 (02-17), Measuring PM Emissions from Aircraft Auxiliary Power Units, Tires and Brakes
[3] ACRP 02-63 (Pending), *Quantifying Airport Ground Access Vehicle Activity for Emissions Modeling*
[4] ACRP Report 102 (02-33), *Guidance for Estimating Airport Construction Emissions*
[5] ACRP Report 71 (02-08), *Guidance for Quantifying the Contribution of Airport Emissions to Local Air Quality*
[6] ACRP Report 84 (02-21), *Evaluation of Airport Emissions within State Implementation Plans*
[7] ACRP 02-43 (Active), *Development of a NO_x Chemistry Module for EDMS/AEDT to Predict NO_2 Concentrations*

Airport GSE comprise a wide assortment of equipment and vehicles that provide essential support services to aircraft when they are on the ground. Other common GSE functions pertain to the service and maintenance of airport terminal buildings and other infrastructure. Emissions inventories are a valuable and commonly used technique for quantifying the types and amounts of emissions from airport-related sources and activities, including those associated with GSE.

1.2 Who Should Use this Guidebook?

This guidebook was specifically prepared for use by stakeholders involved in preparing emissions inventories that may include, or be focused on, airport GSE. In each case, the incentives for preparing an emissions inventory for GSE and the intended application of the results likely differ somewhat. These principal participants mainly include the following:

- **Airport owners and operators**—These include airport managers and staff involved in managing air emissions associated with their airports (including those associated with GSE) for regulatory, planning, and environmental purposes.
- **GSE owners and providers**—These include passenger airlines and air cargo carriers that utilize GSE to provide the necessary ground-based services to their aircraft and other support facilities. This group also includes GSE service providers who contract their services to airlines and cargo carriers.
- **Governmental agencies**—These include the following on the federal, state, and local levels:
  - **FAA**–Responsible for ensuring that airport-related emissions (including those from GSE) are appropriately represented in environmental assessments prepared under the National Environmental Policy Act (NEPA) and the federal Clean Air Act (CAA) (i.e., the General Conformity Rule). The FAA is also involved in the development of models and guidebooks for the computation of airport emissions—again, including those associated with GSE.
  - **U.S. EPA**—Responsible for setting exhaust emission standards for both on- and nonroad motorized vehicles and equipment (including airport GSE).
  - **State and local agencies**—Responsible for the development of State Implementation Plans (SIPs) in designated nonattainment/maintenance areas that encompass airport-related emissions (including those associated with GSE).

Reminder—In addition to airports, airlines, and other GSE providers, non-governmental organizations, consultants, and academia can also benefit from the information contained in the guidebook.

In addition to these principal stakeholders, others with an interest in improving how airport GSE emissions are evaluated comprise various non-governmental organizations (NGOs) that represent the aviation industry, environmental consultants that prepare airport emissions inventories, academic institutions involved in airport air quality research, and others with an interest in ensuring that GSE emissions are appropriately quantified and evaluated.

1.3 Benefits of Using this Guidebook

The overriding aim of this ACRP initiative and guidebook is to provide an improved and consistent approach that will advance how airport GSE are assessed in emission inventories. This objective is achieved by preparing a practical guide on how to conduct the inventory, which includes a methodology on how airport-specific GSE emission data can be obtained for such inventories. The guide also includes recommend default data when these GSE data have not been collected. Inherent benefits toward improving GSE emission inventories from using the protocol in this guidebook include (but are not necessarily limited to) the following:

- **Identifies appropriate data**—Conducting an airport GSE emissions inventory requires a specific set of input data unique to airport environs and this emission source, which are identified in this guidebook.

- **Increases levels of accuracy**—Using airport-specific GSE data and/or updating the former default data can generate more accurate emissions inventories for this source, both of which are objectives of this research project.
- **Fosters consistency**—The application of the suggestions contained in this guidebook for collecting and applying GSE data will help to promote greater consistency and comparability between emissions inventories under different airports, years, and/or scenarios.
- **Reduces costs and enhances safety**—The in-the-field collection of GSE data can be a potentially hazardous undertaking given the locations and operational conditions under which these equipment and vehicles typically maneuver. Without an informed strategy, the manpower, time requirements, and costs can also become disproportional to the returns and, in some cases, may be prohibitive. The data collection methods contained in this guidebook are designed to reduce these costs and risks.
- **Promotes stakeholder coordination**—There are a number of potential participants with an interest, or stake, in the preparation of airport GSE emissions inventories (i.e., airport owners/operators, GSE owners/providers, regulatory agencies). The use and outcomes of this guidebook will help to unify their interests, objectives, and approaches to assessing this source of airport emissions.

References—Guidebook users should learn about other ACRP publications pertaining to airports and air quality. These include the following:

– *ACRP Report 11: Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*
– *ACRP Report 71: Guidance for Quantifying the Contribution of Airport Emissions to Local Air Quality*
– *ACRP Report 78: Airport Ground Support Equipment (GSE) Emission Reduction Strategies, Invention, and Tutorial*
– *ACRP Report 102: Guidance for Estimating Airport Construction Emissions*

How the guidebook is used will depend in large part on the expertise of the users. In some cases, it is expected that some users may possess a high level of knowledge and experience related to computing emissions for airport sources. In other cases, some users may only have a general understanding of airports and are comparatively less accomplished at conducting emission inventories. In both instances, their experience with, and understanding of, airport GSE are also expected to vary.

Other important variables that are expected to govern how this guidebook is used involve the type and size of the airport(s) for which emission inventories are prepared, the level of activity at the airport(s), the degree of accuracy and precision required in the emissions inventory, and the availability of appropriate input data.

1.4 Contents of this Guidebook

The contents of the guidebook are organized around five chapters that follow this introduction and build upon one another in a progressive fashion. However, for those that wish to focus on particular topics of interest, the *Topic Quick Lookup Guide* provides an index of the most commonly cited subject matter.

- **Chapter 2: GSE Types, Functions, and Emissions**—Describes the types and functions of airport GSE, their emissions characteristics, and a brief description of how GSE emissions are currently assessed in emissions inventories using available emissions models and tools.
- **Chapter 3: GSE Emissions Inventories**—Outlines and describes the types of GSE emissions inventories that one might prepare and advises the user on how to structure a GSE inventory based on inventory purpose. Establishes and elaborates upon inventory input data requirements.
- **Chapter 4: GSE Data Collection Protocol**—Provides a consistent and systematic protocol to collect GSE operational and inventory data to satisfy emissions inventory input requirements outlined within Chapter 3. Special attention is given to safety and security measures and regulations specific to airports, statistical methods with which to calculate a sufficient sample size for data collection, and quality assurance checks and procedures necessary to ensure the collected data are appropriate for use.

Topic Quick Lookup Guide

Topic	Chapter/Appx.
Aircraft Classifications	C
Cargo Aircraft	5
Coordination	6
Data Collection Forms	B
Data Collection Protocol	4
Default Data	5
Deicing GSE	5
Emissions Inventory Approaches	3
Emissions Inventory Data Needs	3
FAA's VALE Program	2
FAA's EDMS/AEDT	3
GSE Emissions Standards	2
GSE Emissions Inventory	3
GSE Emissions	2
GSE Fuel Types	5
GSE Population	5
GSE Types	2
Health & Safety Plan	A
Operating Times	4
Passenger Aircraft	5
Quality Assurance	4
Stakeholders	6
Technical Support Materials	D

- **Chapter 5: Modifying and Using Default GSE Emissions Model Data**—In the event that in-the-field data collection cannot be taken due to time or resource constraints, or if GSE equipment data are not available, this chapter specifies suggested default data to be used for the purposes of emissions calculation. Additionally, suggestions are provided on how to adjust these defaults if limited site-specific information is available or if it is otherwise conducive to the selected inventory strategy.
- **Chapter 6: Coordination Best Practices**—Identifies a series of coordination steps useful in securing GSE equipment inventory data from airline fleet owners and station managers, contract fleet owners and operators, ground handlers, and other stakeholders.

To aid in the comprehension of this material, a glossary and lists of references, acronyms, and abbreviations are provided at the end of the guidebook. A compilation of frequently asked questions and answers is also provided to help the user answer questions that might arise in the course of reviewing and applying the information contained in this guidebook. Finally, the following appendices are intended to augment the materials presented within the guidebook for users that require additional details, examples, and/or further explanations:

– **Appendix A:** Example Health, Safety, and Security Plan;
– **Appendix B:** Data Collection Forms and Resources;
– **Appendix C:** Aircraft Size Classifications;
– **Appendix D:** Technical Support Document for the Derivation of Revised AEDT Defaults; and
– **Appendix E:** Proposed New Default TIM for Passenger Aircraft GSE Fleet Mix for Small-Sized Airports.

1.5 *ACRP Report 78*

Throughout this report, reference will be given to *ACRP Report 78: Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial*, prepared by CDM Federal Programs Corporations, KB Environmental Sciences, Inc., and Ricondo & Associates, Inc. *ACRP Report 78* provides important supplementary information that supports the guidance provided in the guidebook.

ACRP Report 78 had a three-fold approach to assessing and mitigating the contribution of GSE on air quality impacts at airports. First, an inventory of GSE at airports was provided. Second, potential strategies to reduce emissions from GSE were developed. Third, a tutorial that describes GSE operations and emission reduction technologies that may be employed by GSE owners and operators was included.

The GSE inventory developed in *ACRP Report 78* supported this project by providing details that otherwise would not have been known about GSE fleets throughout the country. Applications and assumptions can be made from this inventory that can help to improve emission modeling results. The findings of *ACRP Report 78* can also be consulted and integrated where applicable, specifically regarding GSE horsepower, fuel type, population, and load factors. Finally, *ACRP Report 78* also provides a methodology for estimating GSE fleet size based on airport activity levels.

As a result, *ACRP Report 78* could be used as supplementary guidance and support to this project.

CHAPTER 2

GSE Types, Functions, and Emissions

This chapter describes the types and functions of commonly used airport GSE and their emissions characteristics. Most airport GSE operated on the airside of the airport are typically associated with the servicing of aircraft during the ground-based, airport turnaround process. During this period, there are a number of tasks that are performed using GSE including, but not necessarily limited to, the following (listed in alphabetical order):

- Aircraft maintenance and cleaning—including engine and fuselage repairs, waste-water and garbage removal;
- Aircraft maneuvering—including moving aircraft out of a gate, to/from maintenance areas, etc.;
- Aircraft refueling—including fuel transfer from fuel trucks or fuel hydrant systems;
- Airfield maintenance—including grass mowers, pesticide applicators, and paint stripers;
- Deicing and snow removal—including aircraft deicing vehicles, snow scoops and plows, etc.;
- Emergency response—including aircraft rescue and firefighting (ARFF) vehicles, ambulances and police cars;
- Moving payloads—including loading, unloading, and transporting of passengers, baggage and/or cargo; and
- Restocking of provisions—including food, beverages, potable water, and lavatory chemicals.

Notably, airport GSE typically do not comprise the following: construction vehicles and equipment (i.e., dozers, scrapers, haul trucks, etc.); airport staff fleet vehicles; and airport patron, employee, and cargo GAV that travel to, from, and move about the landside of the airport (i.e., private motor vehicles, hotel vans, public buses, etc.).

Representative illustrations and summary descriptions of airport GSE types and functions are provided in alphabetical order. Notably, these types of GSE are limited to powered GSE and do not include non-motorized equipment such as baggage carts, fuel carts, storage tanks, etc., which are typically towed by motorized GSE. For ease of understanding, airport GSE are listed in Table 1.

Reference—*ACRP Report 78* contains useful information and data that are translatable to this initiative.

2.1 GSE Emissions Characteristics

This section provides an overview of the types of emissions generated by conventionally fueled airport GSE, pertinent governmental regulations and programs governing their control, and the utility of alternatively fueled vehicles and equipment.

2.1.1 Types of Emissions

In general terms, the types of emissions generated by conventionally-fueled airport GSE are comparable to those of other types of motorized vehicles and equipment that burn gasoline and

Table 1. Airport GSE.

 **Aircraft Tractor**	Aircraft tractors (i.e., pushback and/or tow tugs) assist with aircraft movements when an aircraft cannot operate its engines, or does not have sufficient maneuverability to move and turn under its own engine power. Most frequently used to push an aircraft back from the gate and onto the aircraft movement area (e.g., taxiway). May also be used to move an aircraft to other locations on an airport (e.g., maintenance hangars). There are two types of pushback tugs/tractors: (1) conventional tugs use tow-bars that are connected to an aircraft's noise wheel, and (2) towbarless tractors scoop up the aircraft noise wheel and lift it off the ground before moving.
 **Air Conditioner**	Also referred to as air carts, these units provide conditioned (i.e., cooled and heated) air to parked aircraft when their main engines and auxiliary power units (APUs) are off. They are commonly utilized at non-contact gates, or when fixed-gate or centralized pre-conditioned air (PCA) units are not present.
 **Air Start**	An air start unit delivers compressed air to an aircraft to help start the engines during instances when the on-board APU is not operational or there are no other means for starting the engines.
 **Baggage Tractor**	Baggage tractors are among the most common and recognizable type of GSE at an airport. Baggage tractors are typically used to move carts containing passenger baggage and/or cargo between aircraft gated on the apron and terminal baggage processing facilities. (See also cargo tractor.)
 **Belt Loader**	Belt loaders serve to facilitate the loading and unloading of baggage and other payloads between an aircraft's baggage/cargo compartments and the baggage/cargo carts.
 **Boarding Stairs**	Whether towed, pushed, or driven into position, boarding stairs provide a means of loading and unloading passengers at hardstands (i.e., remote parking positions) and in the absence of jet bridges at the airport terminal gate.

Cabin Service Truck

Cabin service trucks are designed to provide services and supplies to the aircraft main cabin while parked at the gate. Typically used to deliver beverage and food carts but also used to remove trash and other used materials. They are equipped with a hydraulic lifting system to move the storage compartment to the desired height of the aircraft access door. Most cabin service trucks are equipped and registered to operate both on the airport site and on public roadways (see also catering truck).

Cargo Tractor

Similar in design and utility to baggage tractors, cargo tractors GSE are used primarily to tow cargo carts from one aircraft or airport location to another.

Catering Truck

Similar in design and utility to cabin service trucks, catering trucks provide services and supplies to the aircraft main cabin while parked at the gate. Typically used to deliver beverage and food carts but also used to remove trash and other used materials, most catering trucks are equipped and registered to operate both on the airport site and on public roadways.

Container Loader

Container loaders are highly specialized equipment designed to load and unload cargo containers, pallets, and other vessels from the aircraft cargo hold to a cargo cart or dolly and vice versa. Equipped with pneumatics and rollers to aid in moving the payloads both horizontally and vertically onto and off from the carts, they sometimes also are used to move the cargo containers from one location to another.

Container Transporter

Similar in design and utility to a container loader, container transporters are used primarily to transport cargo containers, pallets, and other vessels between aircraft or between aircraft and other areas of the airport.

Deicer

Deicers are specially designed vehicles equipped with booms or cherry pickers that are used to store, transport, heat, and spray deicing fluid on an aircraft exterior to reduce and/or eliminate ice and snow prior to departure. Typically, these GSE contain two engines: one to power the vehicle and one to heat the deicing fluids.

(continued on next page)

Table 1. (Continued).

 **Emergency Vehicles**	Vehicles and equipment designed to respond to and address medical, fire, or other emergencies, including fire trucks, ambulances, and police cars.
 **Fork Lift**	Commonly used in industrial, manufacturing, and warehousing settings, fork lifts also are used at airports to move and transfer cargo form aircraft cargo compartments to other aircraft and locations at the airport (and vice versa).
 **Fuel Truck**	Self-contained tanker trucks with pumps, filters, hoses, and valves designed to transport fuel from the airport fuel storage facility to the aircraft and dispense fuel into the aircraft fuel tanks. Also known as refuelers.
 **Glycol Recovery Vehicle**	Specially designed trucks equipped with a vacuum system and storage tank for the recovery of excess aircraft deicing fluids that collect on the airport aprons, taxiways, and/or designated deicing pads.
 **Ground Power Unit**	A ground power unit (GPU) is a fuel-powered generator designed to provide electricity to an aircraft when it is parked on the ground and its main engines and on-board APU are off.
 **Heater**	Specially designed heaters used to heat aircraft engines in cold climates to help prevent the freezing of lubricants and other fluids. Also used to heat aircraft cabins and cockpits when the main engines and APU are not operating.
 **Hydrant Pit Cleaner**	A cart equipped with a motor, vacuum device, and storage tank for the recovery of fuel that collects in the hydrant system underground vaults.

Table 1. (Continued).

 Hydrant Truck	A specially designed truck equipped with pipes, valves, and filters to transfer fuel from the fuel hydrant system into the aircraft fuel tanks.
 Lavatory Service	A vehicle designed for, and equipped with, a collection system and storage tank for the recovery and transport of aircraft lavatory wastes. Also used to replenish the disinfecting chemicals into the aircraft lavatory system.
 Maintenance Vehicle	A utility truck designed to transport personnel, tools, and equipment to the aircraft for maintenance and repairs.
 Passenger Bus	Buses and other similar vehicles are sometimes used to transport passengers and employees between aircraft and terminals on the airside. Also referred to as people movers and mobile passenger lounges.
 Snow Removal Equipment	Various forms of vehicles and equipment used to remove snow and ice from runways, taxiways, and ramp areas. Can include loaders, plows, sweepers, and blowers.
 Sweepers	Used for the collection and removal of dirt, debris, and other objects from runways, taxiways, and aprons that could damage aircraft engines. May include sweepers, vacuum systems, and air blowers.
 Water Service	A vehicle designed for, and equipped with, a transfer system (i.e., pipes/hoses, filters, pumps) and storage tank for the provision of water to an aircraft.

Source: *ACRP Report 78: Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial*. 2013.

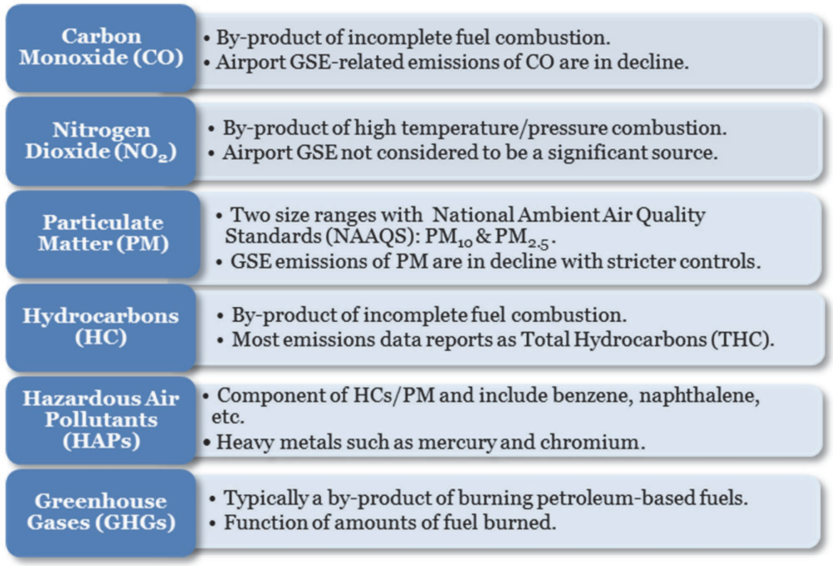


Figure 1. GSE emission types.

diesel as an energy source. For computing airport emission inventories, these types of emissions most often associated with GSE comprise the U.S. EPA "criteria" pollutants[8] (and their precursors), but can also include hazardous air pollutants[9] (HAPs) and/or greenhouse gases[10] (GHGs). Figure 1 provides a summary listing of these types of emissions as they pertain to airport GSE.

As discussed in Chapter 3, the amounts of emissions are typically expressed as the mass (i.e., weight) of pollutants generated over a specified timeframe (i.e., day or year) or activity level (i.e., number of aircraft operations, passengers, etc.).

2.1.2 Emissions Standards

The U.S. EPA, under the federal CAA, is provided the underlying authority for the regulation of air emissions from the vast majority of man-made emission sources, including those classifiable as airport GSE. Commonly, airport GSE are also further classifiable under two sub-categories of mobile sources:

- On-road vehicles—Vehicles that are licensed to travel on public roadways including automobiles, vans, trucks, buses, etc. For airport GSE, these are mostly limited to catering and cabin service trucks.
- Nonroad vehicles—Vehicles and equipment that are not intended to be registered or operated on public roadways. This category broadly includes aircraft, watercraft, locomotives, recreational vehicles, construction vehicles, farm equipment, etc. For airport GSE, this represents the vast majority of vehicles and equipment and comprises baggage tugs, belt loaders, pushback tractors, etc.

> **Note**—The vast majority of airport GSE are classified as nonroad equipment and vehicles. This distinction applies to their intended range as well as their emissions characteristics, both of which differ significantly from on-road vehicles.

The emissions standards for on-road vehicles are typically much more stringent (i.e., having much lower allowable emission rates) when compared to nonroad vehicles and equipment.

[8] The U.S. EPA "criteria" pollutants are pollutants for which there are National Ambient Air Quality Standards (NAAQS) such as carbon monoxide (CO), lead (Pb), ozone (O_3), etc. In the case of O_3, precursor pollutants include volatile organic compounds (VOCs) and nitrogen oxides (NO_x).

[9] HAPs are pollutants for which there are no NAAQS, but are regulated and of concern in connection with their potential effects on human health; HAPs comprise air pollutants such as benzene, naphthalene, toluene, etc.

[10] GHGs are pollutants that are of concern because of their role in climate change and include carbon dioxide, methane, etc.

Table 2. Federal regulations applicable to airport GSE emissions.

Citation	Title	Airport GSE Relevance
CAA Title II: Part A: Motor Vehicle Emission and Fuel Standards	202 – Emission Standards for New Motor Vehicles or New Motor Vehicle Engines 211 – Regulation of Fuels 213 – Nonroad Engines and Vehicles	- Sets engine exhaust emission standards for on-road vehicles (cars, vans, catering vehicles, etc.) - Sets limitations on the use of additives, and the levels of certain compounds, including sulfur, in motor vehicle fuels - Sets engine exhaust standards for nonroad vehicles (e.g., belt loaders, tow tugs, forklifts, etc.)
Energy Policy Act of 2005	National Clean Diesel Emissions Reduction Program, also called the Diesel Emission Reduction Act (DERA), and the SmartWay Program	Provides funding assistance to support the deployment of EPA-verified and certified technologies to reduce diesel-related emissions
Vision 100 Century of Aviation Reauthorization Act: FAA VALE Program	121 – Low-Emission Airport Vehicles and GSE 158 – Emission Credits for Air Quality Projects 159 – Low-Emission Airport Vehicles and Infrastructure	Provides funding for alternative-fueled GSE vehicles as well as low-emission equipment and infrastructure
40 CFR 85	Control of Air Pollution from Mobile Sources	Contains emission performance warranty and other information for engines used in on-road vehicles, including airport GSE
40 CFR 86	Control of Emissions from New and In-Use Highway Vehicles and Engines	Contains exhaust emission standards for engines used in on-road vehicles, including airport GSE
40 CFR 88	Clean Fuel Vehicles	Contains exhaust emission standards for centrally fueled fleets such as on-road airport GSE in certain nonattainment areas
40 CFR 89	Control of Emissions from New and In-Use Nonroad Compression Ignition Engines	Contains exhaust emission standards (Tiers 1, 2, and 3) for compression ignition (e.g., diesel) engines used in some nonroad vehicles, including airport GSE
40 CFR 1039	Control of Emissions from New and In-Use Nonroad Compression Ignition Engines	Contains exhaust emission standards (Tier 4) for compression ignition (e.g., diesel) engines used in some nonroad vehicles, including airport GSE
40 CFR 1048	Control of Emissions from New, Large Nonroad Spark Ignition Engines	Contains exhaust emission standards for large spark ignition (e.g., gasoline) engines used in some nonroad vehicles, including airport GSE
40 CFR 1060	Control of Evaporative Emissions from New and In-Use Nonroad and Stationary Equipment	Contains evaporative emission standards for nonroad engines, including those used in airport GSE
40 CFR 1068	General Compliance Provisions for Engine Programs	Contains basic compliance requirements for engines, including those used in airport GSE

CAA – Clean Air Act
CFR – Code of Federal Regulations
GSE – ground support equipment

Importantly, the CAA preempts individual states from adopting or enforcing their own on-road and nonroad emission standards, with California being the only exception.

Table 2 lists and summarizes the primary federal statutes and programs relevant to the control of emissions from airport GSE.

2.1.3 Emissions Standards for Nonroad Vehicles and Equipment

For the purposes of regulating exhaust emissions from nonroad vehicles and equipment, the U.S. EPA has also subdivided these engines into two broad classes.

- Compression ignition (CI) engines—Also known as diesel engines and typically fueled with diesel fuel, power is derived from the compression and instantaneous combustion of the fuel/air mixture. GSE with CI engines are usually used for moving large payloads and include aircraft tractors and cargo loaders.

Reminder—According to *ACRP Report 78*, nearly 40% of the nationwide GSE fleet have SI engines (i.e., are gas-powered) and about 35% have CI engines (i.e., are diesel-powered).

Emission standards for nonroad CI engines have been established for carbon monoxide (CO), non-methane hydrocarbons (NMHC), oxides of nitrogen (NO_x), particulate matter (PM), and smoke output. EPA has organized these emissions standards into classes (or tiers) based on the date of manufacture and rated engine output (e.g., horsepower), with greater stringency (i.e., lower emissions) associated with increasing emission control levels (i.e., tier 0 < 1 < 2 < 3 < 4) over time. These emission standards and associated requirements are directed primarily at engine manufacturers, but the owners/operators also bear some responsibilities. For example, manufacturers of nonroad CI engines must produce and offer for sale engines that meet the appropriate tier levels of emission standards and provide the necessary maintenance instructions and servicing procedures for the engine owner or operator to follow.

Similarly, it is the responsibility of the owner/operator to follow the manufacturer's maintenance instructions, thus enabling the engine to perform as designed and meet the applicable emission standards. These regulations also prohibit the disabling of emission controls on an engine or equipping an engine with an emissions defeat device.

Since 2010, nonmilitary owners and operators of CI nonroad engines and equipment must also use ultra-low sulfur diesel fuel.

- Spark ignition (SI) engines—Also known as gas engines and typically fueled with a more volatile fuel, such as gasoline. Power is derived from the ignition of the fuel/air mixture with a spark plug. GSE with SI engines are usually used for moving lighter payloads and include baggage tugs, service trucks, etc.

  The federal emission standards for SI nonroad engines have been promulgated for equipment produced after 2004. They are also tiered to reflect increasing emissions controls over time based on the date of manufacture and horsepower, but include both exhaust emissions standards and evaporative emissions standards.

Note—The most commonly used and recognizable GSE at most airports are baggage tugs, which are largely powered by CI engines burning gasoline.

  As with CI engines, the emissions standards and associated requirements are directed primarily at engine manufacturers, but the ultimate owner or operator does have some responsibilities related to emissions. Again, manufacturers of SI nonroad engines must produce and offer for sale engines that meet the appropriate level of emissions standards and provide the necessary maintenance and servicing procedures. Similarly, it is the responsibility of the owner/operator to follow the maintenance and service instructions.

  Fuel regulations require that in those parts of the United States with the worst air quality, SI engines must use reformulated or oxygenated gasoline to help reduce the formation of air pollutants.

With the emergence of alternative fuels and technologies, other fuels now are becoming more commonly used with airport nonroad GSE as discussed in Section 2.1.7.

2.1.4 Emissions Standards for On-Road Vehicles

Emissions standards for on-road vehicles apply primarily to exhaust (i.e., tailpipe) emissions as well as evaporative emissions and are largely a function of the vehicle's age (i.e., date of manufacture), class of vehicle, type of fuel, and capacity and type of engine. As with nonroad engines, engines used in on-road vehicles may be either CI or SI. As with nonroad vehicles, the newer on-road vehicles have more restrictive emissions standards than the older, preceding models.

In air quality nonattainment areas, owners or operators of centrally fueled fleets may be required to participate in the U.S. EPA's clean fuel fleet program requiring the use of low-emission vehicles (40 CFR 88). Additional standards apply to fuels, fuel additives, and fueling, particularly limitations on volatile components, sulfur, and certain toxic compounds such as benzene (40 CFR 80).

In those nonattainment areas having a motor vehicle inspection/maintenance (I/M) program to reduce emissions, the vehicle owner/operator is responsible for meeting the state's requirements for periodic inspection and maintenance.

These types of vehicles may be fueled by a variety of types of fuels, including conventional petroleum-based fossil fuels such as gasoline and diesel, and cleaner-burning fuels such as natural gas, propane, ethanol, methanol, biodiesel, hydrogen, electricity, and other fuels.

2.1.5 Emissions Standards in the State of California

As noted, California presents an exception to the federal preemption of state emission standards for on-road and nonroad mobile sources. For example, Section 209(e) of the CAA allows California to adopt and enforce standards and other requirements relating to the control of emissions from nonroad engines or vehicles (other than construction or agricultural engines or vehicles smaller than 175 horsepower and locomotive engines), the only stipulation being that the California standards are at least as protective of public health and welfare as the applicable federal standards. In addition, other states may choose to adopt the California standards.

Consequently, the California Air Resources Board (CARB) has adopted emissions standards that apply to both CI and SI nonroad engines and vehicles. Of particular importance to owners/operators of GSE in California is the In-Use Offroad Diesel Vehicle Regulation (13 CCR Article 4.8 Sections 2449, 2449.1, 2449.2, and 2449.3) originally adopted in July 2007. In December 2010, CARB amended the regulation so that owners/operators of nonroad CI vehicles greater than 25 horsepower (including GSE) are required to reduce emissions of diesel PM and NO_x.

Importantly, these vehicles are subject to "fleet averaging" to meet the emissions standards that can be accomplished, if necessary, by engine retrofits or fleet turnover. The standard also requires enforcement of a 5-minute idling restriction as well as other requirements. The initial compliance date for the largest fleets was 2014, and smaller fleets have later compliance dates.

> **Note**—California-based emissions standards for mobile sources such as airport GSE are a special case that is unique across the United States. Guidebook users are advised to refer to CARB for information and data on airport GSE emissions characteristics in that state.

2.1.6 FAA's Voluntary Airport Low Emission (VALE) Program

Because of its relevance to airport GSE emissions, the FAA VALE program is further discussed here. Under the *Vision 100 Century of Aviation Reauthorization Act*, the FAA VALE program is intended to offer financial and regulatory incentives to airports to reduce emissions of air emissions voluntarily in geographical locations of the United States that are classified by the U.S. EPA as being nonattainment (or maintenance) with respect to the National Ambient Air Quality Standards (NAAQS).

While numerous types of airport projects are eligible for grants under the VALE program, generally it focuses on alternative-fueled GSE vehicles and low-emission technology infrastructure. GSE acquired through the VALE program can be owned by the airport and made available for use (e.g., leased) by another operator, such as an airline or fixed-base operator (FBO) that is a tenant at the airport. The VALE program also permits an entity other than the airport, such as a tenant airline or FBO, to acquire and use alternatively fueled GSE, but that entity must commit to certain restrictions with regard to the use and disposition of the equipment.

2.1.7 Alternatively Fueled GSE

The use of alternatively fueled and electric-powered GSE is swiftly emerging as an option to conventionally fueled (i.e., gasoline and diesel) GSE at many airports. Presently, the primary alternative fuels known to be used in GSE include compressed natural gas (CNG), liquefied petroleum gas (LPG, also known as propane), ethanol, and biodiesel. These alternative fuels typically generate lower air emissions than the conventional fuels, particularly with respect to CO and PM. Electric-powered GSE generate almost no emissions on-site but have some air quality impacts when accounting for off-airport electric power generation impacts. A more detailed discussion of benefits and challenges of alternatively fueled GSE is presented in *ACRP Report 78.*

CHAPTER 3

GSE Emissions Inventories

This chapter contains an overview of airport GSE emissions inventories including what they are, how they are computed, and how the results are applied. Also discussed are suggestions for accomplishing the work based on real-world experience and practical considerations.

3.1 What Is a GSE Emissions Inventory?

In general terms, an airport emissions inventory is a quantitative assessment of the types and amounts of emissions generated by the various sources of emissions associated with the airport. As discussed in Chapter 2, for airport emissions inventories, the types of emissions most often comprise the U.S. EPA criteria pollutants[11] (and their precursors) but can also include hazardous air pollutants[12] (HAPs) and/or greenhouse gases[13] (GHGs).

The outcome of an airport emissions inventory containing GSE emissions can be organized and presented in a variety of tabular and/or graphical formats depending on the application. Table 3 and Figure 2 present two typical presentation styles.

The amounts of emissions are typically expressed as the mass (i.e., weight) of pollutants generated over a specified timeframe (i.e., day or year) or activity level (i.e., number of aircraft operations, passengers, etc.). In metric units the results are typically reported as kilograms/day (Kg/day) and expressing the individual source contributions as a percentage (%) is also common.

For airports, the sources of emissions commonly include aircraft main engines, APUs, GAVs,[14] fuel facilities, stationary sources (i.e., boilers, generators, live-fire training facilities), and GSE.

3.2 How Is an Airport GSE Emissions Inventory Computed?

For an airport GSE emissions inventory, the results are typically based on the types (i.e., baggage tugs, pushback tractors, etc.) and number of GSE included in the inventory, the frequency or duration of use (i.e., minutes), their fuel types (i.e., gasoline, diesel, etc.), and the corresponding emission rates (i.e., CO kg/hr.) Figure 3 provides a schematic overview and further explanation of these components.

[11] The U.S. EPA "criteria" pollutants are pollutants for which there are National Ambient Air Quality Standards (NAAQS) such as carbon monoxide (CO), lead (Pb), ozone (O_3), etc. In the case of O_3, precursor pollutants include volatile organic compounds (VOCs) and nitrogen oxides (NO_x).
[12] HAPs are pollutants for which there are no NAAQS, but are regulated and of concern in connection with their potential effects on human health; HAPs comprise air pollutants such as benzene, naphthalene, toluene, etc.
[13] GHGs are pollutants that are of concern because of their role in climate change and include carbon dioxide, methane, etc.
[14] GAV comprise cars, trucks, vans, buses, and other motorized means of accessing/egressing the airport by patrons and employees.

Table 3. Airport emissions inventory results.

Table 3 Airport Emissions Inventory Results						
Sources	Pollutants (tons/year)					
	CO	VOC	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	718	146	482	59.7	7.3	7.3
APUs	22.8	1.6	12.7	2.2	2.2	2.2
GSE	81.8	6.3	51.0	0.4	5.9	5.7
Stationary sources	3.6	0.2	4.3	0.1	5.9	5.7
Motor vehicles	261	6.2	35.1	0.8	2.6	1.2
Totals	1,087	160	585	63.1	78.2	76.6

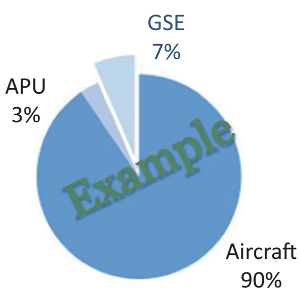


Figure 2. Airport NO_x emissions.

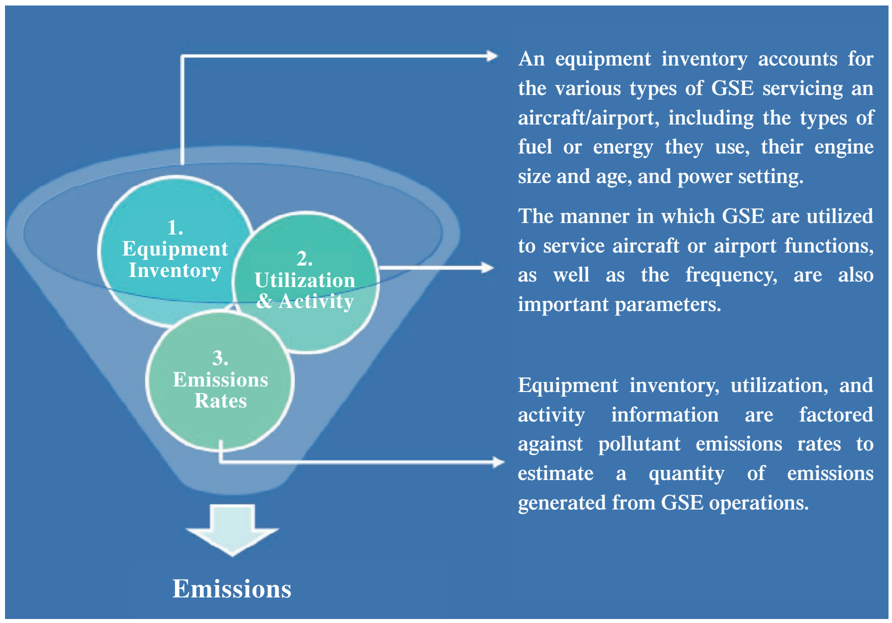


Figure 3. What is a GSE emissions inventory?

3.2.1 FAA's Aviation Environmental Design Tool (AEDT)

The current, and most often used in North America, tool for computing an airport GSE emissions inventory is the FAA's AEDT version 2b). Notably, AEDT replaced FAA's Emissions & Dispersion Modeling System (EDMS) in March of 2015.[15]

AEDT currently computes airport GSE emissions of the following pollutants: CO, NO_2, particulate matter of 10 and/or 2.5 micrometers in diameter (PM_{10}/$PM_{2.5}$), SO_x, and VOC.

AEDT also offers two primary options for computing airport GSE emissions, described and expressed as formulas as follows:

- Aircraft/gate GSE assignment option—Under this option, aircraft-specific GSE assignments (i.e., diesel aircraft tug) are made to individual aircraft types (i.e., B737-400) with corresponding operating times (i.e., 4 minutes) and emission factors (i.e., CO, kg/hr.) (see Equation 1). The default fleet of GSE automatically assigned to an aircraft are indicated by a checked box

[15] AEDT, https://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/aedt/

which can be changed by unchecking/checking the box to remove or add GSE. The default GSE operating times can also be changed by clicking and overriding the given values. (Notably, the horsepower and load factors are based upon the individual GSE type.)

Aircraft/Gate GSE Assignment Option

$$m_{p,a} = \sum_{g \in A_a} E_{p,g} P_g L_g t_{a,g} \qquad \text{Equation 1}$$

where

$m_{p,a}$ = the mass (in grams) of pollutant, p, emitted from all GSE assigned to aircraft
A_a = the set of GSE assigned to aircraft, a
$E_{p,g}$ = the emission factor for pollutant, p (in grams per horsepower-hour) for GSE, g
P_g = the rated power (in brake horsepower) of GSE, g
L_g = the load factor (unitless) of GSE, g
$t_{a,g}$ = for aircraft a, the number of hours GSE operates during one operation

- GSE population-based option–Under this option, the airport GSE fleet is programed into AEDT by inputting the GSE type (i.e., aircraft tractor), the population (or count), the operating times (annually or hourly), fuel type (i.e., gasoline, diesel), horsepower and load factor (see Equation 2). (Notably, gate assignments can also be provided for dispersion modeling purposes).

GSE Population-Based Option

$$m_{p,g} = E_{p,g} P_g L_g N_g t_g \qquad \text{Equation 2}$$

where

$m_{p,g}$ = the mass (in grams) of pollutant, p, emitted annually from GSE, g
$E_{p,g}$ = the emission factor for pollutant, p (in grams per horsepower-hour), for GSE, g
P_g = the rated power (in brake horsepower) of GSE, g
L_g = the load factor (unitless) of GSE, g
N_g = the population of GSE, g (number of units included in the study)
t_g = the time (in hours) that each unit of the population of GSE, g, operates annually

Importantly, airport GSE can be also added to the AEDT that presently do not exist in the model databases. This is accomplished by providing the GSE name/model (i.e., diesel fuel truck), the operating time (minutes) and the appropriate emission factors.

AEDT currently incorporates emissions factor data from the U.S. EPA NONROAD model.[16] NONROAD is a database of emissions factors for a wide array of nonroad vehicles and equipment such as construction, farm, and lawn equipment; boats and other marine vessels; and airport GSE.

3.2.2 GSE Emissions Inventory Applications

For the purposes of this guidebook, there are three primary types or applications of airport GSE emission inventories that are most often prepared. The type of inventory is determined in

[16] U.S. EPA NONROAD Model, http://www.epa.gov/oms/nonrdmdl.htm

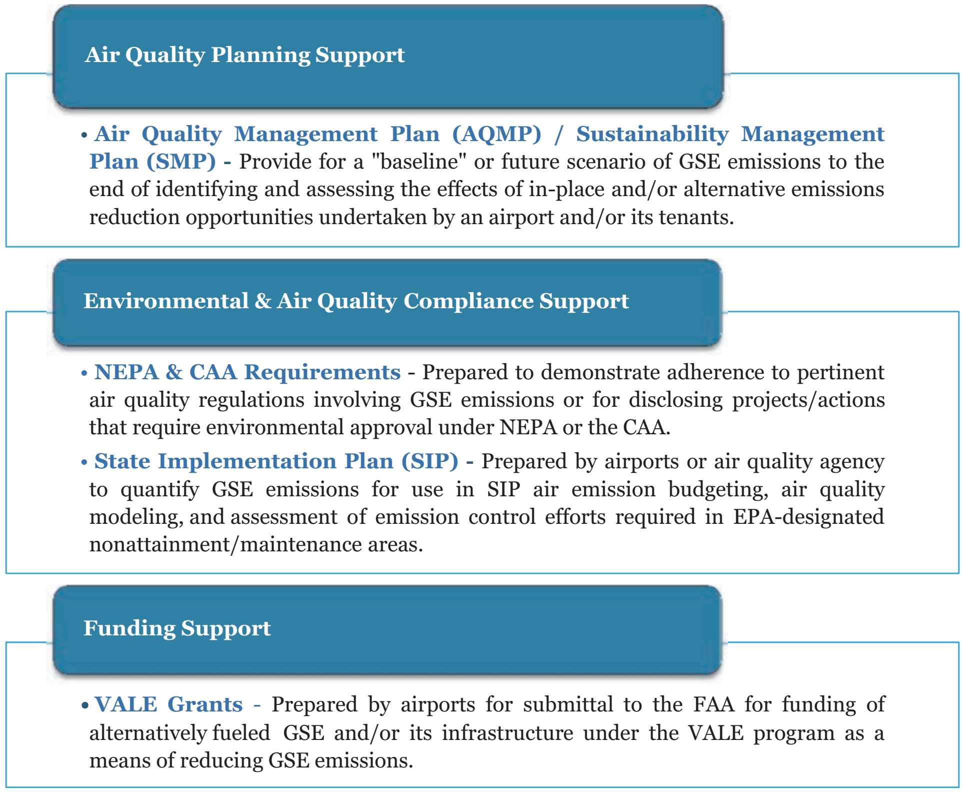


Figure 4. Airport GSE emissions inventory applications.

large part on how the results are to be applied. For ease in communicating their principal characteristics, Figure 4 provides a synopsis of each one followed by a summary discussion.

As shown on Figure 4, the intent and use of a GSE emissions inventory may differ depending on whether the application is for an airport-specific Air Quality or Sustainability Management Plan (AQMP/SMP), a NEPA or CAA document, a State Implementation Plan (SIP), or a funding application.

Airport AQMP and SMP efforts are underpinned by the need to establish a baseline of emissions that (1) aids in the quantification of emissions, including those related to GSE; and (2) identifies potential emissions reduction opportunities focusing on the targeted emission sources.

By comparison, compliance-driven airport emissions inventories are prepared to address federal regulations such as NEPA or any equivalent state-level directives. NEPA applications include the disclosure of emissions (and potentially concentrations via atmospheric dispersion modeling), as well as adherence to mitigation measures potential resulting from the approval of an Environmental Assessment (EA) or Environmental Impact Statement (EIS).

SIPs are required of state and local air quality control governance to remedy violations of the NAAQS in EPA-designated nonattainment and maintenance areas. These plans include emissions inventories of all emissions sources operating in EPA-designated air quality nonattainment areas, including GSE.[17] Likewise, for airports operating in nonattainment areas, federally

[17] *ACRP Report 84: Guidebook for Preparing Airport Emissions Inventories for State Implementation Plans*, outlines best practices, data sources, tools, and methodologies an airport or GSE operator can use to ensure that airport-related emissions are properly accounted in a SIP.

sponsored or obligated projects/actions that would effect a change in the airport's emissions must demonstrate compliance with the SIP under the CAA General Conformity Rule.

In addition, the Airports Council International (ACI) Europe has promulgated the Airport Carbon Accreditation program, which is a voluntary program that enforces the accreditation criteria for airports on an annual basis. Airports that desire to become accredited have their GHGs (i.e., carbon footprints) independently verified in accordance with ISO14064 (*Greenhouse Gas Accounting*). Currently, 25.9% of the global air passenger traffic has been certified under this program.

3.3 Considerations and Approaches to Preparing a GSE Emission Inventory

For guidebook user convenience and to account for the range of factors that are suggested to be considered when preparing an airport GSE emissions inventory, this section describes three alternative approaches. Notably, each approach contains a common set of features that are viewed as key to preparing a GSE emissions inventory, but they are otherwise distinct from one another. Arranged in increasing order of relative complexity (i.e., from the simplest to the most complex), these strategies are briefly described here in terms of their most prominent characteristics.

3.3.1 Basic Approach

The basic approach is the simplest approach and is likely to provide the most conservatively high estimate of an airport's GSE emissions inventory. This is because the GSE data are somewhat generalized and are based upon conservative assumptions. Specifically, the basic approach relies on AEDT default values regarding the GSE fleet mix, fuel types, and use times.

Requiring the least amount of input data, the basic approach is best suited for airports with small GSE fleets or applications where a high degree of accuracy is not necessary.

Basic Approach

- Requires least amount of airport-specific data.
- Relies on AEDT default data.
- Creates conservatively high emission estimates.
- Suitable for small GSE fleets and applications where high levels of accuracy are unnecessary.

3.3.2 Intermediate Approach

The intermediate approach is viewed as transitional between the basic and advanced approaches by producing results with a higher level of accuracy than the former while requiring less input data than the latter. Based on some airport-specific GSE data, this approach also relies on default databases within AEDT for GSE engine types and emission characteristics, but utilizes input data such as the GSE fleet mix to reflect actual airport conditions.

The intermediate approach is generally considered suitable for larger GSE fleets and/or where more accurate results are desired when compared to the basic approach.

Intermediate Approach

- Data needs are in-between the basic and advanced approaches.
- Accounts for airport-specific GSE fleet mix.
- Uses AEDT default data for GSE operating characteristics.
- Applicable to larger GSE fleets and/or where more accurate results are desired.

3.3.3 Advanced Approach

Using the AEDT, the advanced approach produces an airport GSE emissions inventory with the highest level of airport specificity and is considered to be the most accurate. Rather than relying on default input parameters, this approach requires the greatest levels of expertise and effort

Advanced Approach

- Requires greatest amount of input data.
- Produces highest level of GSE emissions inventory accuracy.
- Uses airport-specific GSE fleet mix and operational data.
- Suggested for large GSE fleets and/or airports when greater specificity and accuracy are desired in the results.

by the preparer and is the most data intensive. Data requirements include (but are not limited to) the GSE fleet mix model and fuel types and operating times. This approach is best suited for large-hub commercial airports but can also be applied to small-to-medium hub and general aviation (GA) airports where advanced levels of accuracy and airport specificity are desired.

3.3.4 Factors to Consider When Choosing an Approach

To aid the preparers of airport GSE emissions inventories in evaluating and choosing an approach, this section discusses several of the most important factors, or issues, that will likely be encountered, weighed, and decided upon by the users of this guidebook. For ease of reference, Figure 5 also provides a simple matrix that couples these considerations with the alternative approaches described earlier.

- Preparer expertise—The chosen approach to conducting an airport GSE emissions inventory will likely depend in large part on the expertise of the preparer. In some cases, it is expected that the preparer will possess a high level of knowledge and experience related to computing emissions for airport sources (e.g., aircraft, GSE, APUs). In other cases, it is assumed that the users may only have a general understanding of airports (and GSE) and be comparatively less accomplished conducting an emissions inventory.

  Importantly, this three-level characterization should not be misconstrued to mean that those with low levels of expertise only use the basic approach and those with high level expertise only use the advanced approach. Rather, it is intended to serve as a signal to the preparer of the airport GSE emissions inventory that their expertise should correspond as closely as possible to the level of the analysis, particularly in those cases that are data intensive and a high level of accuracy is required.
- Accuracy—By general definition, accuracy is a function of how close the computed results are to actual values. Therefore, it is the quality of the input data that determines the level of accuracy of the airport GSE emissions inventory (i.e., the quality data in, quality data out analogy). In other words, the use of airport-specific GSE data that are up-to-date and sufficiently detailed is expected to produce results that are more accurate than an assessment that relies on a set of generalized assumptions. Again, the data inputs to the GSE emissions inventory such as equipment type, fuel use, and operating time are all important variables in this regard.

Approach/ Factors	Basic	Intermediate	Advanced
Preparer Expertise	Low	Medium	High
Accuracy	Coarse	Refined	Precise
Data Needs & Availability	Least	Moderate	Detailed
Time & Costs	Least	Moderate	Most

Figure 5. Airport GSE emissions inventory approach factors.

- Data needs and availability—Of the factors and considerations given to preparing an airport GSE emissions inventory, the availability of input data and supporting information is potentially one of the most meaningful and limiting. For example, aircraft and GSE fleet data (e.g., fleet mix, utilization times, etc.) can vary widely between airports of similar size and function. Likewise, among airports of comparable size, the GSE fleet mix can also differ markedly according to the principal air and cargo carriers serving the airport. The fleet mix and operating parameters will also change over time due to technological advancements and/or varying market conditions.

  To further demonstrate the significance of this consideration, Table 4 provides a partial listing of the data expected to be required when preparing an airport GSE emissions inventory using this guidebook. As shown, these data mainly reflect the AEDT GSE inventory options (see Section 3.2.1), the GSE fleet mix, and other operational conditions.
- Preparation time and costs—The preparation time and financial costs for preparing an airport GSE emissions inventory are determined in large degree by the approach selected to complete the work. Therefore, it follows that under the basic approach where the input data needs are comparatively limited, the preparation time and costs are expected to be lower when contrasted against the advanced approach, which involves an array of additional input data.

  Among the other variables that can potentially affect the preparation time and costs for conducting the analyses is the availability of the required input data. In other words, the collection, development, and preparation of the input data for the GSE emissions inventory require research and analyses that are additive to computing the results.

  For example, airport-specific GSE fleet mix, fuel type, and operating time data are typically collected from the equipment owners or developed from field surveys. In other cases, the forecasting of airport operational levels, predicting aircraft fleet mix data, or foreseeing APU/GSE utilization under future-year conditions involves additional research and development time, also adding to the overall costs.

Table 4. Airport GSE emissions inventory data needs.

Data Needs	Description	Approach		
		Basic	Inter.	Advanced
Aircraft/Gate GSE Assignment Option				
• Aircraft type	Aircraft types by model (i.e., B777, A380, etc.)	✓	✓	✓
• GSE type	GSE types by model (i.e., baggage tug, etc.).	✓	✓	✓
• Fuel type	GSE engine fuel type (gasoline, diesel)	✓	✓	✓
• Operating times	Engine-on times (i.e., minutes)		✓	✓
• Horsepower	Brake horsepower			✓
• Load factor	0 to 100%			✓
• Age	Date of manufacture			✓
GSE Population Option				
• GSE type	GSE types by model (i.e., baggage tug, etc.).	✓	✓	✓
• GSE count	No. of GSE by type (i.e., 3 baggage tugs)	✓	✓	✓
• Fuel type	GSE engine fuel type (i.e., gasoline, diesel)	✓	✓	✓
• Operating times	Engine-on times (i.e., hours)		✓	✓
• Horsepower	Brake horsepower			✓
• Load factor	0 to 100%			✓
• Age	Date of manufacture			✓

Note—Nonattainments are listed in the USEPA *Green Book of Non-attainment Areas* by pollutant, state, and county, http://www.epa.gov/airquality/greenbook/

- Other factors—As discussed above, SIPs are prepared to help guide areas with unacceptable air quality into compliance with the NAAQS. Because airport emission inventories (including GSE emissions) are included in SIPs, the airport area's attainment/nonattainment/maintenance classification and degree of nonattainment are important considerations when selecting an approach. Emissions inventories and control measures are incrementally more rigorous in SIPs prepared for nonattainment areas with more severe nonattainment designations compared to those with lower classifications. As a result, preparers of emissions inventories for airports located within severe and extreme nonattainment areas should consider using the approaches that produce the most accurate results.

3.3.5 GSE Emissions Inventory by Fuel Consumption

GSE emissions inventory can be estimated by the total volume of fuel consumed by GSE. Using the EPA's NONROAD model, the fuel flow in grams per horsepower-hour can be obtained. An appropriate fuel flow can be identified for each GSE by using the type of fuel and horsepower rating of the engine and converting into gallons per horsepower-hour. The total volume of fuel consumption can be calculated as a product of total hours of operation of each GSE and fuel flow. The total fuel flow can then be used to calculate GHG emissions. However, drawbacks to this method include difficulty in obtaining fuel consumption information from airports.

3.4 Selecting an Approach

Section 3.3 introduced the three suggested approaches to preparing an airport GSE emissions inventory and briefly discussed their most prominent characteristics. Based on this information, this section is intended to aid guidebook users in choosing the most appropriate approach for their airport(s).

3.4.1 Benefits versus Costs

Figure 6. Balancing benefits and costs of approach selection.

Ultimately, the process of formulating and selecting an approach for preparing an airport emissions inventory becomes a compromise, or balance, as shown in Figure 6, between the benefits of obtaining results that are as accurate and as airport-specific as possible while considering the overall costs in terms of the input data, manpower and time required to complete the work. In some cases, this benefit/cost decision is also a function of who is preparing the inventory and for what purpose.

For example, preparers of an airport GSE emissions inventory for large-hub commercial airports located in severe O_3 nonattainment areas are more incentivized and enabled to conduct a higher level (i.e., more detailed) analysis commensurate with the need for accurate and defensible results. By comparison, preparers of GSE emissions inventories for small/medium hub airports located in attainment areas may possess less incentive and have fewer resources to conduct such detailed analysis. In other instances, airport staff may have multiple airports or an array of other non-GSE emissions sources to quantify but limited resources and time to complete the work.

Finding the suitable balance and selecting the appropriate approach to preparing an airport emissions inventory is typically achieved by evaluating the array of factors discussed in Section 3.3.4 and weighing the benefits and costs of each one individually, then as a group. However, because there is no one approach that fits all for preparing airport emissions inventories, the decision is usually made on a case-by-case (i.e., airport-by-airport) basis.

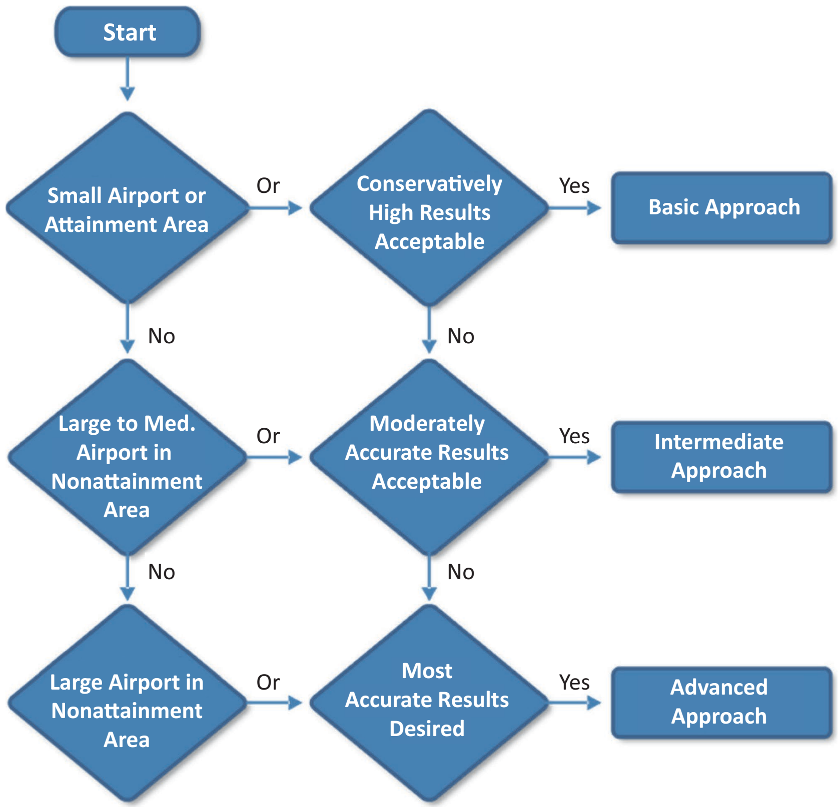


Figure 7. Airport GSE emissions inventory approach selection decision-tree diagram.

3.4.2 Making a Selection

As above in Section 3.3, there are a number of factors to consider when formulating an approach to preparing an airport emissions inventory, and in Section 3.3.4 the pros and cons of each approach are identified. This section serves as a final distillation of the decision-making process to aid guidebook users in the selection process.

Using two important variables, Figure 7 comprises a simple decision-tree diagram to further assist in the selection process. As shown, guidebook users are first urged to take into account the airport size and function (e.g., small, medium, large-hub or GA) and then the assessment's required level of accuracy. Following this course, the scale of the airport's GSE emissions are appropriately matched to the tiered approach and the user is able to determine the desired accuracy of the emission inventory results.

CHAPTER 4

GSE Data Collection Protocol

This section presents a consistent and systematic protocol to collect GSE operational and inventory data to satisfy emissions inventory input requirements identified in Chapter 3. Special attention is also given to safety and security measures and regulations specific to airports, statistical methods with which to calculate a sufficient sample size for data collection, and quality assurance checks and procedures necessary to ensure the collected data are appropriate for use.

4.1 Data Requirements

Reminder—Chapter 3 provides listings and explanations of the data requirements for computing GSE emission inventories using three alternative approaches: basic, intermediate, and advanced.

The target data for an airport GSE emissions inventory is that which is required as input(s) to the computer modeling tools that will be used to compute the emissions inventory. As described in Chapter 3, FAA's AEDT are currently the recommended models for this purpose.

For airport GSE emissions estimates, these models use data on GSE activity by type and activity from GSE assigned to an aircraft gate (i.e., aircraft/gate GSE assignment option) and/or GSE as an overall population (i.e., GSE population-based option). Three alternative approaches (basic, intermediate, and advanced) are also discussed in Chapter 3.

4.2 Health, Safety, and Security

A large component of the overall approach outlined within this protocol requires access to airport airfields and apron areas. It is imperative that all regulations pertaining to airport safety and security are adhered to, and that the safety of personnel is ensured at all times. For any data collection activity involving field presence on airport, a Health, Security, and Safety Plan (HASSP) is suggested to be developed hand-in-hand with the data collection work plan.

Appendix A outlines applicable federal and airport-specific regulations in these areas and how these regulations interface with the development of a HASSP specific to the collection of airport GSE operational data. In addition, an example of a HASSP is also included in Appendix A.

4.3 Data Collection Methods

Data collection methods evaluated for development for this protocol included (1) the apron survey; (2) acquisition of airline/ground handler equipment inventories and/or property lists; and (3) remote sensing methods. Of these, the apron survey is the most complicated to plan, organize, and implement and is thus described in detail. By comparison, the acquisition of GSE inventories/property lists is more straightforward. As for the remote sensing options evaluated in this research, they were determined to be not practicable at this time for most airport applications.

4.3.1 Apron Survey

An apron survey focuses on GSE activity at terminal gates or in areas where aircraft are otherwise being parked and serviced during turnaround or en route operations (Figure 8). A turnaround operation signifies that the aircraft departs from Airport A, arrives at Airport B to exchange passengers and/or cargos, and then returns back to Airport A. An en route operation represents an aircraft departing from Airport A, stopping over at Airport B, and continuing on to its final destination at Airport C.

Aircraft services requiring GSE in these apron areas include aircraft cabin service and climate control; baggage/cargo handling; passenger loading/unloading; aircraft fueling, starting, and maneuvering; deicing; and occasional service and maintenance. Utilization of either fixed-gate or semi-fixed-gate GSE (e.g., a GPU or a belt loader) as well as mobile GSE (e.g., a baggage tractor or hydrant truck) are commonplace; however in the case of mobile GSE, only the portion of activity as they approach, egress, or dwell in the gate area is required as data for the emissions inventory.

Reminder—Chapter 2 provides a comprehensive listing and descriptions of types and functions of GSE commonly found at U.S. airports.

A number of different types of apron areas can exist within the same airport, defined for the purposes of this protocol as:

- Terminal area aprons—Areas where commercial air carrier and air taxi/commuter aircraft are serviced for the purposes of enplaning and deplaning passengers. Inclusive of close-in contact and non-contact gates. Belly cargo handling and gate deicing is considered part of terminal area apron activity.
- Deicing aprons—Areas where aircraft are transported or directed to a remote location from the passenger gates (i.e., to a deicing pad) for either fluid or alternative (e.g., infrared) deicing.
- Cargo aprons—Areas where dedicated cargo air carrier operations (i.e., the exclusive loading/unloading/transfer of cargo) occur at separate facilities from the terminal area.
- GA aprons—Areas where private pilot, air charter, corporate jet, and other miscellaneous commercial aircraft park and receive service.

Figure 8. Airport GSE apron survey viewpoint.

Figure 9. GSE apron survey team member.

Other apron types also exist (e.g., maintenance, remote); however, terminal area and cargo aprons are suggested to be assigned priority in an inventory because they typically account for a majority share of aircraft GSE gate service events, and safety/logistical considerations may make some apron areas (e.g., deicing) more difficult to effectively sample.

4.3.1.1 Survey Team

To conduct an apron survey, deployment of a number of survey members (Figure 9) or team(s) may be necessary, based on airport-specific operational information and the desired level of sampling. The survey team should comprise the following:

- Dispatch—The teams' activities are suggested to be coordinated by a dispatch whose primary responsibilities include: (1) relaying information among teams, airport staff, or other personnel; (2) directing back-up or contingency sampling regimes in the event aircraft operations significantly deviate from the flight schedule; and (3) making decisions to ensure worker health and safety (e.g., if safety, security, ambient conditions, or other airport-specific considerations preclude the research team from being positioned within the apron area, the dispatcher may instruct that the apron survey operations shift to the inside of a vehicle, also referred to as a windshield survey.

  In advance of the field work, the dispatcher should assign each team a series of turnarounds to observe on a given sampling day, based on sampling requirements and the day's flight schedule. Each team can be allocated to a specific, non-overlapping series of gates/apron areas where they can conduct assigned observations. Survey teams are suggested to be assigned apron area(s) for which they are responsible (e.g., Gates 12 through 20), but should not be charged with observing more than one terminal gate at a time (e.g., Gate 12). Each survey team should ideally consist of two to three members, filling the roles described below and depicted on Figure 10:
- Controller—Responsible for aircraft turnaround activity observation, monitoring status of upcoming flights, and communicating to escort personnel and team dispatch any necessary modifications to the transportation and sampling plans as flight arrival/departure status is updated.
- Primary Observer—Responsible for communicating to the survey team GSE approach, egress, and dwelling events.
- Scribe—Responsible for data recording as well as acting as a secondary observer.

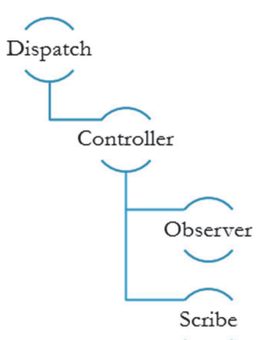


Figure 10. GSE survey team hierarchy.

In cases where budget, staffing resources, airport regulations or other considerations preclude three-person teams, the primary observer may also fulfill the responsibilities of controller. Responsibilities of the scribe should not deviate from those described as this may impact the consistent and reliable recording of operational data.

AEDT equipment emissions characteristics and data that can potentially be captured using an apron survey include aircraft utilization (e.g., cargo versus passenger, narrow-body versus wide-body), operating times (e.g., 30 minutes per enroute arrival), and GSE equipment parameters (e.g., equipment type, fuel type, horsepower).

The following sections present a series of best practices on (1) designing and executing a sampling strategy for an apron survey; (2) establishing a sampling domain for apron observations; (3) creating and utilizing data collection field resources; and (4) recording aircraft GSE utilization and operating time data.

4.3.1.2 Designing a Sampling Strategy

Shown on Figure 11, the first step in sampling design is evaluation of aircraft fleet operational data and anticipated flight schedules to identify the most prevalent carriers (e.g., Delta, UPS, etc.) and their most frequently flown operations (e.g., B752). The operational data are suggested to be obtained and assessed during early coordination steps (see Chapter 6). Reviewing these data offers a two-fold benefit in that it (1) increases the sampling success by maximizing opportunities to observe a particular operation during the sampling period and (2) ensures that the largest share possible of the airport fleet operations are being populated with airport-specific GSE operational data for emissions modeling.

Idea—Airport operators can aid in reducing preparation times and costs for conducting airport GSE emissions inventories by collecting supporting data and information ahead of time.

Depending on which carriers/aircraft represent the majority share of the airport fleet mix, and depending on how many observations would need to be captured to represent that majority share, the protocol user can then make decisions on subsampling, such as to what extent narrow-body and wide-body aircraft should be sampled, or to what extent should passenger or cargo operations be sampled.

Once decided, preliminary sampling is suggested to be conducted with the aim of collecting at least 10 preliminary observations (e.g., observe 10 aircraft turnarounds). This enables the calculation of sample size sufficiency based on the user's acceptable levels of statistical uncertainty or confidence in the sample data.

Once preliminary samples are collected, calculate the mean ($\overline{x}$) and standard deviation (σ_x) of the data (e.g., GSE operating times) from a set of gate service observations and verify that the data to be tested are normally distributed. If so, define acceptable levels of uncertainty (d_r) as well as the minimum acceptable confidence interval (α) with which to determine whether the specified uncertainty is statistically valid. Note, α is expressed as a fractional value, so for instance if the desired confidence is 95%, α would be expressed as $(1 - 0.95 = 0.05)$. Each selected value of α is then related to a Z-score ($Z_{1-\alpha/2}$) on the standard normal distribution and applied to Equation 3 to obtain an estimate of sample size (n).[18]

Reminder—When conducting airport GSE surveys, accurate and airport-specific data are preferred over generalized or presumed information. However, other real-world factors and considerations may impede or moderate this objective.

[18] For a standard list of z-scores: http://www.stat.ufl.edu/~athienit/Tables/Ztable.pdf

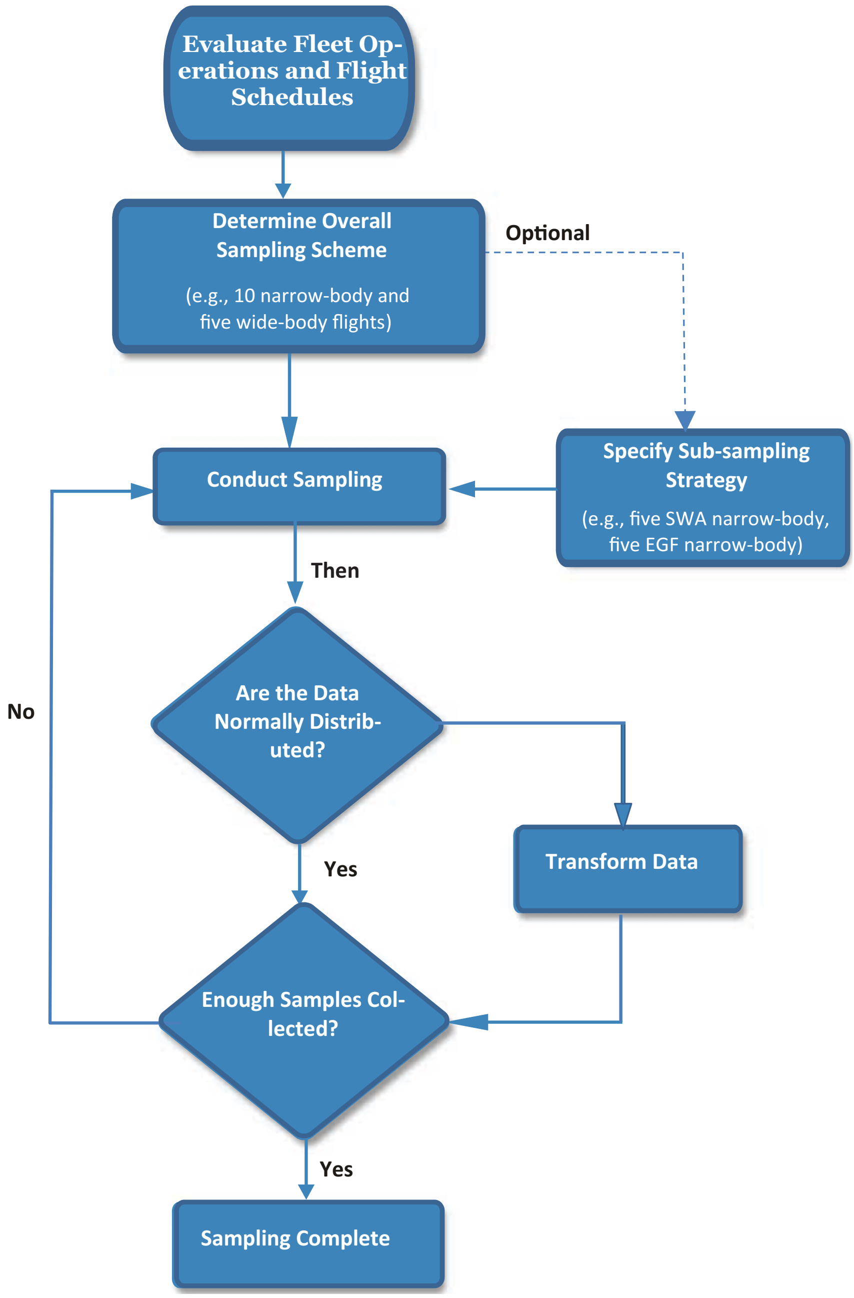


Figure 11. Sampling strategy development.

$$n = \left[Z_{1-\alpha/2} \frac{\sigma_x}{\bar{x}\, d_r} \right]^2 \qquad \text{Equation 3}$$

where

$\bar{x}$ = sample mean
σ_x = sample standard deviation
d_r = defined level of uncertainty
α = minimum acceptable confidence
$Z_{1-\alpha/2}$ = Z-score on the standard normal distribution table

Shown in Table 5, for instance, after 16 observations of a lavatory service truck servicing a narrow-body aircraft, an average running time of 05:29 minutes with a standard deviation of 01:54 minutes was computed. According to Equation 3, 21 samples are required to accept 20% uncertainty in the computed average running time. Because only 16 samples were initially collected, five more samples would need to be obtained to accept a 20% uncertainty on the sample average, and even more samples would be suggested to further reduce the accepted level of uncertainty.

Table 5 further illustrates that, with an assigned statistical confidence of 80%, additional sampling would be suggested to further reduce the uncertainty in the data averages to 10% (with the exception of the hydrant truck). The exercise demonstrates that there is a trade-off between estimated sample size, statistical confidence, and acceptable uncertainty/error.

Given the inherent variability in GSE operations, and how this variability is impacted by airport-, aircraft-, airline-, and potentially climate-related variables, the protocol user might find it sufficient to accept 20% uncertainty in an estimated average, especially if there are time or budget constraints that would preclude additional sampling. Reducing the level of averaging in the data set (e.g., computing averages and sample sizes for each individual air carrier) may decrease the observed variance and uncertainty but would also require additional samples from each subsampling parameter to form a sufficient basis of statistical comparison.

4.3.1.3 Sampling Domain

The event sampling domain (ESD) for each gate service event can be segregated into two areas (see Figure 12). The direct ESD is suggested to be generally demarcated using the apron/taxiway edge, boundary of responsibility line/stand safety line, restricted stand-by area lines, equipment parking lines, and vehicle limit lines on the airfield pavement. In addition, a conditional ESD is suggested to be included, encompassing adjacent gates to the left and right of the direct ESD so long as these gates are not occupied and it is obvious that equipment traversing or dwelling in the conditional ESD are servicing the aircraft turnaround occurring in the direct ESD.

The only activity outside of this area that are suggested to be included in the ESD is aircraft tractor activity, as it is a typical operation for the tractor to leave to escort the aircraft and then return to the area to park. This is not necessarily the case for other equipment, so activities for these other assorted equipment outside of the designated sampling domain will be captured separately using other data collection methods (see Chapter 5).

Table 5. Example sample size, 80% confidence.

GSE Type	Time per LTO		Observed n	Estimated n, ∝ = 0.05 (% uncertainty)		
	$\bar{x}$	σ_x		20%	15%	10%
Aircraft tractor	00:05:29	00:01:54	16	5	9	**21**
Baggage tractor	00:19:56	00:08:17	17	7	13	**30**
Belt loader	00:44:09	00:26:08	17	11	**20**	**44**
Cabin service truck	00:31:10	00:09:19	14	4	7	**15**
Hydrant truck	00:08:38	00:02:18	14	3	5	12
Lavatory service	00:06:57	00:04:43	7	**20**	**35**	**79**

Bolded font signifies that additional samples are suggested.
LTO = landing/takeoff operation.
$\bar{x}$ = sample average;
σ_x = sample standard deviation; and
n = sample size.

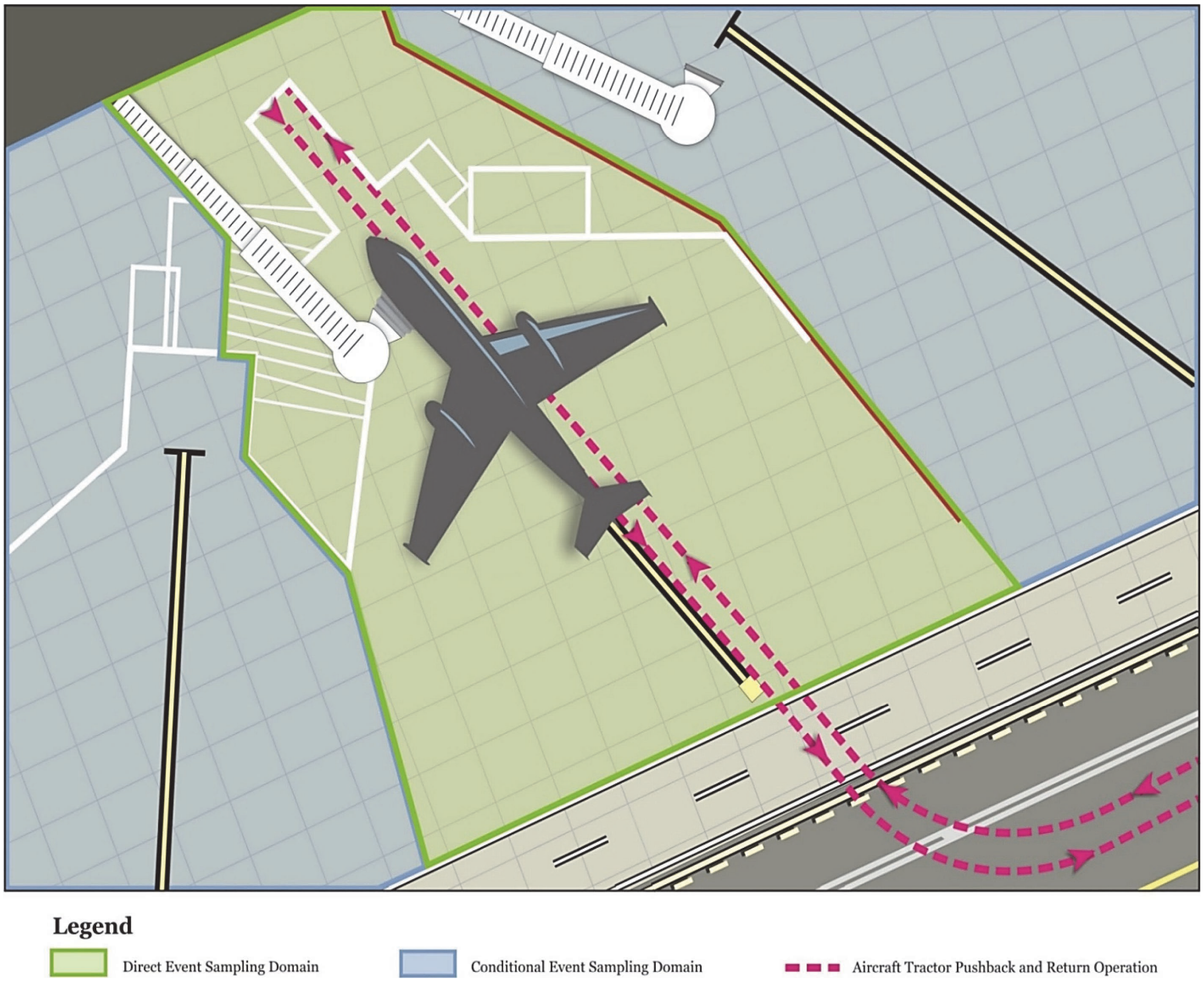


Figure 12. Apron survey gate service event sampling domain (ESD).

4.3.1.4 Field Resources

Appendix B provides example apron survey data collection resources to be provided to field observers, such as the GSE Operating Time Observation Form shown as Figure 13. These resources are intended to facilitate logistics, ensure adherence to a HASSP, and familiarize the workers where necessary with the appearance of GSE and typical operations at an aircraft apron. Also provided in Appendix B are suggested templates for recording equipment utilization, operating time, and equipment data, including the following:

- Team Sampling Itinerary—A matrix denoting the sampling order, scheduled time of arrival/departure, scheduled gate, flight operator, flight number, and aircraft type.
- Airport Planning Manual Terminal Servicing Guide—A graphical display of typical GSE service positions and approach order during aircraft arrival/departure services; one each per aircraft included in the team's sampling itinerary. The intent of this information is to provide a general understanding of the likely locations and times GSE will be present at the aircraft.
- Survey Team Gate Assignment Map—Indicates to a team which gate(s)/area(s) are under their responsibility and which are assigned to other team(s).
- Visual Guide for Typical Apron GSE—Provides representative pictures of each type of GSE (e.g., belt loader), in the event an observer encounters a piece of equipment that they cannot identify with certainty or are otherwise unfamiliar.

Aircraft Type: MD82 **Turnaround:** ☐ **Operator:** AAL **Date:** 7/10/2014
Apron Type: Terminal C **Enroute:** ☐ **Tail:** N585 **Airport:** DFW
Team: B **Time In:** 10:17:09 **Gate:** C33
Scribe: Joe Smith **Time Out:** 11:10:20 **Flight:** 132

GSE		Start	Stop	Start	Stop	Start	Stop
Belt Loader							
☒ Forward	☐ Aft	10:20:01	11:02:35				
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
Baggage Tractor							
☐ Forward	☒ Aft	10:18:53	10:24:54				
☒ Forward	☐ Aft	10:20:32	10:20:53	10:25:27	10:28:31		
☒ Forward	☐ Aft	10:28:09	10:30:22				
☐ Forward	☒ Aft	11:05:05	11:08:59				
☒ Forward	☐ Aft	10:37:41	10:43:41				
☐ Forward	☒ Aft	10:56:10	11:01:39				
☐ Forward	☐ Aft						
Aircraft Tractor							
Power In/Push Back		10:19:29	10:19:57	11:08:18	11:13:12		
Tug In/Push Back							
Air Start							
Cabin Service Truck							
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
Catering Truck							
☐ Forward	☒ Aft	10:19:19	10:38:50				
☒ Forward	☐ Aft	10:19:20	10:41:04				
☐ Forward	☐ Aft						
Air Conditioners/Heaters							
Air Conditioner							
Heater							
Deicer							
Forklift							
Fuel Truck							
Ground Power Unit							
Hydrant Fueling							
☐ Cart	☒ Truck	10:30:08	10:41:21				
Lavatory Service							
☐ Cart	☒ Truck	10:40:45	10:47:32				
On-road Vehicle							
☐ Pickup	☒ Van	10:39:50	10:43:10				
☐ Pickup	☐ Van						
☐ Pickup	☐ Van						
Water Service							
☐ Powered	☐ Gate						
Passenger Stairs							
Other: 400 Hz gate power		10:18:06	11:03:17				
Other: PCA		10:20:12	11:03:50				
Other:							

Notes: Pick-up truck observed to be associated with refueling activities.
Water service observed but not timed.

Figure 13. Airport GSE survey form.

- Equipment Data Plate Examples—Illustrates to the user what an equipment data plate looks like in the event that any information therefrom can be gleaned from parked GSE in the assigned areas (e.g., horsepower, model year).

In addition, Appendix A presents an example Health, Safety, and Security Plan (HASSP) that provides a general description of the levels of personal protection and safe operating guidelines expected from all personnel performing the GSE surveys.

4.3.1.5 Aircraft GSE Utilization

Aircraft utilization relates to the types of GSE required to service an aircraft, their service positions, and assigned duties based on an aircraft's service purpose (e.g., passenger, commuter, cargo, mixed cargo); aircraft type (e.g., narrow-body, wide-body, regional jet); and trip configuration (e.g., turnaround versus en route). It is also advantageous for the survey team to record which airline or carrier is operating the aircraft to allow for the potential distinction of GSE utilization among carriers (e.g., some carriers practice "quick" turnarounds).

To collect this information, field observers are suggested to be issued a *GSE Operating Time Observation Form* (Appendix B). The form has multiple formats tailored as to whether the observation is occurring at a terminal apron, a cargo apron, or some other area. The form also provides opportunities to record aircraft tail number, type, flight number, carrier, gate, and trip configuration. During data post-processing, this information can be used to research additional information about the aircraft's operation as well as to combine any secondary data (e.g., number of passengers, weight of baggage/cargo, trip distance) acquired for that flight via coordination with airlines/ground handlers to the utilization data collected during the apron observations.

The *GSE Operating Time Observation Form* also allows for the identification of service positions for select GSE (e.g., whether a baggage tractor is servicing the forward or aft loading door, or whether a cargo loader is moving cargo into the upper or lower deck of an applicable aircraft) (Figure 14).

Further, the form provides the ability for the observer to differentiate aircraft tractor operating times based on the aircraft maneuvering method observed. For example, aircraft maneuvering as they approach/depart the gate can be categorized and defined as follows:

- Power-in/Pushback—The aircraft taxis in to the gate area under its own engine power until it is parked. The aircraft tractor is attached once flight safety checks and aircraft service have been completed, and the tractor powers the aircraft out of the gate area to the taxiway. The aircraft tractor is considered running from the time it leaves with the aircraft to the time it returns to its parking position at the gate.
- Tug-in/Pushback—The aircraft is escorted to its gate stop line under the power of the aircraft tractor. The tractor operating time begins once the aircraft is in visual sight of the sampling domain, stops during gate service, and resumes once flight safety checks and aircraft service have been completed, when the tractor powers the aircraft out of the gate area to the taxiway. The aircraft tractor is considered running from the time it leaves with the aircraft to the time it returns to its parking position at the gate.

4.3.1.6 Operating Times (Gate Turnaround)

Again, the main utility of an apron survey includes the recording of GSE operating times as they approach, egress, and dwell at an aircraft while performing the variety of passenger movement, cargo movement, and aircraft servicing functions.

As mobile equipment encroach upon the sampling domain for a gate service event, observers should mark the time (HH:MM:SS) and assume the equipment has its engine running unless there is a visual signal that the equipment operator turns off the ignition. Equipment with multiple

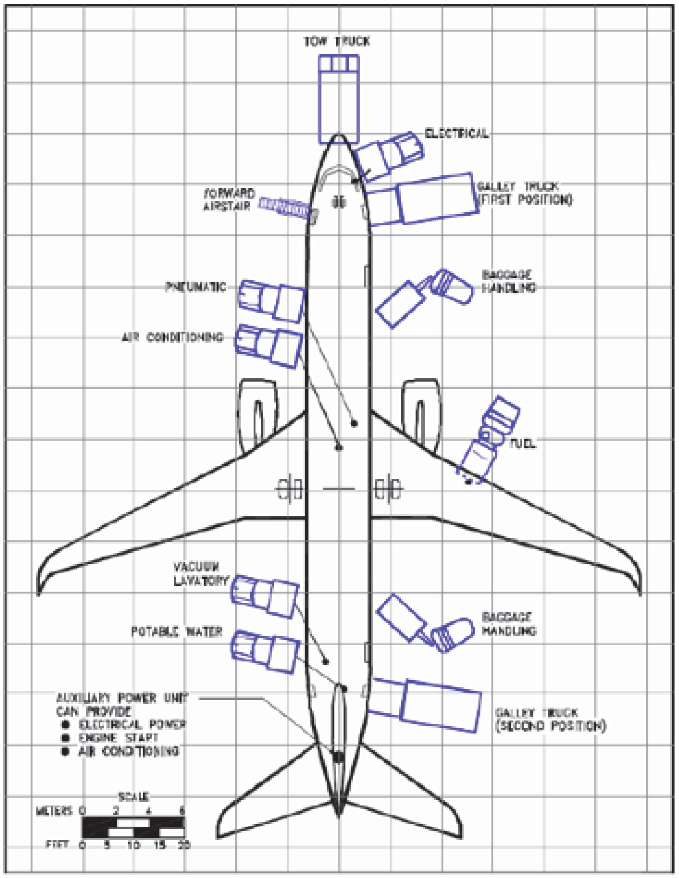


Figure 14. Typical aircraft GSE positions.

approaches within a gate service event, such as baggage tractors, are suggested to be assigned start and stop times (HH:MM:SS) each time they leave and return through the boundary of the sampling domain. The only exception is the aircraft tractor.

Fixed or semi-fixed equipment, such as GPUs, are suggested to be considered operational once there is a clear signal that the device is being activated by an operator or attached to the aircraft, and considered non-operational if visual cues indicate it's been deactivated.

4.3.2 GSE Inventory/Property Lists

The preferred method for collecting information on GSE equipment parameters such as make/model, engine make/model, fuel type, and power rating is via acquisition of airline/ground handler equipment inventories or property lists. These data are best obtained from the air and cargo carriers, ground support providers, and/or the airport (see Chapter 6).

However, to supplement the preferred method, one can also attempt to collect as much of this information as possible from parked and/or dwelling equipment in the terminal, cargo, and/or GA areas. In this case, observers should, to the extent permissible, inspect the equipment cabins, engine compartments, and/or fuel compartments to locate the equipment data plate and record information that either directly fills out the fields on the Equipment Parameter Observation Form or provides the opportunity to look the information up at a later time (e.g., recording the serial number).

Idea—As discussed in Chapter 6, coordination with airlines, cargo carriers and other airport ground support providers may enhance the quantity and quality of the GSE database for computing a GSE emissions inventory.

4.3.3 Remote Sensing

As mentioned at the beginning of this section, the initial draft protocol included ideas for testing the efficacy and utility of remote sensing techniques in GSE field surveys. The techniques identified for testing in the research included thermal imaging (e.g., to determine if GSE power is on/off), global position system (GPS) tracking of GSE, and video recognition of GSE activity. During the protocol testing completed at several airports during the research, these remote sensing options were found to be unreliable, not cost-effective, and/or not acceptable within the security requirements of the airports. For these reasons, remote sensing techniques for collecting GSE data in support of computing emissions inventories are not suggested at this time.

4.3.4 Data Collection Time

The amount of time required to collect GSE data is dependent on the airport's arrival and departure schedule and the type of aircraft being surveyed. For example, cargo aircraft typically have a longer turnaround time than passenger aircraft. As a result, the amount of time needed to sample cargo aircraft may be longer than the amount of time needed to sample passenger aircraft. During the planning phase of sampling, the dispatcher is assigned the task of organizing a series of turnarounds for each team to observe. If possible, in order to reduce the time needed to collect results, it is highly suggested that the dispatcher select successions of quick turnarounds.

As a means of providing an example of data collection time that is needed to survey, the days and number of samplers for each airport surveyed for ACRP Project 02-46 are shown in Table 6.

4.4 Quality Assurance

The purpose of a quality assurance routine is to both qualitatively and quantitatively assess collected data to ensure that the data are useful, reliable, and valid before the data are used in follow-on analyses. Figure 15 offers a systematic approach to assuring data quality collected using this protocol.

4.4.1 Data Cleaning

The process of data cleaning is also referred to as code and value cleaning. The purpose is to determine whether each variable in a data set contains only legitimate codes or values and whether these seem reasonable. For example, if GSE fuel mix data are collected and are coded

Table 6. Airports sampled, survey days, and number of samplers.

Airport	Type of Sampling	Number of Days Sampled	Number of Samplers	Number of Turnaround Observations
Logan International (BOS) Boston, MA	Passenger only	2	2	16
Portland International (PDX) Portland, OR	Passenger only	2	1	11
Dallas-Fort Worth International (DFW) Dallas, TX	Passenger only	2	2	18
Oakland International (OAK) Oakland, CA	Cargo only	3	1	11
T.F. Green (PVD) Providence, RI	Passenger only	3	2	11

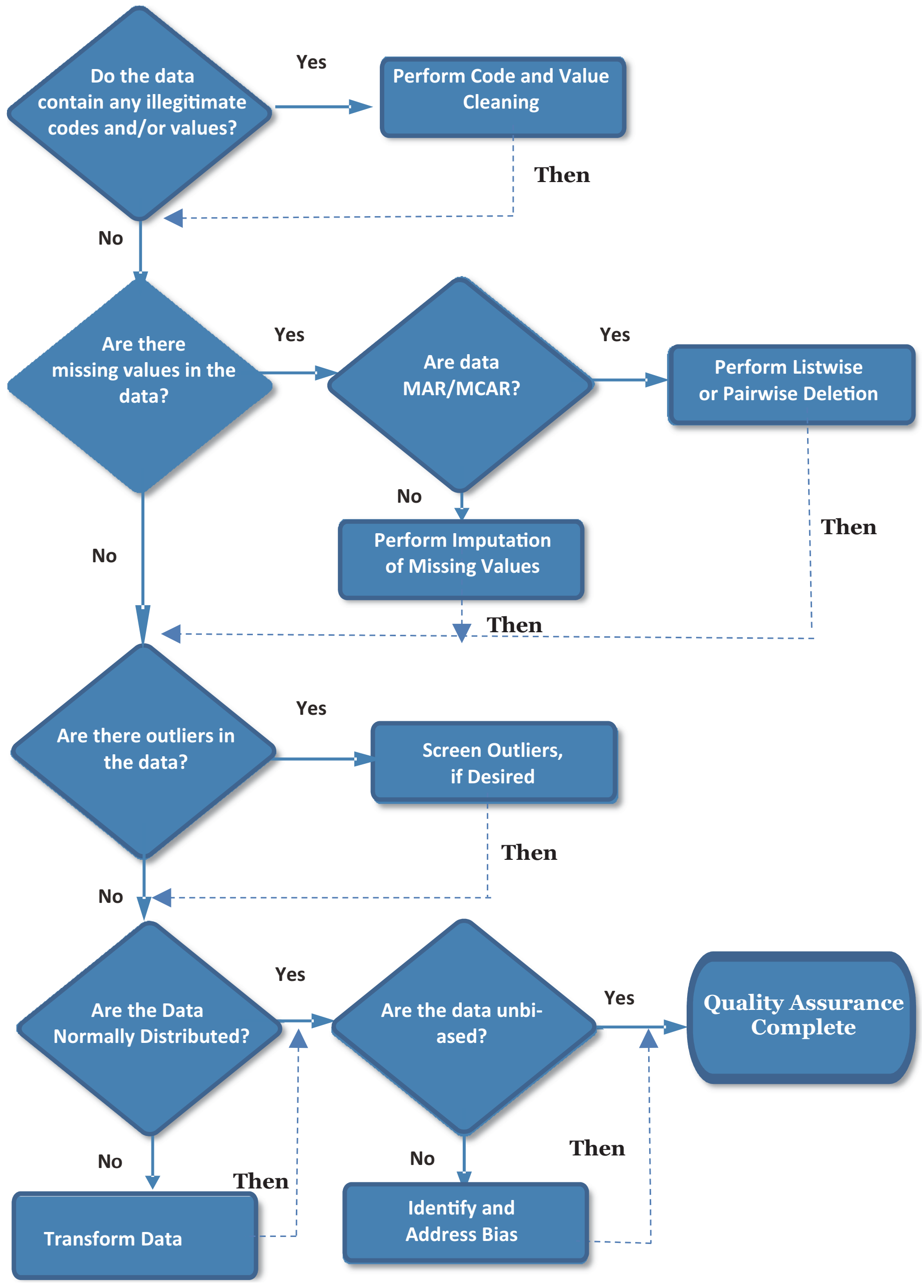


Figure 15. Quality assurance routine.

(e.g., D = diesel, G = gasoline, L = LPG, C = CNG, and E = electric), and all data under the fuel type variable are coded with only these letters, then the variable is considered clean. In contrast, if there is a value coded with X or a value that is not a character but a number, then that value would need to be verified.

In terms of GSE operating times, if the modal GSE service time during a turnaround was 30 minutes with a range of between 20 and 40 minutes, and it was discovered that there was a turnaround time of 12 minutes (which could be a legitimate value), then the authenticity of that value would need to be verified, possibly through other sources. The cleaning process helps flag these illegitimate and unreasonable values. If warranted, they can be considered outliers to be eliminated, substituted with the correct value if recorded incorrectly, or treated as missing values to be replaced.

4.4.2 Missing Data

Encountering missing data may happen for a number of reasons, including having limited access to information or missing values due to random processes. Randomly missing data can be (1) missing completely at random (MCAR) or (2) missing at random (MAR).

Data are MCAR when the missing data are in no way related to any other variables or other missing information in a given data set, and there is no pattern to the missing data, which rarely occurs. On the other hand, missing data are MAR when their absence can be explained, or is dependent on, other variables for which one has full information. For example, missing data for fuel truck operating times in the range of 50 to 60 minutes would not be MAR if most of the operating times fell in the 50 to 60 minutes range in the first place.

If the missing data conform to MCAR or MAR criteria, then there is no explicit problem with ignoring or deleting the missing observations, but with the caveat that there may be complications if there is a significant amount of missing data. Options for the deletion of MCAR/MAR data include:

- List-wise deletion—In this instance, if an arrival time for a baggage tug is recorded and the departure time is missing, both observations can be discounted despite the validity of the recorded arrival time. Concerns with this method are that resulting sample size reduction may increase the estimate of measurement error, and the survey may not meet the sample size requirement.
- Pair-wise deletion—In this case, if an observation has missing data for any one variable, but there are data present for other variables, the observation can still be used. For example, if a series of eight aircraft turnarounds were observed and only six of them recorded a baggage tractor, then summary statistics for the baggage tractor would be computed on the six available measurements. Meanwhile, if an aircraft tractor was observed for all eight of these turnarounds, the summary statistics for the aircraft tractor would be computed based on all eight measurements; that is, the sample set would not be reduced to six just because of the missing baggage tractor values.

If data do not conform to MAR or MCAR criteria, missing data cannot be ignored and the data set is subject to imputation—referring to the practice of substituting a missing value with one that is a reasonable approximation or surrogate. One method is called mean substitution, where all missing values of a variable are replaced with the average of that variable. This is reasonable when the sample mean is a good estimate of the total population mean.

Another imputation method is via multivariate regression analysis, whereby a regression equation is generated with only complete data, using several independent variables to predict a dependent variable (the one with missing data).

Some statistical software and tools available for data screening include SPSS, NCSS, and Microsoft Excel. SPSS is capable of executing the aforementioned data screening techniques. NCSS performs data screening in a database and reports the type of data (discrete or continuous), normality of each variable, missing value patterns, and presence of outliers. Furthermore, Microsoft Excel has an add-in functionality called Data Analysis. Some useful tools include creating histograms, obtaining descriptive statistics, and doing regression on data. Other statistical software that may be useful includes SAS, Stata, and R.

4.4.3 Outliers and Data Distribution

Analyzing the distribution of data allows one to identify outliers, verify the normality of the distribution, and find trends among variables. Some visual tools for displaying data include frequency tables, histograms and bar graphs, box and whisker plots, and scatterplots. The first four tools display data for one variable at a time (i.e., univariate), while the last tool looks at the relationship between two or more variables (i.e., multivariate).

With respect to an airport GSE survey, the univariate case is suggested to be primarily considered because emissions calculations for each type of GSE is additive and some variables are independent of one another. Upon data collection, post-processing, and quality assurance screening, the potential for multivariate analysis can be additionally considered.

Options for displaying the distribution of data are briefly discussed below.

- Frequency table—A frequency table provides counts of how many times a given variable is observed in a data set, and is useful in that it easily reveals data entry errors (e.g., using non-existent or erroneous values for fuel type).
- Histograms/bar graphs—These represent a frequency table in graphic form and are useful to visually inspect the general shape of the distribution. Histograms are suggested to be used for frequency counts of continuous variables (e.g., turnaround time) and bar graphs for frequency count of categorical variables (e.g., fuel type). Descriptive statistics give more detailed information on how close the distribution is to a normal distribution, conveyed as either skewness or kurtosis (Figure 16).

  As shown, skewness relates to the symmetry of a distribution. A data set that is not approximately symmetric about its sample median is skewed. "Skewed to the left" is when the histogram has a long tail to the left, whereas "skewed to the right" signifies a long tail to the right. Kurtosis refers to the clustering of scores toward the center of a distribution. Data can be distributed close to the mean (small standard deviation) or far from the mean (large standard deviation).

- Box and whisker plot—A box and whisker plot shows the spread or distribution of a data series based on calculated statistical quartiles and percentiles and is a good visual tool to identify extreme values in numerical data. An important feature of a box and whisker plot is the interquartile range (IQR), which is a measure of statistical dispersion and is defined as the difference between the third quartile (Q3, or the 75th percentile of the data) and the first quartile (Q1, or the 25th percentile of the data). Conventionally, an outlier is defined as a data point that is farther than ±1.5 IQRs from the median value (i.e., the 50th percentile) but less than ±3.0 IQRs. An extreme outlier exceeds ±3.0 IQRs. Figure 17 provides an example box and whisker plot and denotes the demarcations for Q3, Q1, IQR, median, 1.5 IQR, and outliers.
- Scatterplot—It may also be useful to use scatterplots to compare two or more variables at a time (Figure 18). For example, for a belt loader, the forward position operating time can be plotted against the aft position operating time, or vice versa. In examining the interrelationship of two or more variables, unusual patterns of variability may be found among the variables. For instance, such plots may reveal extreme values that can be labeled as outliers. Furthermore, trends may be found among variables that were otherwise undiscernible.

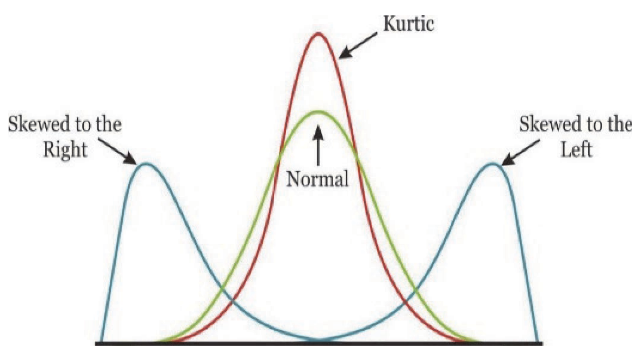


Figure 16. Skewness/Kurtosis about the normal distribution.

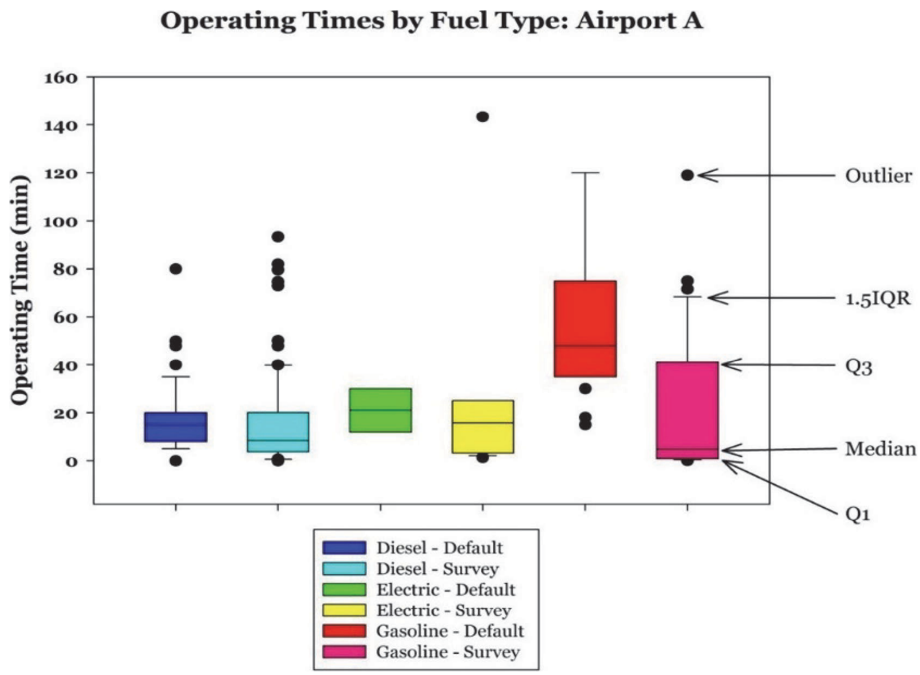


Figure 17. Example box and whisker plot.

4.5 Sampling Error and Bias

Sampling error occurs when a value derived to represent a large population is estimated from a subset of the population; it is the difference between the estimated value and its true population value due to random selection. It can be estimated using statistical confidence intervals and probability values. Because of the nature of the data collection methods, especially windshield surveys and remote sensing and measurement, it is important to know the estimated error of the calculations. Sampling bias occurs when a sample is not truly random and representative of the population.

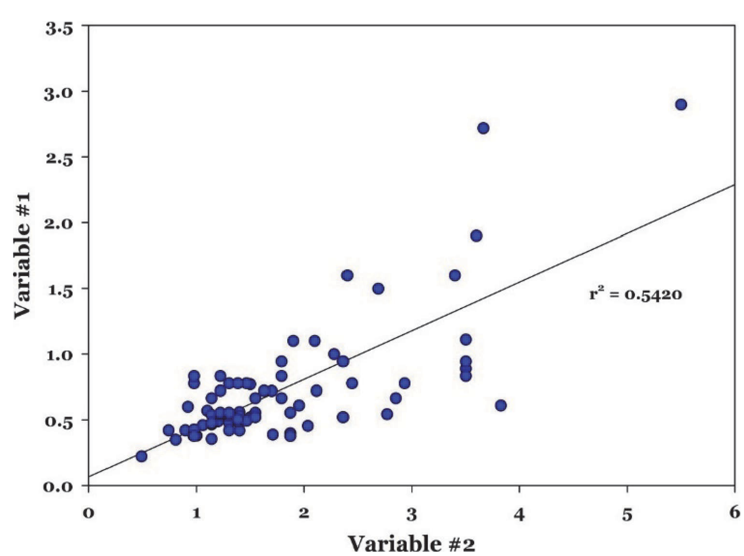


Figure 18. Example scatterplot.

For each data variable to be collected, the sampling error can be calculated using statistical software and tools. For instance, one could compute a 95% confidence interval for a set of normally distributed data and perform hypothesis testing on the data using a *t*-test. A two-sided *t*-test at a 95% confidence level tests a hypothesis on the computed sample average. If the hypothesis is not statistically rejected, it signifies that one could be 95% confident that the sample average lies within the true population average, given a margin of error assigned specific to the 95% confidence interval. Similarly, a one-sided *t*-test would test whether the sample average is significantly less than or greater than the true population average. A test for statistical significance, using statistical values called *p*-values, is also commonly conducted in conjunction with these types of hypothesis tests.

Because every airport is different, there are different standards and practices for GSE utilization. Each airline may have different practices for GSE as well. Moreover, there may be limitations on the selected airports and aprons for the study, so GSE utilization may not be representative. Therefore, to some degree sampling bias is unavoidable. For example, it may be that only certain airlines allow apron surveys to be done, and these airlines' GSE procedures have a greater turnaround time on average than other airlines. Then the operating times for GSE would be overestimated. Although a larger sample size would increase the precision of the results, this may not reduce sampling bias.

CHAPTER 5

Modifying and Using Default GSE Emissions Model Data

This chapter contains suggested practices and supporting data for computing airport GSE emissions inventories using updated default input parameters in place of those currently available.

5.1 Background Information

Chapter 3 identified and described the principal tools for computing airport GSE emissions inventories. As discussed, the current (and most often used in North America) tool for computing an airport GSE emissions inventory is the FAA's EDMS. However, EDMS will be succeeded by FAA's AEDT (Version 2b), which is scheduled to be released in 2015.

Reminder—Chapter 3, GSE Emissions Inventories, provides listings and explanation of the data requirements for computing GSE emissions inventories using three alternative approaches: Basic, Intermediate, and Advanced.

Idea—As discussed in Chapter 6, coordination with airlines, cargo carriers and other airport ground support providers may enhance the quantity and quality of the GSE database for computing a GSE emissions inventory.

It was further disclosed that within AEDT there are two methods (or options) for computing airport GSE emissions inventories: (1) Aircraft/Gate GSE Assignment Option and (2) GSE Population-Based Option. Each option has specific input parameters, most are the same (i.e., GSE type, operating time, etc.) but with some differences (i.e., the need to identify aircraft types, by model).

Chapter 3 presented three alternative approaches for computing an inventory, basic, intermediate and advanced, each with a common set of features but differing from each other by their complexity, accuracy, and data requirements.

Importantly, some of the "default" input data for computing airport GSE emissions inventories in AEDT are likely out-of-date and/or not necessarily representative of current conditions or reflective of individual airports. In particular, the vehicles and equipment that constitute the default GSE fleet mix and their operating times (i.e., TIM) may be outmoded due to the changes in aircraft designs and/or GSE owner/operator operational practices.

In response to this apparent shortcoming, Chapter 4 presented a protocol by which to collect airport GSE operational information to satisfy the AEDT GSE emissions inventory input data requirements. The suggested procedures are applicable to using the two available methods (i.e., aircraft/gate assignment or population based) and the three alternative approaches (i.e., basic, intermediate, advanced).

Based upon the application of the GSE data collection protocol at a number of U.S. airports of varying size, function and location—combined with additional airport-related GSE data obtained from other studies—an updated set of default GSE operational data has been developed. This chapter presents these data that are intended to be used in place of the default data currently in AEDT or in the event that airport-specific data cannot be collected due to time or resource constraints.

5.2 Redefining Default Data

Among the assortment of default data contained in AEDT that are relied upon by model users to compute airport GSE emission inventories, some parameters characterize potentially greater degrees of influence on the results when compared to others. It is also acknowledged that the efforts and costs to substantiate the use of alternative default data can sometimes exceed the benefits. Therefore, the following GSE emissions inventory default data are suggested on the basis of their significance and ease of use.

5.2.1 GSE Fleet Mix and Operational Times

Among the airport GSE default input parameters that are contained in AEDT for computing GSE emissions inventories, vehicle/equipment fleet mix and TIM are two of the most important. As discussed in Chapter 2, the vast majority of airport GSE are typically associated with the servicing of air carrier, cargo, and GA aircraft during the ground-based, airport turnaround process. These GSE comprise (but are not limited to) aircraft and baggage tractors, belt loaders, cabin service trucks, etc. And as defined in Chapter 3, the GSE operating times are the times the vehicle/equipment engines are on and generating emissions.

5.2.1.1 Passenger Aircraft

Table 7 contains a listing of the current AEDT default GSE fleet mix for passenger aircraft, broken out by aircraft size (i.e., wide-, narrow-, and small-bodied). Also shown are the corresponding "default" TIM for each GSE type presently contained in the models (i.e., Model Default TIM) for the aircrafts studied (i.e., the only aircrafts that were averaged from EDMS were aircrafts that were observed; only 340B, DH8D, and C402 were averaged for small-bodied aircraft EDMS defaults). Similarly, the airport GSE TIM specifically computed in support of this ACRP project are listed for comparative purposes (i.e., ACRP Project 02-46 TIM).

These data sets reveal that in some cases, there are few to no differences in the GSE fleet mix and TIM between what is contained in AEDT and the results from the ACRP research. Wide-body cabin service/catering trucks and narrow-body aircraft tractors are two such examples. In other cases, the data show that there are variances in either the GSE fleet mix components, the TIM, or both when comparing the two data sets. The differences in the baggage tractor TIMs for wide-, narrow-, and small-body aircraft are notable examples as are the absences of air start units for wide- and narrow-body aircraft distinguished by the ACRP data.

Based upon these findings, Table 7 also identifies the suggested default GSE fleet mix and their TIM to be used in AEDT for passenger aircraft. For ease of recognition, these vehicles/equipment and TIM are depicted in bold fonts.

5.2.1.2 Cargo Aircraft

As discussed in connection with the passenger aircraft GSE default fleet mix and TIM, the same data sets for cargo aircraft are listed and compared in Table 8.

Again, these data sets reveal that in some cases, there are few to no differences in the cargo aircraft GSE fleet mix and TIM between what is contained in AEDT and the results from the ACRP research. Wide-body aircraft tractors and belt loaders are two such examples. In other cases, Table 8 also shows that there are variances in either the GSE fleet mix components, the TIM, or

Table 7. Passenger aircraft GSE fleet mix and operating TIM.

GSE Fleet Mix	Model Default TIM	ACRP 02-46 TIM	Proposed New Default TIM
Wide-Body Aircraft			
Aircraft tractor	8	12	12
Baggage tractor***	120	53	53***
Belt loader	35	42	42
Cabin service/catering truck*	28	28	28
Cargo/container loader	80	50	50
Lavatory truck	25	17	17
Air conditioner	30	NA	-
Air start	7	NA	-
APU***	26	25	25***
Fuel/hydrant truck*	20	37	37
Service truck**	15	11	11
Water service	12	NA	5****
Narrow-Body Aircraft			
Aircraft tractor	7	7	7
Baggage tractor***	61	28	28***
Belt loader	41	47	47
Cabin service/catering truck*	17	21	21
Air conditioner	30	41	41
Air start	7	NA	-
APU***	26	15	15***
Fuel/hydrant truck*	14	17	17
GPU	40	35	35
Lavatory truck	14	8	8
Service truck**	14	9	9
Water service	12	5	5
Small-Body Aircraft			
Aircraft tractor	5	9	9
Baggage tractor***	27	13	13
Belt loader	23	22	22
Cabin service/catering truck*	6	6	6
Fuel/hydrant truck*	20	9	9
GPU	40	35	35
Lavatory truck	0	4	4
Service truck**	11.5	NA	-

NA = Not Applicable. TIM = Operating Time-in-Mode.
Bold font = suggested default GSE fleet mix and TIM.
*Cabin service and catering trucks are separate in AEDT. Fuel and hydrant trucks are separate in EDMS. TIM represents average between the two.
**Service Truck includes all service vehicles, including minivan.
***Gate-only observations. Final suggestion for baggage tractors is suggested to be higher (based on airport size) to account for the time it takes to travel to loading/unloading area. Final suggestion for APUs is suggested to be higher (based on airport size) to account for taxi-in and taxi-out times.
****Wide-bodied water service based on narrow-bodied aircraft.

Table 8. Cargo aircraft GSE fleet mix and operating TIM.

GSE Fleet Mix	Model Default TIM	ACRP 02-46 TIM	Proposed New Default TIM
Wide-Body Aircraft			
Aircraft tractor	8	7	**7**
Belt loader	27	23	**23**
Cargo tractor* **	0	29	**29*** **
Cargo/container loader*	73	91	**91**
Fuel/hydrant truck*	33	24	**24**
Lavatory truck	13	6	**6**
Service truck**	12	3	**3**
Air conditioner	23	NA	-
Air start	7	NA	-
Baggage tractor	90	NA	-
Cabin service	14	NA	-
Fork lift	0	NA	-
GPU	0	55	**55**
Water service	12	NA	-
Narrow-Body Aircraft			
Aircraft tractor	0	5	**5**
Belt loader	0	4	**4**
Cargo tractor* **	0	13	**13*** **
Cargo/container loader	0	47	**47**
Fuel/hydrant truck	0	25	**25**
GPU	0	66	**66**
Other	0	11	**11**

NA = Not Applicable. TIM = Operating Time-in-Mode.
Bold font = suggested default GSE fleet mix and TIM.
*Fuel and hydrant trucks are separate in AEDT. TIM represents average between the two.
**Service truck includes all service vehicles.
***Gate-only observations. Final suggestion for baggage tractors is suggested to be higher (based on airport size) to account for the time it takes to travel to loading/unloading area. Final suggestion for APUs is suggested to be higher (based on airport size) to account for taxi-in and taxi-out times.

both when comparing the two data sets. For example, the replacement of baggage tractors with cargo tractors and air conditioners with GPUs are two notable changes. It is also noteworthy that the ACRP data also now cover narrow-body cargo aircraft GSE.

Based upon these findings, Table 8 identifies the suggested cargo aircraft "default" GSE fleet mix and their TIM to be used in AEDT. Again, for ease of recognition, these vehicles/equipment and TIM are depicted in "bold" fonts.

5.2.1.3 TIM by Airport Size

Airport size classifications were derived by means of operations per year. Table 9 lists the total number of airport operations in 2014 for each airport and its size classification. Airports with less than 100,000 total operations per the most recent calendar year (2014) were considered to be small-sized airports. Airports with 100,000–400,000 operations were considered to be medium-sized airports. Airports with more than 400,000 operations were considered to be large-sized airports.

GSE TIMs were also classified by airport size (small, medium, or large-hub airport). The same methodology was used to calculate the proposed new default TIM. A weighted average of ACRP observations from this study, previous studies, and the study completed by KM Chng[17] (KM Chng Environmental 2004) as was for the TIMs by aircraft size.

Table 9. Total airport operations in 2014 and size classification.

Airport	Number of Total Operations in 2014 (thousands) *	Airport Size
PVD	75	Small
TPA	184	Medium
BOS	368	Medium
SAN	191	Medium
BWI	245	Medium
PDX	216	Medium
OAK**	204	Medium
PHL***	419	Large
MSP	412	Large
ATL	868	Large
DFW	680	Large

*Operations data were obtained from FAA's Airport Operations and Ranking Reports using the Air Traffic Activity Data System (http://aspm.faa.gov/opsnet/sys/Main.asp?force=atads).
**Cargo observations only.
***Study completed by KM Chng Environmental. GSE 2004 Survey Prepared for KBE in support of the *PHL Capacity Enhancement Program Environmental Impact Statement*. 2004.

Passenger Aircraft: Small-Sized Airports. Passenger aircraft at small-sized airports are not able to be summarized, as only one small airport was included in GSE survey operations for this study. Furthermore, only narrow-bodied aircraft were able to be observed due to the limitations in aircraft operation turnaround scheduling.

Passenger Aircraft: Medium-Sized Airports. Suggested TIMs for GSE supporting wide-body, narrow-body, and small-body aircraft were compiled by airport size based on the number of total operations in the most recent calendar year (2014). Table 10 represents GSE TIMs by passenger aircraft size at medium-sized airports. The five airports that were classified as medium-sized were TPA, BOS, SAN, BWI, and PDX (see Table 9 for airport size classification).

Passenger Aircraft: Large-Sized Airports. Table 11 represents GSE TIMs by passenger aircraft size at large-sized airports. The three airports that were classified as large-sized were MSP, ATL, and DFW (see Table 9 for airport size classification).

Cargo Aircraft: Medium-Sized Airports. Cargo aircraft were only sampled at Oakland, CA (a medium-sized airport). See Table 9 for proposed suggestions of cargo aircraft GSE TIMs for a medium-sized airport.

Cargo Aircraft: Large-Sized Airports. No cargo aircrafts were observed at large-sized airports for this study. However, the study completed by KM Chng[19] at PHL did observe cargo aircrafts (narrow-bodied: B727; wide-bodied: A300, A310, DC10).

[19] KM Chng Environmental. GSE 2004 Survey Prepared for KBE in support of the *PHL Capacity Enhancement Program Environmental Impact Statement*. 2004.

Table 10. Proposed new default TIM for passenger aircraft GSE fleet mix for medium-sized airports.

GSE Fleet Mix	Model Default TIM	ACRP 02-46 TIM	Proposed New Default TIM
Wide-Body Aircraft			
Aircraft tractor	8	7	**7**
Baggage tractor* **	120	30***	**35**
Belt loader	35	82	**82**
Cabin service/catering truck*	28	33	**33**
Cargo/container loader	80	NA	-
Lavatory truck	25	NA	-
Air conditioner	30	NA	-
Air start	7	NA	-
APU***	26	52***	**57**
Fuel/hydrant truck*	20	24	**24**
Service truck**	15	15	**15**
Water service	12	NA	-
Narrow-Body Aircraft			
Aircraft tractor	7	6	6
Baggage tractor***	61	25***	30
Belt loader	41	52	**52**
Cabin service/catering truck*	17	24	**24**
Air conditioner	30	41	**41**
Air start	7	NA	-
APU***	26	16***	**21**
Fuel/hydrant truck*	14	17	**17**
GPU	40	34	**34**
Lavatory truck	14	7	**7**
Service truck**	14	10	**10**
Water service	12	5	**5**
Small-Body Aircraft			
Aircraft tractor	5	6	**6**
Baggage tractor***	27	8***	**13**
Belt loader	23	36	**36**
Cabin service/catering truck*	6	NA	-
Fuel/hydrant truck*	20	6	**6**
GPU	40	27	**27**
Lavatory truck	0	2	**2**
Service truck**	11.5	NA	-

NA = Not Applicable. TIM = Operating Time-in-Mode.
Bold font = suggested default GSE fleet mix and TIM.
*Cabin service and catering trucks are separate in AEDT. Fuel and hydrant trucks are separate in AEDT. TIM represents average between the two.
**Service truck includes all service vehicles, including minivan.
***Gate-only observations. Final suggestion for baggage tractors is higher (based on airport size) to account for the time it takes to travel to loading/unloading area. Final suggestion for APUs is higher (based on airport size) to account for taxi-in and taxi-out times.

Table 11. Proposed new default TIM for passenger aircraft GSE fleet mix for large-sized airports.

GSE Fleet Mix	Model Default TIM	ACRP 02-46 TIM	Proposed New Default TIM
Wide-Body Aircraft			
Aircraft tractor	8	12	12
Baggage tractor***	120	55***	62
Belt loader	35	40	40
Cabin service/catering truck*	28	68	68
Cargo/container loader	80	50	50
Lavatory truck	25	8	8
Air conditioner	30	NA	-
Air start	7	NA	-
APU***	26	18***	23
Fuel/hydrant truck*	20	38	38
Service truck**	15	4	4
Water service	12	NA	-
Narrow-Body Aircraft			
Aircraft tractor	7	7	7
Baggage tractor***	61	32***	39
Belt loader	41	44	44
Cabin service/catering truck*	17	19	19
Air conditioner	30	NA	-
Air start	7	NA	-
APU***	26	15***	22
Fuel/hydrant truck*	14	17	17
GPU	40	44	44
Lavatory truck	14	10	10
Service truck**	14	9	9
Water service	12	NA	-
Small-Body Aircraft (KM Chng Study only)			
Aircraft tractor	5	9	9
Baggage tractor***	27	23***	30
Belt loader	23	20	20
Cabin service/catering truck*	6	6	6
Fuel/hydrant truck*	20	11	11
GPU	40	35	35
Lavatory truck	0	4	4
Service truck**	11.5	NA	-

NA = Not Applicable. TIM = Operating Time-in-Mode.
Bold font = suggested default GSE fleet mix and TIM.
*Cabin service and catering trucks are separate in AEDT. Fuel and hydrant trucks are separate in AEDT. TIM represents average between the two.
**Service truck includes all service vehicles, including minivan.
***Gate-only observations. Final suggestion for baggage tractors is higher (based on airport size) to account for the time it takes to travel to loading/unloading area. Final suggestion for APUs is higher (based on airport size) to account for taxi-in and taxi-out times.

5.2.1.4 Non-Gate GSE Operating Times

There are some types of GSE that also operate while away from the gate when traveling between gates or between gates and the terminal. These GSE mainly comprise baggage/cargo tugs, cabin service/catering/lavatory trucks, and fuel trucks.

As a means of accounting for these GSE operational times away from the gates and their resultant emissions, the approximate travel distances between the centroids of several airport terminals and the airside gates, fuel facilities, and cargo areas were measured. Table 12 presents the approximate distances at each of the airports sampled for this project. From this, average

Table 12. Airport distances from terminal to gate.

Airport	Size	Terminal	Distance (miles)
MSP #1	L	1	0.1
MSP #1	L	2	0.33
MSP #1	L	3	0.3
MSP #1	L	4	0.25
MSP #2	L	1	0.1
ATL	L	1	0.29
ATL	L	2	0.49
ATL	L	3	0.67
ATL	L	4	0.86
ATL	L	5	1.08
DFW	L	1	0.15
DFW	L	2	0.15
DFW	L	3	0.15
DFW	L	4	0.15
DFW	L	5	0.15
TPA	M	1	0.24
TPA	M	2	0.25
TPA	M	3	0.17
TPA	M	4	0.27
TPA	M	5	0.28
BOS	M	1	0.25
BOS	M	2	0.26
BOS	M	3	0.25
BOS	M	4	0.24
BOS	M	5	0.4
BOS	M	6	0.31
BOS	M	7	0.15
SAN	M	1	0.14
SAN	M	2	0.19
SAN	M	3	0.34
SAN	M	4	0.45
BWI	M	1	0.22
BWI	M	2	0.18
BWI	M	3	0.16
BWI	M	4	0.2
BWI	M	5	0.26
BWI	M	6	0.23
PDX	M	1	0.26
PDX	M	2	0.21
PVD	S	1	0.22

Table 13. Non-gate GSE operating times.

Airport Size	Average Distance (miles)	Average TIM (minutes)
Large	0.34	6.8
Medium	0.25	5
Small	0.22	4.4

distances were computed grouped by airport size (small, medium, or large). Average distances from each terminal to the baggage claim area were measured. From these average distances by airport size, an average TIM was estimated (Table 13).

Table 13 provides some surrogate (or default) values for use in the absence of airport-specific TIM measured values. Using an estimated speed of 20 mph, these data were developed by measuring the approximate travel distances between the centroids of several airport terminals and the airside gates, fuel facilities, and cargo areas.

As shown, these TIM data are provided for large- and medium/small sized airports, are suggested to be additive to the TIMs when the GSE are at the gates, and are only applicable to those GSE that are expected to travel outside the aircraft service area.

5.2.1.5 Deicing Operating Times

Presently, AEDT does not include operating times for GSE deicing vehicles. These specially designed GSE are equipped with booms or cherry pickers that are used to store, transport, heat, and spray deicing fluid on an aircraft exterior to reduce and/or eliminate ice and snow prior to departure.

At the request of the ACRP Project 02-46 panel, the research team submitted a plan to sample deicing activities in advance of delivering this protocol, to the end of being able to acquire data prior to the termination of the 2013–2014 deicing season (if determined cost reasonable and viable) and fulfill the ACRP 02-46 research objectives outlined in the amplified work plan (AWP).

After consideration the research team proposed that field sampling of deicing activities is not the ideal approach for data collection within ACRP Project 02-46 for the following reasons:

- Safety and security: There are safety considerations related to being at or near aircraft and equipment movement areas during inclement weather conditions; further, air traffic control or other parties within the boundary of responsibility may restrict access for safety reasons.
- Logistics: The logistical planning of a field survey during a deicing event is hampered by (1) being able to reliably monitor interested airports' meteorological conditions to predict a good sampling time; (2) cost-effectively moving personnel to the desired airport in time to establish field presence and implement the sampling; and (3) having airport escort personnel available on relatively short notice in poor ambient conditions.
- Vantage point limitations: The only viable approach to sample (if safety, security, and logistics considerations allow sampling) is the windshield survey where observations are made while the research team remains in an escort vehicle. Limitations to this approach include a significant opportunity to miss equipment activities on all sides of the aircraft, as well as reduced visibility in the event domain due to precipitation.

As a means of accounting for these GSE operational times and their resultant emissions, the research team observed several video logs of complete deicing procedures at a variety of airports. The seasonal dependency of collecting deicing observations as well as the limited constraints on accessing a restricted area prevented the research team from collecting deicing observations. As a result, video observations were determined to be the best resource for compiling deicing observations. A complete list of deicing video log details are provided in Table 14.

Table 14. Deicing video log details.

Aircraft Type	AEDT Category	Airline	Airport	# Trucks	Spray Time	Limited View	Other Comments
CRJ9	LCJP	USA	IND	2	6.00	No	Good, complete video. Lost track of 2nd truck at end.
A320/321	LCJP	JetBlue	JFK	4	2.33	No	Starts at 5:20.
B737	LCJP	DAL	DTW	2	8.95	No	Originally 1 row for 2 records (8:57 and 6:57)
B737	LCJP	DAL	DTW	2	6.95	No	Originally 1 row for 2 records (8:57 and 6:57)
A310	HCJP	FDX	IND	4	3.48	No	Originally 1 line for 4 records; split into 4 lines (3:29 (x2), 4:49, 6:22); The low time was for the two trucks deicing the tail, the longer times were for the two deicing the wings.
A310	HCJP	FDX	IND	4	3.48	No	
A310	HCJP	FDX	IND	4	4.82	No	
A310	HCJP	FDX	IND	4	6.37	No	

As a means of accounting for deicing GSE operational times and their resultant emissions, Table 15 provides some default deicing TIM values for use in the absence of airport-specific values. These data were derived by observing aircraft deicing activities recorded on video (see Table 14) and averaging the TIM by aircraft size. TIM data are provided for wide- and narrow/small-body aircraft and are suggested to be considered representative of the times to de-ice each aircraft.

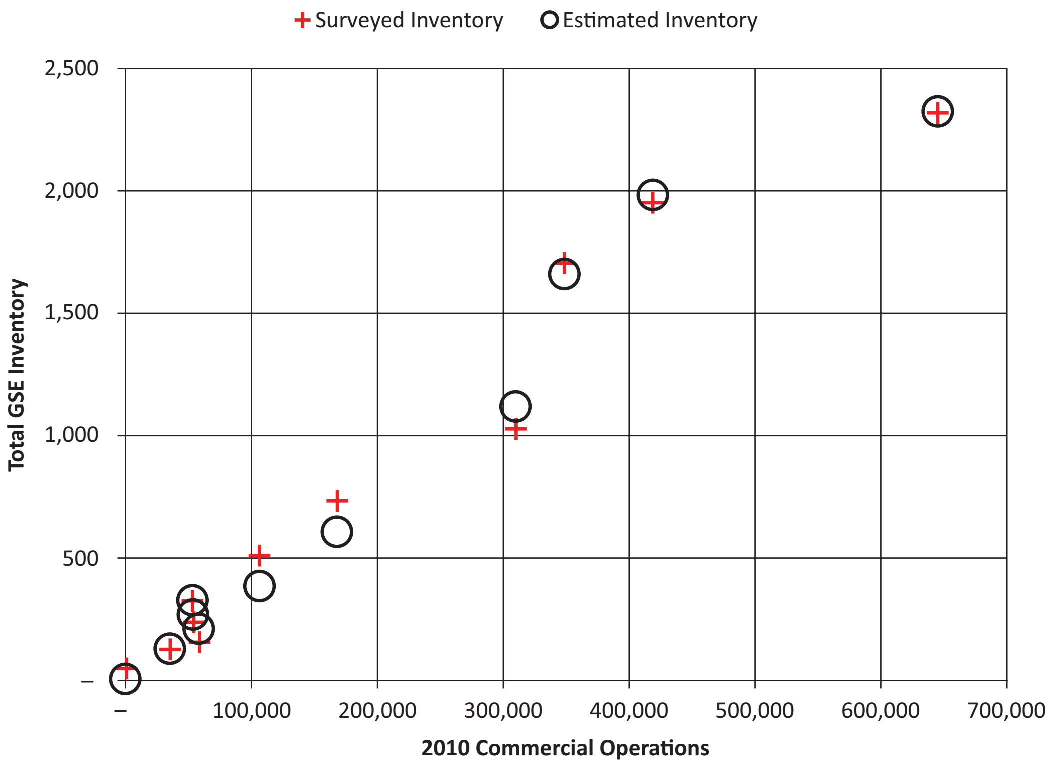
5.2.2 GSE Population-Based Fleet Size and Mix

As discussed in Chapter 3, one of the two available methods for computing GSE emission inventories in AEDT is the GSE population-based option. Under this option, the entire airport GSE fleet is input to the models by GSE type (e.g., baggage tug) and total number (i.e., 100 units). In cases where data cannot be obtained through GSE owner/operator/provider records or through in-the-field surveys, this chapter describes a method by which these data may be estimated and used in substitution or as default data to compute the GSE emissions inventory.

Notably, this method was derived as part of the *ACRP Report 78* research and is based upon the collection and assessment of GSE population data at several airports located across the United States of varying sizes, operational levels, climates, and GSE populations.

Table 15. Deicing GSE operating times.

Aircraft Size	Average Number of Trucks	Average TIM (minutes)
Wide-Body	4	4.5
Narrow- & Small-Body	2.5	6



Source: *ACRP Report 78: Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial*, 2012.

Figure 19. Airport operations versus total GSE.

An airport's GSE fleet size and make-up can be estimated using this method from the number of annual commercial aircraft operations at the airport.

Figure 19, from *ACRP Report 78,* provides the computed relationships between commercial aircraft operations and the corresponding GSE fleet size at the study airports. For example, an airport with 100,000 annual operations is shown to have a total GSE fleet of approximately 500 units (i.e., vehicles/equipment). As discussed, this is a proxy and not to be taken as the actual size of the example airport's GSE fleet.

As shown in Table 16 (also from *ACRP Report 78*), the make-up (i.e., fleet mix) of an airport GSE fleet is characteristically comprised of 23.6% baggage/cargo tugs, 9.7% belt loaders, 1.4% lavatory trucks, etc. Again, this fleet composition is based on surveys of several airports of varying size, operational levels, etc., but is considered to be a good representation of most U.S. airports.

Using an airport with 100,000 annual operations as an example of the surrogate fleet of 500 airport-wide GSE derived from Figure 19, roughly 23.6% (or 118) are expected to be baggage/cargo tugs, 9.7% (or 48) are belt loaders, and 1.4% (or 7) are lavatory trucks.

These data can then be input to AEDT to aid in computing an airport GSE emissions inventory.

5.2.3 Non-Gate GSE Operating Times

The data and information provided in Section 5.2.1 addresses the GSE operating times (or TIM) when the GSE are at, or in the vicinity of, the aircraft gate. However, there are some types of GSE that also operate while away from the gate when traveling between gates or between gates and the terminal. These GSE mainly comprise baggage/cargo tugs, cabin service/catering/lavatory trucks, and fuel trucks.

Table 16. Airport GSE fleet mix composition.

GSE Type	% of Fleet
Baggage tugs/cargo tugs	23.6
Cars/pickups/vans/suvs	12.4
Other	9.8
Belt loaders	9.7
Aircraft tractor/tugs	7.3
Deicing trucks	5.3
Fork lifts	4.7
Lifts	4.6
Cabin service/catering trucks	4.1
Air conditioners/heaters	3.9
Carts	3.9
Generators/GPUs/GPU-ACs	2.5
Cargo loaders	1.8
Lavatory trucks	1.4
Fuel trucks	1.4
Hydrant trucks	1.1
Passenger stairs	1.0
Maintenance trucks	0.6
Air start units	0.5
Light carts/light stands	0.4
Buses	0.1
Total	**100**

As a means of accounting for these GSE operational times away from the gates and their resultant emissions, Table 17 provides some surrogate (or default) values for use in the absence of airport-specific TIM measured values. The data were developed by measuring the approximate travel distances between the centroids of several airport terminals and the airside gates, fuel facilities, and cargo areas.

These TIM data are provided for large- and medium/small sized airports and should be additive to the TIMs when the GSE are at the gates and are only applicable to those GSE that are expected to travel outside the aircraft service area.

5.2.4 Deicing GSE Operating Times

Presently, AEDT does not include operating times for GSE deicing vehicles. As discussed in Chapter 2, these specially designed GSE are equipped with booms or cherry pickers that are used to store, transport, heat, and spray deicing fluid on an aircraft exterior to reduce and/or eliminate ice and snow prior to departure.

Table 17. Non-gate GSE operating times.

Airport Size	Average Distance (miles)	Average TIM (minutes)
Large	0.34	6.8
Medium	0.25	5
Small	0.22	4.4

Table 18. Deicing GSE operating times.

Aircraft Size	Average Number of Trucks	Average TIM (minutes)
Wide-Body	4	4.5
Narrow- & Small-Body	2.5	6

As a means of accounting for these GSE operational times and their resultant emissions, Table 18 provides some default TIM values for use in the absence of airport-specific values. These data were derived by observing aircraft deicing activities recorded on video.

As shown, these TIM data are provided for wide- and narrow/small-body aircraft and should be considered representative of the times to deice each aircraft.

5.2.5 GSE Engine Load Factors

The GSE engine load factor is an approximate measure of the engine power setting, expressed as a percentage ranging from 0% to 100%. In other words, an engine operating at maximum full power has a 100% load factor and a nonoperating engine has a load factor of 0%. Because of various design and operational considerations, most fossil-fueled engines operate at something measurably less than full power.

For the purposes of providing up-to-date default GSE engine load factor data for use in AEDT, Table 19 contains a listing of alternative values, by GSE type. These load factors were

Table 19. GSE engine load factors.

Equipment Type	NESCAUM	CARB	ICAO	AEDT	Average
Air conditioner	0.39	--	0.50	0.75	0.55
Air start	0.02	--	0.50	0.90	0.47
Aircraft tractor	0.12	0.54	0.25	0.80	0.43
Baggage tractor	0.02	0.37	0.50	0.55	0.36
Belt loader	0.07	0.34	0.25	0.50	0.29
Bobtail	--	0.37	0.25	0.55	0.39
Cabin service truck	--	--	0.25	0.53	0.39
Cargo loader	0.06	0.34	0.25	0.50	0.29
Cargo tractor	--	0.36	0.25	0.54	0.38
Cart	--	--	--	0.50	0.50
Catering truck	--	--	0.25	0.53	0.39
Deicer	0.07	--	0.60	0.95	0.54
Fork lift	0.09	0.2	0.25	0.30	0.21
Fuel truck	0.08	--	0.50	0.25	0.28
Generator	--	--	--	0.82	0.82
GPU	0.1	--	0.50	0.75	0.45
Hydrant cart	--	--	--	0.70	0.70
Hydrant truck	--	--	0.50	0.70	0.60
Lavatory truck	0.14	--	0.25	0.25	0.21
Lift	0.27	0.34	0.25	0.50	0.34
Other	--	0.34	--	0.50	0.42
Passenger stand	0.07	0.4	0.25	0.57	0.32
Service truck	0.09	--	0.25	0.20	0.18
Sweeper	--	--	--	0.51	0.51
Water service	--	--	0.25	0.20	0.23

Table 20. Fuel mix as reported in *ACRP Report 78.*

GSE Type	Fuel/Power Type (%)		
	Diesel	Gasoline	Electric
Air start	95.9	3.3	0.8
Aircraft tractor	77.8	9.4	12.8
Baggage tractor	18.2	62.1	19.7
Belt loader	29.7	52.9	17.4
Cabin service truck	77.0	22.6	0.4
Cargo loader	90.9	8.7	0.5
Catering truck	77.0	22.6	0.4
Fuel truck	86.0	11.4	2.6
GPU	78.1	9.2	0.0
Hydrant truck	73.1	26.9	0.0
Lavatory truck	20.5	70.2	9.3
Service truck	39.1	60.9	0.0

Source: *ACRP Report 78: Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial*, 2012.

derived from a composite of data presently contained in AEDT (default values), supplemented with data obtained from other sources including CARB, NESCAUM, and ICAO. As shown, the values range from 18% to 82%, depending on the GSE type, and should be recognized as average conditions.

5.2.6 GSE Fuel Types

The majority of airport GSE are still mainly powered by gasoline and diesel engines, but this trend is changing with the recent and growing emergence of electric-powered and alternatively fueled GSE. Presently, AEDT accounts for and computes emissions from GSE burning gasoline and diesel. It is assumed that electric-powered GSE generate no emissions.

ACRP Report 78 included an assessment of GSE fuel type data at several airports of varying sizes, operational levels, climates, and GSE populations located across the United States. These data were further supplemented with similar data obtained from other participating GSE owners/operators/providers. From this assessment, Table 20 contains a listing of GSE fuel types segregated by GSE type.

In the absence of airport-specific GSE fuel type data, these data can be input to AEDT as defaults to aid in computing an airport GSE emissions inventory.

CHAPTER 6

Coordination Best Practices

As briefly discussed in Chapters 1 and 5, coordination among the participants (or stakeholders) involved in the planning, conducting, and/or application of airport GSE emissions inventories is very common and often necessary to achieve the desired outcomes. This section presents suggested approaches and best practices that these stakeholders can undertake to accomplish and improve this process.

6.1 Stakeholders

As with most activities involving airport-related air quality, the computing of airport GSE emissions inventories can encompass an assortment of stakeholders. These stakeholders and their involvement include (but may not necessarily be limited to) those listed and described in Table 21.

As shown, airport authority connections with GSE emissions are an extension of the owner/operator of the airport, a potential GSE owner/operator, and its responsibility in managing ground-based operations. Airlines, cargo carriers and ground support providers are all prospective owners/operators of airport GSE. The FAA is also involved in airport ground operations as well as general conformity determinations that may include GSE emissions. Environmental agencies on the federal, state, or local levels may also be involved in managing air emissions in designated nonattainment areas, including those associated with airport GSE. And finally, airports, environmental agencies, and contractors are all potentially involved in the preparation of the airport GSE emissions inventories.

6.2 Coordination Opportunities

As described previously in this guidebook, the airport GSE emissions inventory process typically progresses from initiation to completion over three distinct and sequential stages: (1) planning, (2) preparation, and (3) application. This process can take months and, in some cases, up to a year to complete depending on size of the airport and its GSE fleet, the approach to preparing the inventory (i.e., basic, intermediate, advanced) and the availability of the input data. The descriptions of these stages, or phases, are listed in Table 22 and expanded upon in this section with the principal aim of recommending when stakeholder coordination is the most appropriate and effective.

6.2.1 Planning Phase

During the airport GSE emissions inventory planning phase, all of the participants should coordinate and agree upon the purpose and need for the assessment. As discussed in Chapter 3,

Table 21. Airport GSE emissions inventory stakeholders.

Stakeholder	Involvement
▪ Airport authority	- Airport owner/operator - Owner/operator of airport GSE - Involved in airport ground operations - Preparer of GSE emissions inventories
▪ Airlines and cargo carriers	- Owners/operators of airport GSE
▪ Ground support providers	- Owners/operators of airport GSE
▪ Inventory preparer	- Involved in GSE surveys and conducting emissions inventories
Governmental Agencies	
- FAA	- Involved in airport ground operations - Responsible for general conformity determinations in nonattainment areas
- Environmental agencies	- Involved in managing emissions in designated nonattainment areas - Preparer of GSE emissions inventories for SIPs

the purpose of the assessment may include air quality planning, compliance and/or funding support. The appropriate authorizations, consents and funding support for conducting the work should also be established during this initial phase.

Individually, the GSE owners/operators/providers should prepare schedules (i.e., listings or databases) of their GSE fleet disclosing the numbers, types, age, fuel use, etc., for use during the preparation phase. The reporting of certain proprietary information and data such as GSE ownership, age, etc., may need to be identified and reconciled at this time.

Finally, the inventory preparer(s) should identify the approach to conducting the emissions inventory and develop the data collection protocol.

Reminder—Airport operational levels can change over time due to a range of economic and regulatory factors and therefore obtaining the most up-to-date data is key to producing accurate airport GSE emissions inventories.

Table 22. Opportunities for stakeholder coordination during the airport GSE emissions inventory development process.

Participant	Responsibility
I. Planning Phase	
Airport authority	- Authorize or consent to GSE emissions inventory work.
GSE owners/operators	- Prepare schedule of airport GSE by type, model, fuel, age, etc.
Inventory preparers	- Identify approach and develop data collection protocol.
Agencies - environmental	- Identify purpose and need of emissions inventory results (if applicable).
II. Preparation Phase	
Airport authority	- Accommodate and assist with GSE data collection process.
GSE owners/operators	- Provide schedule of airport GSE and assist with data collection process.
Preparers	- Complete data collection process, prepare emissions inventory, and report results.
III. Application Phase	
Airport authority	- Utilize results for environmental assessments, air quality management plans, funding applications, etc.
GSE owners/operators	- Utilize results for GSE fleet management and emission reduction plans.
Agencies - Environmental - FAA	- Utilize results for SIP preparation. - Utilize results for Conformity Determinations.

6.2.2 Preparation Phase

During the preparation phase, the data collection process is conducted by assembling the data, information, and supporting materials identified and deemed necessary during the planning phase for preparing the GSE emissions inventory. Depending on the approach, these data may include (but, again, are not necessarily limited to) the GSE schedules, the GSE operating times and fuel types, etc. Some of these data may be collected during field surveys or by using the tools and methods contained in this guidebook.

Note—Stakeholder coordination opportunities on matters pertaining to computing GSE emissions can be frequent and meaningful through the preparation phase, but then they diminish somewhat in the application phase.

Using these input data, the inventory preparers compute the GSE emissions inventory, conduct the necessary quality assurance/quality control procedures, and report the results during this phase.

At this point, all of the stakeholders should review the work and any oversights, discrepancies, or errors that arise from this review should be identified and reported to the preparers along with any necessary clarifications, corrections, and/or alternative remedies.

6.2.3 Application Phase

During the application phase, the outcomes of the GSE emission inventories are utilized by the individual stakeholders—each according to their needs. For example, the airport authority, GSE owners/operators/providers, and/or environmental agencies may use the results to develop or advance emissions management and reduction strategies involving airport GSE. More specifically, the airport and the FAA may also use the results to meet disclosure and reporting requirements under NEPA and the CAA.

In a similarly supporting role, environmental agencies could outreach to airport owners/operators to review and comment upon the appropriate components of the SIP that pertain to airport GSE emissions to help ensure that they are properly accounted for and documented.

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Commonly Asked Questions and Answers

The following list of frequently asked questions and answers is intended to address topics that are expected to arise when reviewing or using this guidebook. They are developed with the two primary stakeholders in mind: airport operators and air quality regulatory agencies.

What is the typical GSE fleet composed of?

Answer: The typical GSE fleet varies by airport, aircraft, and weather. GSE fleet varies by aircraft, depending on the contents of the aircraft (i.e., passenger versus. cargo). The size of the aircraft is also considered when assigning a GSE fleet to an aircraft. Larger aircraft will require more powerful equipment. In addition, the use of some GSE are dictated largely by climatic (e.g., deicing vehicles, ground A/C and heating units, etc.). Typical GSE equipment can be found in Chapter 2.

What if airport-specific GSE observations cannot be taken to use in AEDT?

Answer: If airport-specific observations cannot be taken, the research team has outlined a method for estimating both GSE fleet population and the TIM for each piece of GSE equipment by aircraft size. See Chapter 5 for details.

How do GSE emissions differ from other vehicle emissions?

Answer: In general terms, the types of emissions generated by conventionally-fueled airport GSE are comparable to those of other types of motorized vehicles and equipment that burn gasoline and diesel as an energy source. See Chapter 2 for more details.

What is the difference between on-road and nonroad GSE?

Answer: On-road vehicles are vehicles licensed to travel on public roadways including automobiles, vans, trucks, buses, etc. For airport GSE, these are mostly limited to catering and cabin service trucks. Nonroad vehicles are vehicles and equipment not intended to be registered or operated on public roadways. This category broadly includes aircraft, watercraft, locomotives, recreational vehicles, construction vehicles, farm equipment, etc. For airport GSE, this represents the vast majority of vehicles and equipment and comprises baggage tugs, belt loaders, push-back tractors, etc. See Chapter 2 for more details.

What are the typical functions of a GSE fleet?

Answer: The typical functions are:

- Aircraft maintenance and cleaning, including engine and fuselage repairs, waste-water and garbage removal;
- Aircraft maneuvering, including moving aircraft out of a gate, to/from maintenance areas, etc.;
- Aircraft refueling, including fuel transfer from fuel trucks or fuel hydrant systems;

- Airfield maintenance, including grass mowers, pesticide applicators, and paint stripers;
- Deicing and snow removal, including aircraft deicing vehicles, snow scoops and plows, etc.;
- Emergency response, including ARFF vehicles, ambulances, and police cars;
- Moving payloads, including loading, unloading, and transporting of passengers, baggage and/or cargo; and
- Restocking of provisions, including food, beverages, potable water, and lavatory chemicals.

See *ACRP Report 78*, Section 3.1.1 for additional details.

What are the relevant federal statutes and programs pertaining to GSE?

Answer: A summary listing of the primary federal statutes and programs pertaining to the manufacturing, ownership and operation of GSE is presented in Tables 3-3 and 3-4 from *ACRP Report 78*.

Are alternative GSE fuels being considered at airports?

Answer: A variety of alternatives fuels are being considered at different airports. See Section 3.4.1 of *ACRP Report 78* for more details.

Does climate affect the typical GSE assignment?

Answer: GSE equipment is dependent on the weather. Cold climates require deicing equipment to be utilized, whereas warmer climates may not require the removal of snow and ice. See *ACRP Report 78*, Table 3-1, for more details.

What type of pollutants does GSE equipment emit?

Answer: Criteria pollutants and greenhouse gases. See Chapter 2 for more details.

Glossary

Air carrier: An operator (e.g., airline) in the commercial system of air transportation consisting of aircraft that hold certificates of Public Convenience and Necessity issued by the department of transportation to conduct scheduled or nonscheduled flights within the country or abroad.

Air pollution: One or more chemicals or substances in high enough concentrations in the air to harm humans, other animals, vegetation, or materials. Such chemicals or physical conditions (such as excess heat or noise) are called air pollutants.

Airport operators: Airport owners/operators and their representatives (e.g., consultants and contractors). Among the various emission source categories typically included in SIPs, airports characteristically encompass a unique assembly of mobile sources including aircraft, APUs, and GSE. As such, airport operators are well incentivized and uniquely positioned to ensure that these emissions are properly represented and accounted for in SIPs.

Attainment area: Any area that meets the NAAQS established for the criteria air pollutants

Auxiliary power units (APUs): APUs are small turbine engines used by many commercial jet aircraft to start the main engines; provide electrical power to aircraft radios, lights, and other equipment; and to power the onboard air conditioning (heating and cooling) system.

Carbon monoxide (CO): A product of incomplete combustion, is relatively non-reactive, and is mostly associated with motor vehicle traffic. High CO concentrations develop primarily during winter when periods of light winds interact with ground level temperature inversions (typically from the evening through early morning) and reduce the dispersal of vehicle emissions. Motor vehicles also exhibit increased CO emission rates at low air temperatures. When inhaled at high concentrations, CO combines with hemoglobin in the blood and reduces its oxygen-carrying capacity, resulting in reduced oxygen reaching the brain, heart, and other body tissues. This condition is especially critical for people with cardiovascular diseases, chronic lung disease, or anemia.

Clean Air Act (CAA): The federal law regulating air quality. The first CAA, passed in 1967, required that air quality criteria necessary to protect the public health and welfare be developed. Since 1967, there have been several revisions to the CAA. The CAA Amendments (CAAA) of 1990 represent the fifth major effort to address clean air legislation.

Clean Air Act Amendments (CAAA) of 1990: The CAAA of 1990 represent the fifth major effort to address clean air legislation. Revisions include significant strengthening of CAA, especially by adding detailed requirements for federal actions to conform to State Implementation Plans (SIPs), expanding the list of hazardous air pollutants from eight to 189, and strengthening the operating permit program.

Criteria pollutant: A pollutant determined to be hazardous to human health and regulated under the U.S. EPA's National Ambient Air Quality Standards. The 1970 amendments to the CAA require the U.S. EPA to describe the health and welfare impacts of a pollutant as the "criteria" for inclusion in the regulatory regime. The standards are designed to protect both the public health—known as primary standards—and welfare (or the natural environment)—known as secondary standards—when applied to ambient (i.e., outdoor) conditions. Criteria pollutants are CO, nitrogen oxides (NO_x), volatile organic compounds (VOCs), sulfur oxides (SO_x), particulate matter (PM) equal to or less than 10 micrometers (coarse particulates or PM_{10}), PM equal to or less than 2.5 micrometers (fine particulates or $PM_{2.5}$), and lead (Pb).

Emission factor: The rate at which pollutants are emitted into the atmosphere by one source or a combination of sources.

Emissions: Releases of gases to the atmosphere (e.g., the release of carbon dioxide during fuel combustion). Emissions can be either intended or unintended releases.

Emissions and Dispersion Modeling System (EDMS): The EDMS is designed to assess the air quality impacts of airport emissions sources, particularly aviation sources. In 1998, the FAA revised its policy on air quality modeling procedures to identify EDMS as the *required* model to perform air quality analyses for aviation sources instead of the *preferred* model. This revised policy ensures the consistency and quality of aviation analyses performed for the FAA. The FAA continues to enhance the model under the guidance of its government/industry advisory board to more effectively determine emission levels and concentrations generated by typical airport emission sources.

Emissions inventory: A list of air pollutants emitted into the atmosphere of a community, state, nation, or the Earth, in amounts per some unit time (e.g., day or year) by type of source. An emission inventory has both political and scientific applications.

General aviation: The portion of civil aviation that encompasses all facets of aviation except air carriers. It includes any air taxis, commuter air carriers, and air travel clubs that do not hold Certificates of Public Convenience and Necessity.

General Conformity Rule: Rule that ensures that federal actions comply with the NAAQS. In order to meet this CAA requirement, a federal agency must demonstrate that every action that it undertakes, approves, permits or supports will conform to the appropriate SIP. Refer to the EPA website for more details.

Greenhouse gases (GHG): Gases that trap heat in the atmosphere. The most prevalent GHGs are CO_2, methane (CH_4), and nitrous oxide (N_2O), and fluorinated gases.

Ground support equipment (GSE): Equipment that services aircraft after arrival and before departure at an airport and also the vehicles that support the operation of the airport. The types of GSE at airports include aircraft tugs, baggage tugs, deicers, fuel trucks, hydrant carts, catering trucks, cargo tractors, water trucks, lavatory trucks, cabin service, belt loaders, and cargo loaders.

Jet fuel: Includes both naphtha-type and kerosene-type fuels meeting standards for use in aircraft turbine engines. Although most jet fuel is used in aircraft, some is used for other purposes such as generating electricity.

Landing and takeoff (LTO) cycle: One aircraft LTO is equivalent to two aircraft operations (one landing and one takeoff). The standard LTO cycle begins when the aircraft crosses into the mixing zone as it approaches the airport on its descent from cruising altitude, lands, and taxis to the gate. The cycle continues as the aircraft taxis back out to the runway for takeoff and climbout as it heads out of the mixing zone and back up to cruising altitude. The five specific operating modes in a standard LTO are approach, taxi/idle-in, taxi/idle-out, takeoff, and climbout. Most aircraft go through this sequence during a complete standard operating cycle.

Maintenance area: Any area that is in transition from formerly being a nonattainment area to an attainment area.

National Plan of Integrated Airport Systems (NPIAS): The NPIAS identifies nearly 3,400 existing and proposed airports that are significant to national air transportation and thus eligible to receive federal grants under the Airport Improvement Program.

National Ambient Air Quality Standards (NAAQS): Air quality standards established by the EPA to protect human health (primary standards) and to protect property and aesthetics (secondary standards).

National Environmental Policy Act (NEPA): An Act established " . . . to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality." [42 USC § 4321—*Congressional declaration of purpose*]

Nitrogen oxides (NO_x): Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced, for example, by the combustion of fossil fuels in vehicles and electric power plants. In the atmosphere, nitrogen oxides can contribute to formation of photochemical ozone (smog), impair visibility, and have health consequences; they are considered pollutants.

Nitrogen dioxide (NO_2): A pollutant that acts as a respiratory irritant. NO_2 is a major component of the group of gaseous nitrogen compounds commonly referred to as NO_x. A precursor to ozone formation, NO_x is produced by fuel combustion in motor vehicles, stationary sources used in industrial activities, ships, aircraft, and rail transit. Typically, NO_x emitted from fuel combustion is in the form of nitric oxide (NO) and NO_2. NO is often converted to NO_2 when it reacts with ozone or undergoes photochemical reactions in the atmosphere.

Nonattainment area: Any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the NAAQS.

Non-methane volatile organic compounds (NMVOCs): Organic compounds, other than methane, that participate in atmospheric photochemical reactions.

Ozone: A colorless gas with a pungent odor, having the molecular form of O_3, found in two layers of the atmosphere, the stratosphere and the troposphere. Ozone is a form of oxygen found naturally in the stratosphere that provides a protective layer shielding the Earth from ultraviolet radiation's harmful health effects on humans and the environment. In the troposphere, ozone is a chemical oxidant and major component of photochemical smog. Ozone can seriously affect the human respiratory system.

Ozone precursors: Chemical compounds, such as carbon monoxide, methane, non-methane hydrocarbons, and nitrogen oxides that, in the presence of solar radiation, react with other chemical compounds to form ozone, mainly in the troposphere.

Particulate matter ($PM_{10/2.5}$): Solid particles or liquid droplets suspended or carried in the air. Particulate matter equal to or less than 10 microns in diameter (PM_{10}) and particulate matter equal to or less than 2.5 microns in diameter ($PM_{2.5}$) represent fractions of particulate matter that can penetrate deeply into the respiratory system and cause adverse health effects. Particulate matter in the atmosphere results from many kinds of dust- and fume-producing industrial and agricultural operations, fuel combustion, and atmospheric photochemical reactions.

Parts per million (ppm): Number of parts of a chemical found in one million parts of a particular gas, liquid, or solid.

Regulatory agencies: State, regional, and/or local air quality regulatory and planning agencies involved in preparing and updating SIPs. In this role, their work involves the preparation of emissions inventories for all emissions sources within the nonattainment and maintenance area (including airports), determining the appropriate amounts of emissions allowable regionally, and formulating the necessary emissions reduction strategies and milestones to meet the NAAQS within prescribed timeframes.

State Implementation Plan (SIP): Under the federal CAA, states are required to submit an SIP to the U.S. EPA for those counties or regions where air quality conditions do not meet one or more of the NAAQS. The SIP describes how each nonattainment region will attain and maintain the NAAQS. SIPs typically include emissions inventories, air quality monitoring data, emissions reduction goals and objectives, timetables, emissions control measures and strategies considered necessary for nonattainment and maintenance areas to meet the NAAQS, and enforcement mechanisms.

Sulfur dioxide (SO_2): A compound composed of one sulfur and two oxygen molecules. Sulfur dioxide emitted into the atmosphere through natural and anthropogenic processes is changed in a complex series of chemical reactions in the atmosphere to sulfate aerosols. These aerosols are believed to result in negative radiative forcing (i.e., tending to cool the Earth's surface) and result in acid deposition (e.g., acid rain).

Time-in-mode (TIM): The time that GSE are on and in use servicing an aircraft.

Volatile organic compounds (VOCs): Organic compounds that evaporate readily into the atmosphere at normal temperatures. VOCs contribute significantly to photochemical smog production and certain health problems.

Acronyms and Abbreviations

AAAE—American Association of Airport Executives
AASHTO—American Association of State Highway and Transportation Officials
ACI–NA—Airports Council International–North America
ACRP—Airport Cooperative Research Program
AFV—alternative-fuel vehicle
AOA—air operations area
APTA—American Public Transportation Association
APU—auxiliary power unit
ARFF—Aircraft Rescue and Firefighting
ASCE—American Society of Civil Engineers
ASIG—Aircraft Service International Group
ASU—air start unit
ATL—Hartsfield-Jackson Atlanta International Airport
B100—biodiesel (100 percent)
B20—biodiesel blend (20 percent biodiesel, 80 percent petroleum diesel)
B85—biodiesel blend (85 percent biodiesel, 15 percent petroleum diesel)
BHP—brake horsepower
BOS—Logan International Airport (Boston)
BSFC—brake-specific fuel consumption
CAA—Clean Air Act
CARB—California Air Resources Board
CCR—California Code of Regulations
CFR—Code of Federal Regulations
CI—compression ignition
CNG—compressed natural gas
DFW—Dallas-Fort Worth International Airport
EDMS—Emissions and Dispersion Modeling System
EPA—Environmental Protection Agency
EV—electric vehicle
FAA—Federal Aviation Administration
FBO—fixed-based operator
FOD—foreign object debris
FTA—Federal Transit Administration
GA—general aviation
GHG—greenhouse gas
GPU—ground power unit
GSE—ground support equipment
HAP—hazardous air pollutant

I/M—inspection/maintenance
ICE—internal combustion engine
IPCC—Intergovernmental Panel on Climate Change
IRIS—Integrated Risk Information System
NAAQS—National Ambient Air Quality Standards
NTSB—National Transportation Safety Board
O&M—operations and maintenance
O_3—ozone
PCA—preconditioned air
PHL—Philadelphia International Airport
PM—particulate matter
PM_{10}—particulate matter, aerodynamic diameter of 10 micrometers or less
$PM_{2.5}$—particulate matter, aerodynamic diameter of 2.5 micrometers or less
SIDA—Security Identification Display Area
SIP—State Implementation Plan
SI—spark ignition
TCRP—Transit Cooperative Research Program
TIP—Tribal Implementation Plan
TPA—Tampa International Airport
TRB—Transportation Research Board
TSA—Transportation Security Administration
ULSD—ultra-low sulfur diesel
UPS—United Parcel Service
VALE—voluntary airport low emission
VOC—volatile organic compound

APPENDIX A

Example Health, Safety, and Security Plan

This Appendix contains two versions of an example Health, Safety, and Security Plan (HASSP) form for personnel performing an in-the-field survey of airport ground support equipment (GSE). Version 1 is intended to serve a model on how the form could be filled out with fictitious names, places and dates. Version 2 has remained unaltered and is intended to provide guidebook users with a facsimile they can copy, complete and/or edit.

Version 1
(Sample)

1. HEALTH, SAFETY, AND SECURITY PLAN APPROVAL

This Health, Safety, and Security Plan (HASSP) was prepared for personnel performing an in-the-field survey of airport ground support equipment (GSE). It was prepared based on the best available information regarding the physical and chemical hazards known or suspected to be present at the Airport being assessed. While it is not possible to discover, evaluate, and protect in advance against all possible hazards which may be encountered during the completion of this project, adherence to the requirements of the HASSP will significantly reduce the potential for occupational injury.

By signing below, I acknowledge that I have reviewed and hereby approve the HASSP associated with **Task 4** (*Develop Draft Protocol for Collecting GSE Operational Data*) of ACRP 02-46: *Improving Ground Support Equipment Operational Data for Airport Emissions Modeling Amplified Work Plan (AWP).*

This HASSP has been written for the exclusive use of GSE Surveys, Inc., its employees, and sub-contractors. The plan is written for specified site conditions, dates, and personnel, and must be amended if these conditions change.

Written by:

John Doe, Project Manager
GSE Surveys, Inc.

____

Example

Approved by:

Jane Dane, Health & Safety Officer
GSE Surveys, Inc.

____

2. INTRODUCTION

This Health, Safety, and Security Plan (HASSP) provides a general description of the levels of personal protection and safe operating guidelines expected from all personnel[1] associated with **Task 4** (*Develop Draft Protocol for Collecting GSE Operational Data*) of ACRP 02-46: *Improving Ground Support Equipment Operational Data for Airport Emissions Modeling Amplified Work Plan (AWP).*

Example

The scope of work for this task is to conduct ground service equipment (GSE) fleet and activity surveys at __ABC Airport_____________________________ (the Airport), located at __XYZ City_______________________, on ________ [Sampling date; ex., 01/01/2015] ________________.

The Airport site map, indicating site perimeter and survey areas as well as points of entry and exit is provided as **Exhibit A-1** to this HASSP.

The GSE surveys will comprise the collection of the following data:

- Number and type of vehicles by aircraft code;
- Difference between type of operations (i.e., dedicated cargo vs. passenger operations);
- Time in operational mode (including idling); and
- Gate deicing vehicles.

The provisions of this HASSP are mandatory for all personnel engaged in fieldwork associated with the GSE surveys being conducted at the Airport. A copy of this HASSP shall be maintained by the Health and Safety Officer (H&SO) during the fieldwork and made available for review by all personnel at all times. Record keeping will be maintained in accordance with this HASSP and any applicable federal, state, and local regulations.

[1] For the purpose of this HASSP, the term "personnel" refers to all the individuals (i.e., project manager, health and safety officer, airport escort, research team and subcontractors) involved in the GSE fleet and activity surveys performed at the Airport.

3. ORGANIZATIONAL STRUCTURE

This section of the HASSP describes lines of authority, responsibility, and communication as they pertain to health and safety functions associated with the GSE fleet and activity surveys performed at the Airport. The purpose of this section is to identify the personnel who impact the development and implementation of the HASSP and to describe their roles and responsibilities. This section also identifies the research team and subcontractors involved in work operations and establishes the lines of communication among them for safety and health matters.

The organizational structure and health program is consistent with OSHA requirements in 29 Code of Federal Regulations (CFR) §1910.120(b)(2). In addition, the site H&SO has the responsibility and authority to develop and implement this HASSP and verify compliance; as well as the lines of authority, responsibility, and communication for safety and health functions.

This section is reviewed and updated as necessary to reflect the current organizational structure of the personnel performing the fieldwork.

Roles and Responsibilities

All personnel should comply with the requirements of this HASSP. The specific responsibilities and authority of management, security, safety and health, and other personnel are provided in **Table 1** and further identified by name and company in **Table 2**.

Table 1 – Roles and Responsibility of Personnel

Role	Responsibilities
Project Manager (PM)	The PM has the responsibility and authority to direct all work operations. The PM coordinates safety and health functions with the Health and Safety Officer (H&SO), has the authority to oversee and monitor the performance of the H&SO, and bears ultimate responsibility for the proper implementation of this HASSP.
Health and Safety Officer (H&SO)	The H&SO has full responsibility and authority to develop and implement this HASSP and to verify compliance. The H&SO reports to the PM. The H&SO is on-site or readily accessible to the site during all work operations and has the authority to halt site work if unsafe conditions are detected.
Airport Escort Personnel (AEP)	The AEP is responsible for escorting the research team and/or subcontractors to airport airfields and apron areas and assuring that safety and security are adhered to and that the safety of personnel is ensured at all times.
Research Team and Subcontractors	The research team and other subcontractors are responsible for complying with this HASSP, using the proper personal protective equipment (PPE) and/or gear, reporting unsafe acts and conditions, and following the work and safety and health instructions of the PM, H&SO, and AEP.

Table 2 – Identification of Fieldwork Personnel

Role	Name/Title	Company
Project Manager	John Doe	GSE Surveys, Inc.
H&SO	Jane Doe	GSE Surveys, Inc.
Airport Escort	Josh Doe	ABC Airport
Airport Escort	Mark Doe	ABC Airport
Airport Escort	Mary Doe	ABC Airport
Research Team Member	Alex Doe	GSE Surveys, Inc.
Research Team Member	Paul Doe	GSE Surveys, Inc.
Research Team Member	Michael Doe	GSE Surveys, Inc.
Research Team Member	Nick Doe	GSE Surveys, Inc.
Research Team Member	Robert Doe	GSE Surveys, Inc.
Subcontractor	Bryan Doe	GSE Surveys, Inc.
Subcontractor	Brad Doe	GSE Surveys, Inc.

HASSP Information and Site-Specific Briefings for Personnel

All personnel shall review this HASSP and will be provided a site-specific briefing by the H&SO prior to the commencement of work to ensure that all personnel engaged in fieldwork are familiar with this HASSP and the information and requirements it contains. Additional briefings are provided as necessary to notify personnel of any changes to this HASSP as a result of information gathered during ongoing site characterization and analysis. Conditions for which additional briefings shall be scheduled include, but are not limited to: changes in site conditions, changes in the work schedule/plan, newly discovered hazards, and incidents occurring during fieldwork.

4. SAFETY MEASURES ON AIRCRAFT APRONS AND AIRFIELD

This section of the HASSP describes the various safety and security measures that all personnel should be aware of when performing the GSE fleet and activity surveys performed at the Airport (within aircraft apron and airfield areas). It is imperative that all regulations pertaining to airport safety and security are adhered to, and that the safety of personnel is ensured at all times.

The safety and security measures within this HASSP are consistent with the requirements of FAA's Federal Aviation Regulations (FARS) 14 CFR §107.

Apron Practices

All personnel will be escorted by a designated AEP when conducting fieldwork. When on the aircraft aprons, personnel must remain with their escort at a distance that continuously enables direct visual sighting and verbal communication until they have exited the Security Identification Display Area (SIDA)[2]. Personnel should also be aware of the common requirement that escorts ensure all secured doorways between the SIDA, secured areas and sterile areas are completely shut with locks engaged prior to leaving the area. If logistically it is required to move between the apron and the sterile area to reach sampling locations, personnel should understand that it is also their responsibility to enable their escort to do so without impediment.

Personnel will not encroach upon restricted apron areas and will conduct all data collection at sufficient distance from the aircraft and GSE so as not to interfere with operations. Further, assigned personnel will, via signature of the HASSP, ensure that they understand and will abide by all pavement markings, signage, warnings and advisories necessary to ensure safe apron operation, and will not engage in any activity that generates Foreign Object Debris (FOD) on the ramp.

Airfield Access and Travel

During fieldwork, close coordination with airport personnel and security staff will be required to ensure that personnel will be allowed to access and traverse the airfield with the equipment and supplies necessary to conduct field observations. Knowledge of the following general guidelines and best practices can be employed to facilitate airfield access and travel to the extent required for ACRP 02-46.

Vehicles may be escorted into the SIDA in conjunction with an approved reason to escort and must possess a valid state registration. The escorted vehicle will be inspected before being allowed to enter the SIDA. Escort vehicles entering and exiting the airfield through secure access gates are required to stop and wait for the gate to close behind them, barring passage of any subsequent vehicles, even if the point of entry/exit is staffed by a gate security officer. It is the responsibility of each individual to enable their escort to adhere to these procedures without impediment.

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[2] The SIDA is a portion of an airport, specified in the airport security program, in which security measures are carried out. This area includes the secured area and may include other areas within the airport's perimeter boundary that require an individual to continuously display identification media (e.g., a badge).

Due to screening requirements, unscreened baggage cannot be carried through to the Air Operations Area (AOA)[3] or the SIDA via entrance through secured airfield or airport access gates. Further, field equipment bags and other vehicle items may be subject to inspection prior to being allowed airfield access.

Personnel will not encroach upon restricted airfield areas or otherwise interfere with the safe movement of other vehicles and aircraft. Further, assigned personnel will, via signature of the HASSP, ensure that they understand and will abide by all pavement markings, signage, warnings and advisories necessary to ensure safe operation, and will not engage in any activity that generates FOD. Although the AEP is the only individual(s) permitted to drive airport vehicle(s), all other personnel are required to have an understanding of the airfield markings, signage, warnings and advisories.

5. POTENTIAL HAZARDS

This section of the HASSP identifies the potential health and safety hazards associated with GSE fleet and activity surveys to be performed at the Airport, and evaluates the risks to personnel. During field observations at the Airport, there is potential for personnel to be exposed to: chemical, physical, and biological hazards. These are discussed in detail below.

Chemical Hazards

In airports the main sources of air pollution are exhaust from aircraft engines, aircraft auxiliary power units (APU), other combustion engines (e.g., vehicles, handling and loading equipment etc.), vapor emissions from refueling aircraft, and larger dust particles from brakes, tires, asphalt, soil etc. Personnel working in close proximity to these types of sources may be exposed to a complex mixture of pollutants by incidental skin exposure, eye contact or inhalation.

The main pollutants of concern can be divided into: petroleum hydrocarbons; polycyclic aromatic hydrocarbons (PAHs); volatile organic compounds (VOCs); inorganic gases like sulfur dioxide (SO_2), carbon monoxide (CO), and nitrogen dioxide (NO_2); and particulate matter (PM).

<u>Petroleum Hydrocarbon</u>

Hydrocarbon fuels (including gasoline, diesel fuel and jet fuel) are complex mixtures of hydrocarbons and additives. The constituents of hydrocarbon fuels possess a range of vapor pressures. For highly volatile components, chronic exposures or exposures to a high concentration may cause unconsciousness, coma, and possible death from respiratory failure. Exposure to low concentrations of vapor may produce flushing of the face, slurred speech, and mental confusion. Fuels are also irritating to the skin, and may cause drying and dermatitis as a result of prolonged contact.

Various components and additives of the fuels can themselves present significant additional hazards. The aromatic compounds benzene, toluene, ethylbenzene and xylene (BTEX) are of the

[3] The AOA includes aircraft movement areas, aircraft parking areas, loading ramps, and safety areas, for use by regulated aircraft, and any adjacent areas (e.g., general aviation areas). Encompasses the runways, taxiways, aprons and other areas of the airport intended to be used by aircraft for taxiing, takeoff, landing, maneuvering, and parking. This area does not include the secured area.

main concern in relation to fieldwork activities. However, some additives used for performance enhancement (e.g., methyl tert-butyl ether - MTBE), oxygenation (e.g., alcohols and MTBE) and water scavenging (e.g., ethylene glycol methyl ether - EGME) can also present significant hazards as a result of prolonged inhalation or skin exposure. Tetra-ethyl and tetra-methyl lead, both of which have been identified as carcinogens and present moderate skin contact hazards, are added to aviation gasoline for anti-knock control.

There are no set limits for petroleum hydrocarbons; however, gasoline guidelines may be used instead. Both the OSHA permissible exposure limits (PELs) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) for gasoline are 300 parts per million (ppm).

Material safety data sheets (MSDS) for these chemical substances are provided as **Exhibit A-2** to this HASSP.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are produced during combustion events due to inadequate oxidation of fuel. PAHs in the pure state are yellowish crystalline solids. They are found in coal tar and in products of incomplete combustion. These chemicals have varying degrees of potency for causing cancer, with benzo(a)pyrene being among the most potent (in low concentrations). Benzo(a)pyrene is often used as an indicator compound for PAH pollution. In airports PAHs are mainly produced due to incomplete combustion in aircraft and diesel engines. PAHs will exist bound to particulate matter and as gases in the exhaust gas. Some significant PAH compounds include:

- Anthracene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(d,e,f)phenanthrene
- Chrysene
- Fluoranthene
- Fluorene
- Indeno(1,2,3,c,d)pyrene

MSDS for the primary chemical substances are provided as **Exhibit A-2** to this HASSP.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are a very large group of organic compounds mainly present as gases. Some VOCs (e.g., benzene), are carcinogenic while others (e.g., aldehydes, can cause irritation of eyes and airways. In airports VOCs mainly originate from fuel vaporized during fueling and unburned or partly burned fuel in the exhaust gas. Some VOCs will be bound to particulate matter in exhaust gas. Aldehydes are also formed by photochemical reactions in the surrounding air.

Inorganic Gases

Sulfur dioxide (SO_2) is a colorless gas also with a strong characteristic odor. SO_2 is emitted into the atmosphere by both natural processes and by man-made sources such as the combustion of sulfur-containing fuels and sulfuric acid manufacturing. When combined with other substances in the air, SO_2 can precipitate out as rain, fog, snow, or dry particles (commonly referred to as "acid rain"). Sulfate particles are a major cause of reduced visibility in many areas of the United States. Aircraft engines are a key source of SO_2 in airports. The inhalation of elevated concentrations of SO_2 can cause irritation of the mucous membranes, bronchial damage, and can exacerbate pre-existing respiratory diseases such as asthma, bronchitis, and emphysema.

Carbon monoxide (CO) is a colorless, odorless, tasteless gas that is a product of incomplete combustion of organic materials. In the ambient environment, it may temporarily accumulate into localized "hot-spots," especially in calm weather conditions and in the wintertime when CO forms easily and is chemically most stable. CO can be absorbed by the lungs and react with hemoglobin to reduce the oxygen-carrying capacity of the blood. At elevated concentrations CO can have cardiovascular and central nervous system effects.

Nitrogen dioxide (NO_2) is a reddish-brown to dark brown gas with an irritating odor. NO_2, nitric oxide (NO), and the nitrate radical (NO_3) are collectively called oxides of nitrogen (NO_x). These three compounds are interrelated, often changing from one form to another in chemical reactions. The principal man-made source of NO_x is fuel combustion in motor vehicles and power plants with aircraft also contributing. NO_2 emissions from these sources are highest during high-temperature combustion conditions. Reactions of NO_x with other chemicals (such as VOCs) can lead to ozone formation and acidic precipitation. Additionally, secondary PM can be formed within the atmosphere from precursor gases, such as NO_x, through gas-phase photochemical reactions or through liquid phase reactions in clouds and fog droplets. In humans, NO_2 can be a lung irritant capable of producing pulmonary edema at high concentrations and can lead to other respiratory illnesses such as bronchitis and pneumonia.

Particulate Matter

Particulate matter (PM) is made up of small solid particles and liquid droplets suspended or settling out of the atmosphere. PM consists of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. PM can be formed from both natural and man-made sources including forest fires and wind erosion over exposed soils (i.e., fugitive dust); the incineration of solid wastes; and as an exhaust product from the internal combustion engine. Of growing concerns are the effects of PM on visibility and the potential impairment to human health by small PM (i.e., ultrafine particle emissions or PM0.1). The regulatory standards for PM are segregated by sizes: less than or equal to 10 micrometers (denoted PM_{10}) and less than or equal to 2.5 micrometers (denoted $PM_{2.5}$).

Assessment of Exposure Hazards

Inhalation – Inhalation of chemical hazards will be greatly minimized through use of administrative controls and PPE such as air respirators.

Skin Contact – Direct contact of chemical hazards to skin will be minimized through use of administrative controls, and dermal protective equipment.

Eye Contact – Direct eye contact with chemical hazards will be minimized through the use of eye protective gear such as safety glasses.

Personnel will minimize exposure hazards by conducting all data collection at sufficient distance from the exhaust areas of aircraft engines, GSE and/or vehicle engines.

For lists of air contaminants and their representative permissible exposure limits (PELs) refer to 29 CFR §1910.1000 Table Z-1 and Z-2. Personnel's exposure to any substance listed in Tables Z-1 and Z-2 shall be limited in accordance with the requirements of 29 CFR §1910.1000.

First aid measures relevant to the chemical substances mentioned are described in the respective MSDS provided as **Exhibit A-2** to this HASSP.

Physical Hazards

Aside from adhering to all regulations, signs, markings and advisories discussed in the preceding sections, awareness of the physical surroundings is critical, and to increase visibility a safety vest will be required at all times when conducting data collection outside of a vehicle. Caution will be needed to protect from jet blast or jet engine ingestion if engines are running, including securing loose articles of clothing. Personnel will be mindful of the status of aircraft engine rotational lights which will be illuminated if an aircraft engine is running. Additionally, all markings noting restricted areas around an engine will be identified to prevent engine suction.

Furthermore, during field observations at the Airport, there is potential for personnel to be exposed to physical hazards such as slips, trips, falls, and heat/cold stress as well as noise and ultraviolet (UV) radiation as described below.

Slips, Trips, and Falls

Slips, trips & falls can happen anywhere while performing fieldwork and can result in falls, injuries, possibly disability or death. For instance, in the event field observations occur near glycol application areas, recommended PPE and/or gear includes waterproof clothing, waterproof shoes, and eye protection. In and around the deiced aircraft the ramp will become more hazardous, because GSE have a reduced ability to stop and personnel in the area may be more prone to slip-and-falls.

The physical hazards associated with slips, trips and falls are detailed in **Table 3**.

Table 3 – Identifying slips, trips, falls

Type	Definition	Causes
Slip	Too little friction or traction between feet (footwear) and walking/working surface, resulting in loss of balance	▪ Wet product or spills on smooth floors or walking surfaces (e.g., water, mud, grease, oil, food, blood, etc.). ▪ Dry product or spills making walking surface slippery (e.g., dusts, powders, granules, wood, and plastic wrapping). ▪ Transitioning from one surface to another ▪ Sloped walking surfaces ▪ Ramps & gang planks without skid-

		or slip-resistant surfaces ▪ Metal surfaces (e.g., platforms, sidewalk and road covers) ▪ Loose, irregular surfaces such as gravel ▪ Weather hazards
Trip	Foot or lower leg hits object and upper body continues moving, resulting in loss of balance Stepping down to lower surface & losing balance	▪ Uncovered hoses, cables, wires or extension cords across aisles or walkways ▪ Clutter, obstacles in aisles, walkway & work areas ▪ Changes in elevation or levels ▪ Unmarked steps or ramps ▪ Irregularities in walking surfaces ▪ Thresholds or gaps ▪ Damaged, non-uniform, improper or irregular steps ▪ Debris, accumulated waste materials ▪ Objects protruding from walking surface ▪ Uneven surfaces and sidewalk/curb drops
Fall	Occurs when too far off center of balance	▪ Two types: 1. Fall at same level (i.e., fall to same walking or working surface, or fall into or against objects above same surface) and 2. Fall to lower level (i.e., fall to level below walking or working surface)
Environmental Conditions Increasing Risk of Trips & Slips		▪ Poor lighting, glare, shadows ▪ Bulky PPE (includes improper footwear, loose clothing) ▪ Excess noise or temperature ▪ Fog or misty conditions ▪ Poor housekeeping ▪ Inadequate or missing signage

Heat and Cold Stress

During field observations at the Airport, personnel may be exposed to heat and cold stress, which could vary based upon work activities, PPE/clothing selection, geographical locations, and weather conditions. The guidance in **Table 4** and **Table 5** should be used in identifying and treating heat-related illnesses and cold-related injuries, respectively.

Table 4 – Identifying and Treating Heat-related Illnesses

Type of Heat-Related Illnesses	Description	First Aid
Mild Heat Strain	The mildest form of heat-related illness. Victims exhibit irritability, lethargy, and significant	▪ Provide the victim with a work break during which he/she may relax, remove any excess protective

Type of Heat-Related Illnesses	Description	First Aid
	sweating. The victim may complain of headache or nausea. This is the initial stage of overheating, and prompt action at this point may prevent more severe heat-related illness from occurring	clothing, and drink cool fluids. ▪ If an air-conditioned spot is available, this is an ideal break location. ▪ Once the victim shows improvement, he/she may resume working; however, the work pace should be moderated to prevent recurrence of the symptoms.
Heat Exhaustion	Usually begins with muscular weakness and cramping, dizziness, staggering gait, and nausea. The victim will have pale, clammy moist skin and may perspire profusely. The pulse is weak and fast and the victim may faint unless they lie down. The bowels may move involuntarily.	▪ Immediately remove the victim from the work area to a shady or cool area with good air circulation (avoid drafts or sudden chilling). ▪ Remove all protective outerwear. ▪ Call a physician. ▪ Treat the victim for shock. (Make the victim lie down, raise his or her feet 6–12 inches, and keep him or her cool by loosening all clothing). ▪ If the victim is conscious, it may be helpful to give him or her sips of water. ▪ Transport victim to a medical facility as soon as possible.
Heat Stroke	The most serious of heat illness, heat stroke represents the collapse of the body's cooling mechanisms. As a result, body temperature may rise to 104 degrees Fahrenheit or higher. As the victim progresses toward heat stroke, symptoms such as headache, dizziness, nausea can be noted, and the skin is observed to be dry, red, and hot. Sudden collapse and loss of consciousness follows quickly and death is imminent if exposure continues. Heat stroke can occur suddenly.	▪ Immediately evacuate the victim to a cool and shady area. ▪ Remove all protective outerwear and as much personal clothing as decency permits. ▪ Lay the victim on his or her back with the feet slightly elevated. ▪ Apply cold wet towels or ice bags to the head, armpits, and thighs. ▪ Sponge off the bare skin with cool water or rubbing alcohol, if available. ▪ The main objective is to cool without chilling the victim. ▪ Give no stimulants or hot drinks. ▪ Since heat stroke is a severe medical condition requiring professional medical attention, emergency medical help should be summoned immediately to provide on-site treatment of the victim and proper transport to a medical facility.

Table 5 – Identifying and Treating Cold-related Injuries

Type of Cold-Related Injuries	Description	First Aid
Hypothermia	Hypothermia occurs when the body cannot maintain a normal core temperature of 98.6 to 99.9 degrees Fahrenheit. Hypothermia can take a victim by surprise since it can occur above the freezing point. Wind, physical exhaustion and wet clothing all make a person more prone to hypothermia. Usually victims of hypothermia have the following symptoms: ▪ numbness, stiffness or pain (especially in the neck, arms and legs), ▪ poor coordination, slurred speech and drowsiness, ▪ slow, irregular breathing and heartbeat/pulse, ▪ puffiness in the face, ▪ low blood pressure, ▪ listlessness, confusion and disorientation (It is not unusual to see someone who makes little or no effort to get out of the cold or keep warm), ▪ collapse or exhaustion after rest, ▪ severe shivering, and death is a possibility.	▪ Unconscious persons with severe hypothermia should be treated aggressively by experienced medical personnel and transported to a hospital. If no pulse is detected, CPR should be administered immediately until help arrives. ▪ Remove the person out of frozen, wet or tight clothes. ▪ Rewarming the person in a warm bed or bath with warm packs, warm and dry clothes, or blankets can treat mild hypothermia in young and otherwise healthy persons. ▪ Have the victim drink something warm (if conscious) but do not give caffeine or alcohol. (Never give anything by mouth to someone who is unconscious).
Frostnip	Frostnip occurs when the face or extremities are exposed to cold wind, causing the skin to turn white. Symptoms include: firm, cold, white areas on the face, ears or extremities, peeling or blistering that may appear similar to sunburn, and mild hypersensitivity to cold persists.	▪ The frost-nipped area should be treated by rewarming the area with an unaffected hand or a warm object. Do not apply hot water.
Frostbite	Frostbite occurs when there is freezing of the skin. It can occur without hypothermia when the extremities do not receive sufficient heat from	▪ Remove restrictive clothing or jewelry near the affected area or body part ▪ Warm the frozen part and exer-

Type of Cold-Related Injuries	Description	First Aid
	central body stores because of inadequate clothing or circulation. The most vulnerable parts of the body are the nose, cheeks, ears, fingers, and toes. Damage from frostbite can be serious; scarring, tissue death, and amputation are all possible as is permanent loss of movement in the affected parts. Frostbitten areas may appear cold, hard, white, and anesthetic. On warming, area becomes blotchy, red, swollen and painful. Depending on the extent of the injury, the area may recover normally or deteriorate to gangrene.	cise it but do not walk on frostbitten feet ▪ Warm the frozen part quickly with sheets, blankets and warm water ▪ Remove wet clothing from the affected area and gently dry the affected part ▪ Place the affected part next to a warm part of the body if warm water is not available ▪ Seek medical attention immediately ▪ Don't rub the affected areas ▪ Don't break any blisters ▪ Don't drink caffeine or alcohol to treat for hypothermia or frostbite ▪ Don't re-warm the frozen tissue if tissue refreezing is a possibility ▪ Don't use hot water (use warm water only)

Noise

During field observations at the Airport, personnel may be exposed to noise. The most significant sources of noise and vibrations from airport operations are aircraft during the landing and takeoff (LTO) cycles, followed by a variety of ground operations equipment including aircraft taxiing; operation of GSE (e.g., passenger buses, mobile lounges, fuel trucks, aircraft tugs, aircraft and baggage tractors, and dolly carts); APUs; and aircraft engine testing activities in airports with aircraft maintenance activities. Other indirect sources of noise include ground vehicle traffic from access roads leading to the airport.

PPE and/or gear (such as ear plugs and/or muffs) are required to reduce the potentially deleterious exposure to aircraft engine, GSE and/or vehicle engine noise in the apron areas.

UV Radiation

Depending on geographical location of the Airport where the GSE surveys are being performed and weather conditions, personnel may be exposed to ultraviolet (UV) radiation during fieldwork. The sun emits energy over a broad spectrum of wavelengths: visible light that you see, infrared radiation that you feel as heat, and UV radiation that you cannot see or feel. UV radiation has a shorter wavelength and higher energy than visible light. It affects human health both positively and negatively. Short exposure to UVB radiation (mostly absorbed by the ozone layer, but some does reach the earth's surface) generates vitamin D, but can also lead to sunburn depending on an individual's skin type. Fortunately the atmosphere's stratospheric ozone layer shields us from most UV radiation. What does get through the ozone layer; however, can cause skin cancer, cataracts, suppression of the immune system, and premature aging of the skin.

To protect against exposure to UV radiation, personnel will wear sunglass-type safety glasses at all times when working outdoors during daylight hours, utilize a commercial sunblock with a minimum solar protection factor (SPF) of 15, cover up and seek shade (as necessary).

Biological Hazards

Although the potential for biological hazards (such as mosquitoes, ticks, bees, and wasps) at the Airport are slim to none, care must be taken to ensure that these types of injuries are avoided.

Contact with insects can cause injury and illness to personnel. Mosquitoes can potentially carry and transmit the West Nile Virus or Eastern Equine Encephalitis (EEE). Ticks can transmit Lyme disease or Rocky Mountain Spotted-Fever. Bees and wasps can sting by injecting venom, which causes some individuals to experience anaphylactic shock (an extreme allergic reaction). When entering areas that provide a habitat for insects (e.g., grass areas), wear light-colored clothing, long pants and shirt, and spray exposed skin areas with a DEET-containing repellent. Keep away from high grass wherever possible. Keep your eyes and ears open for bee and wasp nests. If bitten by insects, see a doctor if there is any question of an allergic reaction.

Personal Protective Equipment (PPE) and/or Gear

The purpose of PPE and/or gear is to provide a barrier, which will shield or isolate individuals from the chemical physical, and/or biological hazards that may be encountered during work activities. **Table 6** lists the minimum PPE and/or gear required during the GSE fleet and activity surveys performed at the Airport and additional PPE as deemed necessary. The specific PPE guidelines are consistent with OSHA's requirements in 29 CFR 1910.132.

Additionally, **Table 6** lists other essential items that should be carried on each transport vehicle during fieldwork.

Table 6 – PPE and Gear

Type of PPE	Description
High-visibility Safety Vest	Must have reflective tape and be visible from all sides. Must be worn at all times during fieldwork.
Footwear	No open-toe shoes and/or sandals Waterproof shoes (when necessary)
Work Uniform	No shorts/cutoff jeans/sleeveless shirts/loose or bulky clothing Waterproof clothing (when necessary)
Hearing Protection	Ear plugs and/or muffs

Cold Weather Gear (if applicable)	Warm clothing
Eyewear	Must wear sunglass-type safety glasses
Sun screen/Insect repellant (if applicable)	Must apply minimum solar protection factor (SPF) of 15 and DEET-containing repellent
Other Essential Items:	
First Aid Kit	Should be carried on each transport vehicle. The number of first aid kits and the content of each kit shall reflect the degree of isolation, the number of personnel performing fieldwork, and the hazards reasonably anticipated at the work site.
Fire Extinguisher	Should be carried on each transport vehicle.
Water	Should be carried on each transport vehicle.

Of note, each subcontractor is responsible for equipping its personnel with any required PPE and/or gear.

6. EMERGENCY ACTION PLAN

Although the potential for an emergency to occur is remote, the two major categories of emergencies that could potentially occur during fieldwork to personnel are: 1) illnesses and physical injuries (including injury-causing chemical exposure), and 2) catastrophic events (such as fire, explosion, earthquake, or chemical spill). The Airport shall have in place an Airport Emergency Plan (AEP) per the requirements of 14 CFR §139.

Prior to the start of field work, the Airport Escort shall brief field work personnel on security and safety procedures as well as the AEP, and other airport-specific emergency procedures. All personnel shall consult and adhere to airport-specific emergency action plan(s) and procedures.

Information regarding the nearest hospital (with emergency care) to the Airport is listed below. Driving directions and map to the hospital from the Airport are presented as **Exhibit A-3**.

Name of Nearest Hospital (with emergency care):

ABC Hospital

Address/Location: 123 Hospital Lane, City, State, Zip code

Telephone: (123)456-7891

7. STOP WORK AUTHORITY

All personnel have the right and duty to stop work when conditions are unsafe, and to assist in correcting these conditions. Whenever the H&SO determines that workplace conditions present an uncontrolled risk of injury or illness to personnel, immediate resolution with the appropriate supervisor shall be sought. The H&SO shall implement corrective actions so that operations may be safely resumed. Resumption of safe operations is the primary objective; however, operations shall not resume until all fieldwork personnel have concurred that workplace conditions meet acceptable safety standards.

8. PERSONNEL ACKNOWLEDGMENT

By signing below, the undersigned acknowledges that he/she has read and reviewed the KB Environmental Inc. HASSP associated with **Task 4** (*Develop Draft Protocol for Collecting GSE Operational Data*) of ACRP 02-46: *Improving Ground Support Equipment Operational Data for Airport Emissions Modeling Amplified Work Plan (AWP).*

The undersigned also acknowledges that he/she has been instructed in the contents of this document and understands the information pertaining to the specified work, and will comply with the provisions contained therein.

Print Name	Signature	Organization	Date
John Doe	Insert signature	GSE Survey, Inc.	01/01/1900
Mark Doe	Insert signature	ABC Airport	01/01/1900

EXHIBIT A-1: AIRPORT SITE MAP

The Airport site map, indicating site perimeter and survey areas as well as points of entry and exit is provided below.

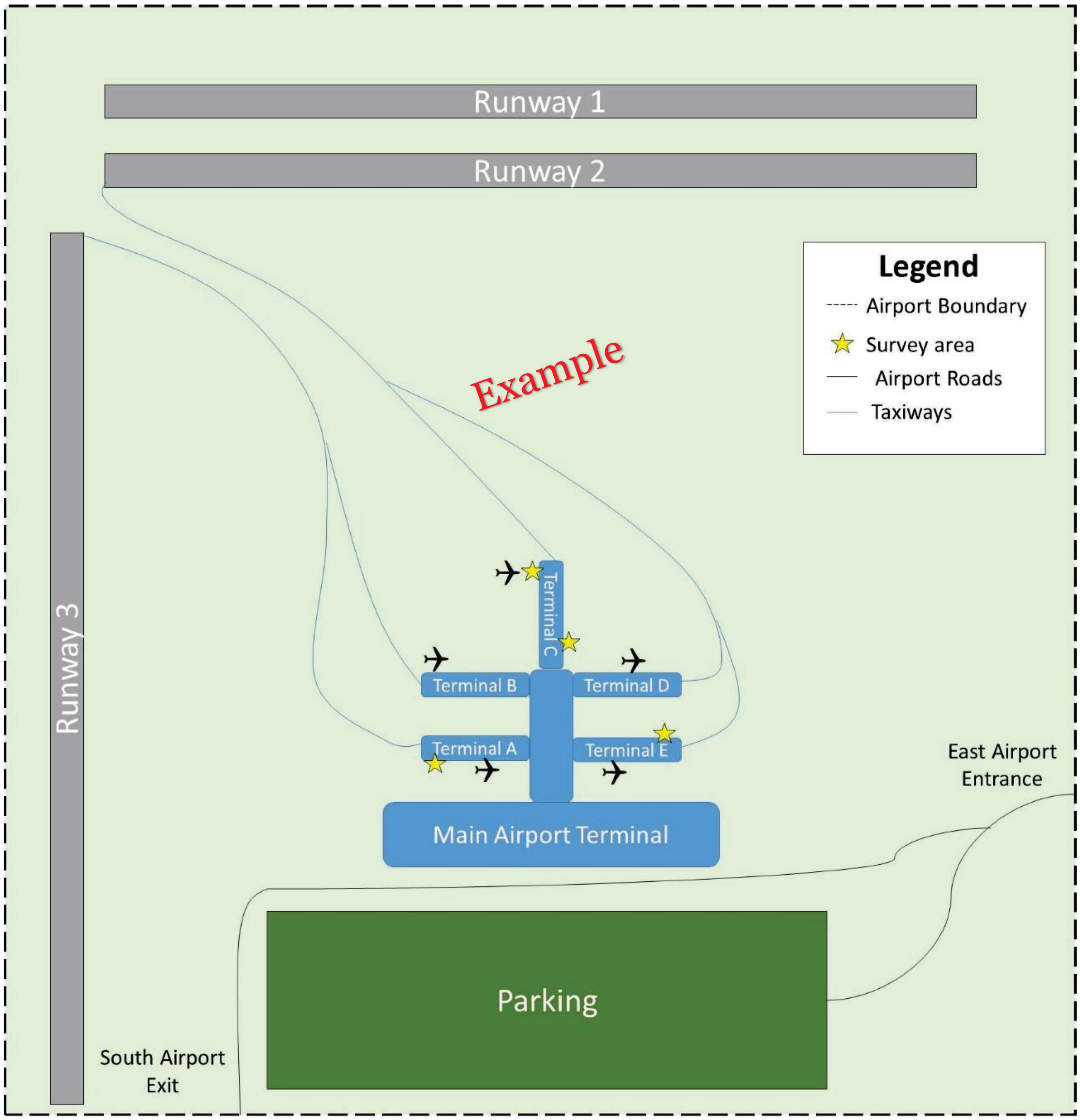

EXHIBIT A-2: MATERIAL SAFETY DATA SHEETS (MSDS)

ScienceLab.com
Chemicals & Laboratory Equipment

Health	2
Fire	1
Reactivity	0
Personal Protection	H

Material Safety Data Sheet
Propylene glycol MSDS

Section 1: Chemical Product and Company Identification

Product Name: Propylene glycol

Catalog Codes: SLP1162, SLP2974

CAS#: 57-55-6

RTECS: TY2000000

TSCA: TSCA 8(b) inventory: Propylene glycol

CI#: Not applicable.

Synonym: 1,2,-propanediol, 1,2-dihydroxypropane

Chemical Name: Propylene Glycol

Chemical Formula: CH3CHOHCH2OH

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: 1-800-901-7247
International Sales: 1-281-441-4400

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Propylene glycol	57-55-6	100

Toxicological Data on Ingredients: Propylene glycol: ORAL (LD50): Acute: 20000 mg/kg [Rat]. 22000 mg/kg [Mouse]. DERMAL (LD50): Acute: 20800 mg/kg [Rabbit].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of ingestion. Slightly hazardous in case of skin contact (irritant, permeator), of eye contact (irritant), of inhalation.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

p. 1

Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: 371°C (699.8°F)

Flash Points: CLOSED CUP: 99°C (210.2°F). OPEN CUP: 107°C (224.6°F) (Cleveland).

Flammable Limits: LOWER: 2.6% UPPER: 12.5%

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances: Slightly flammable to flammable in presence of heat

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: When heated to decomposition it emits acrid smoke and irritating fumes.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Absorb with an inert material and put the spilled material in an appropriate waste disposal. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

p. 2

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, reducing agents, acids, alkalis, moisture.

Storage:
Hygroscopic. Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 23°C (73.4°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 10 (mg/m3) from AIHA Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid. (Oily liquid.)

Odor: Practically Odorless.

Taste: Practically Tasteless.

Molecular Weight: 76.1g/mole

Color: Colorless. Clear

pH (1% soln/water): Not available.

Boiling Point: 188°C (370.4°F)

Melting Point: -59°C (-74.2°F)

Critical Temperature: Not available.

Specific Gravity: 1.036 (Water = 1)

Vapor Pressure:
0 kPa (@ 20°C) 0.08 mmHg at 20 C 0.129 mmHg at 25 C

Vapor Density: 2.62 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: The product is more soluble in water; log(oil/water) = -0.9

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, acetone.

p. 3

Solubility: Soluble in cold water, hot water, acetone.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, excess heat, exposure to moist air or water

Incompatibility with various substances: Reactive with oxidizing agents, reducing agents, acids, alkalis.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Hygroscopic; keep container tightly closed. Incompatible with chloroformates, strong acids (nitric acid, hydrofluloric acid), caustics, aliphatic amines, isocyanates, strong oxidizers, acid anhydrides, silver nitrate, reducing agents.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact.

Toxicity to Animals:
Acute oral toxicity (LD50): 18500 mg/kg [Rabbit]. Acute dermal toxicity (LD50): 20800 mg/kg [Rabbit].

Chronic Effects on Humans: May cause damage to the following organs: central nervous system (CNS).

Other Toxic Effects on Humans:
Hazardous in case of ingestion. Slightly hazardous in case of skin contact (irritant, permeator), of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May affect genetic material (mutagenic). May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause mild skin irritation. It may be absorbed through the skin and cause systemic effects similar to those of ingestion. Eyes: May cause mild eye irritation with some immediate, transitory stinging, lacrimation, blepharospasm, and mild transient conjunctival hyperemia. There is no residual discomfort or injury once it is washed away. Inhalation: May cause respiratory tract irritation. Ingestion: It may cause gastrointestinal tract irritation. It may affect behavior/central nervous system(CNS depression, general anesthetic, convulsions, seizures, somnolence, stupor, muscle contraction or spasticity, coma), brain (changes in surface EEG), metabolism, blood (intravascular hemolysis, white blood cells - decreased neutrophil function), respiration (respiratory stimulation, chronic pulmonary edema, cyanosis), cardiovascular system(hypotension, bradycardia, arrhythmias, cardiac arrest), endocrine system (hypoglycemia), urinary system (kidneys), and liver. Chronic Potential Health Effects: Skin: Prolonged or repeated skin contact may cause allergic contact dermatitis. Ingestion: Prolonged or repeated ingestion may cause hyperglycemia and may affect behavior/CNS (symptoms similar to that of acute ingestion). Inhalation: Prolonged or repeated inhalation may affect behavior/CNS (with symptoms similar to ingestion), and spleen

Section 12: Ecological Information

Ecotoxicity:
Ecotoxicity in water (LC50): >5000 mg/l 24 hours [Goldfish]. >10000 mg/l 48 hours [guppy]. >10000 mg/l 48 hours [water flea].

BOD5 and COD: Not available.

p. 4

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
Pennsylvania RTK: Propylene glycol Minnesota: Propylene glycol TSCA 8(b) inventory: Propylene glycol

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Example

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R21/22- Harmful in contact with skin and if swallowed. S24/25- Avoid contact with skin and eyes.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 0

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Supplier MSDS -LOLI -RTECS -HSDB

p. 5

Other Special Considerations: Not available.

Created: 10/10/2005 08:24 PM

Last Updated: 05/21/2013 12:00 PM

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p. 6

EXHIBIT A-3: DRIVING DIRECTIONS AND MAP TO NEAREST HOSPITAL (WITH EMERGENCY CARE

Directions to Nearest Hospital from Airport (example):

1) Exit the Airport at Exit ABC
2) Turn left onto Airport Rd.
3) Follow Airport Rd. for 2 miles
4) Turn left onto Hospital Rd.

Map of Driving Directions to the Nearest Hospital (example):

Example

[End of Version 1]

Version 2

1. HEALTH, SAFETY, AND SECURITY PLAN APPROVAL

This Health, Safety, and Security Plan (HASSP) was prepared for personnel performing an in-the-field survey of airport ground support equipment (GSE). It was prepared based on the best available information regarding the physical and chemical hazards known or suspected to be present at the Airport being assessed. While it is not possible to discover, evaluate, and protect in advance against all possible hazards which may be encountered during the completion of this project, adherence to the requirements of the HASSP will significantly reduce the potential for occupational injury.

By signing below, I acknowledge that I have reviewed and hereby approve the HASSP associated with **Task 4** (*Develop Draft Protocol for Collecting GSE Operational Data*) of ACRP 02-46: *Improving Ground Support Equipment Operational Data for Airport Emissions Modeling Amplified Work Plan (AWP).*

This HASSP has been written for the exclusive use of ________, its employees, and subcontractors. The plan is written for specified site conditions, dates, and personnel, and must be amended if these conditions change.

Written by:

____

Approved by:

____

2. INTRODUCTION

This Health, Safety, and Security Plan (HASSP) provides a general description of the levels of personal protection and safe operating guidelines expected from all personnel[1] associated with **Task 4** (*Develop Draft Protocol for Collecting GSE Operational Data*) of ACRP 02-46: *Improving Ground Support Equipment Operational Data for Airport Emissions Modeling Amplified Work Plan (AWP).*

The scope of work for this task is to conduct ground service equipment (GSE) fleet and activity surveys at ____________________________ (the Airport), located at ___ ______________________, on ______________________.

The Airport site map, indicating site perimeter and survey areas as well as points of entry and exit is provided as **Exhibit A-1** to this HASSP.

The GSE surveys will comprise the collection of the following data:

- Number and type of vehicles by aircraft code;
- Difference between type of operations (i.e., dedicated cargo vs. passenger operations);
- Time in operational mode (including idling); and
- Gate deicing vehicles.

The provisions of this HASSP are mandatory for all personnel engaged in fieldwork associated with the GSE surveys being conducted at the Airport. A copy of this HASSP shall be maintained by the Health and Safety Officer (H&SO) during the fieldwork and made available for review by all personnel at all times. Record keeping will be maintained in accordance with this HASSP and any applicable federal, state, and local regulations.

[1] For the purpose of this HASSP, the term "personnel" refers to all the individuals (i.e., project manager, health and safety officer, airport escort, research team and subcontractors) involved in the GSE fleet and activity surveys performed at the Airport.

3. ORGANIZATIONAL STRUCTURE

This section of the HASSP describes lines of authority, responsibility, and communication as they pertain to health and safety functions associated with the GSE fleet and activity surveys performed at the Airport. The purpose of this section is to identify the personnel who impact the development and implementation of the HASSP and to describe their roles and responsibilities. This section also identifies the research team and subcontractors involved in work operations and establishes the lines of communication among them for safety and health matters.

The organizational structure and health program is consistent with OSHA requirements in 29 Code of Federal Regulations (CFR) §1910.120(b)(2). In addition, the site H&SO has the responsibility and authority to develop and implement this HASSP and verify compliance; as well as the lines of authority, responsibility, and communication for safety and health functions.

This section is reviewed and updated as necessary to reflect the current organizational structure of the personnel performing the fieldwork.

Roles and Responsibilities

All personnel should comply with the requirements of this HASSP. The specific responsibilities and authority of management, security, safety and health, and other personnel are provided in **Table 1** and further identified by name and company in **Table 2**.

Table 1 – Roles and Responsibility of Personnel

Role	Responsibilities
Project Manager (PM)	The PM has the responsibility and authority to direct all work operations. The PM coordinates safety and health functions with the Health and Safety Officer (H&SO), has the authority to oversee and monitor the performance of the H&SO, and bears ultimate responsibility for the proper implementation of this HASSP.
Health and Safety Officer (H&SO)	The H&SO has full responsibility and authority to develop and implement this HASSP and to verify compliance. The H&SO reports to the PM. The H&SO is on-site or readily accessible to the site during all work operations and has the authority to halt site work if unsafe conditions are detected.
Airport Escort Personnel (AEP)	The AEP is responsible for escorting the research team and/or subcontractors to airport airfields and apron areas and assuring that safety and security are adhered to and that the safety of personnel is ensured at all times.
Research Team and Subcontractors	The research team and other subcontractors are responsible for complying with this HASSP, using the proper personal protective equipment (PPE) and/or gear, reporting unsafe acts and conditions, and following the work and safety and health instructions of the PM, H&SO, and AEP.

Table 2 – Identification of Fieldwork Personnel

Role	Name/Title	Company
Project Manager		
Health and Safety Officer		
Airport Escort		
Airport Escort		
Airport Escort		
Research Team Member		
Research Team Member		
Research Team Member		
Research Team Member		
Research Team Member		
Subcontractor		
Subcontractor		

HASSP Information and Site-Specific Briefings for Personnel

All personnel shall review this HASSP and will be provided a site-specific briefing by the H&SO prior to the commencement of work to ensure that all personnel engaged in fieldwork are familiar with this HASSP and the information and requirements it contains. Additional briefings are provided as necessary to notify personnel of any changes to this HASSP as a result of information gathered during ongoing site characterization and analysis. Conditions for which additional briefings shall be scheduled include, but are not limited to: changes in site conditions, changes in the work schedule/plan, newly discovered hazards, and incidents occurring during fieldwork.

4. SAFETY MEASURES ON AIRCRAFT APRONS AND AIRFIELD

This section of the HASSP describes the various safety and security measures that all personnel should be aware of when performing the GSE fleet and activity surveys performed at the Airport (within aircraft apron and airfield areas). It is imperative that all regulations pertaining to airport safety and security are adhered to, and that the safety of personnel is ensured at all times.

The safety and security measures within this HASSP are consistent with the requirements of FAA's Federal Aviation Regulations (FARS) 14 CFR §107.

Apron Practices

All personnel will be escorted by a designated AEP when conducting fieldwork. When on the aircraft aprons, personnel must remain with their escort at a distance that continuously enables direct visual sighting and verbal communication until they have exited the Security Identification Display Area (SIDA)[2].

Personnel should also be aware of the common requirement that escorts ensure all secured doorways between the SIDA, secured areas and sterile areas are completely shut with locks engaged prior to leaving the area. If logistically it is required to move between the apron and the sterile area to reach sampling locations, personnel should understand that it is also their responsibility to enable their escort to do so without impediment.

Personnel will not encroach upon restricted apron areas and will conduct all data collection at sufficient distance from the aircraft and GSE so as not to interfere with operations. Further, assigned personnel will, via signature of the HASSP, ensure that they understand and will abide by all pavement markings, signage, warnings and advisories necessary to ensure safe apron operation, and will not engage in any activity that generates Foreign Object Debris (FOD) on the ramp.

Airfield Access and Travel

During fieldwork, close coordination with airport personnel and security staff will be required to ensure that personnel will be allowed to access and traverse the airfield with the equipment and supplies necessary to conduct field observations. Knowledge of the following general guidelines and best practices can be employed to facilitate airfield access and travel to the extent required for ACRP 02-46.

Vehicles may be escorted into the SIDA in conjunction with an approved reason to escort and must possess a valid state registration. The escorted vehicle will be inspected before being allowed to enter the SIDA. Escort vehicles entering and exiting the airfield through secure access gates are required to stop and wait for the gate to close behind them, barring passage of any subsequent vehicles, even if the point of entry/exit is staffed by a gate security officer. It is the responsibility of each individual to enable their escort to adhere to these procedures without impediment.

[2] The SIDA is a portion of an airport, specified in the airport security program, in which security measures are carried out. This area includes the secured area and may include other areas within the airport's perimeter boundary that require an individual to continuously display identification media (e.g., a badge).

Due to screening requirements, unscreened baggage cannot be carried through to the Air Operations Area (AOA)[3] or the SIDA via entrance through secured airfield or airport access gates. Further, field equipment bags and other vehicle items may be subject to inspection prior to being allowed airfield access.

Personnel will not encroach upon restricted airfield areas or otherwise interfere with the safe movement of other vehicles and aircraft. Further, assigned personnel will, via signature of the HASSP, ensure that they understand and will abide by all pavement markings, signage, warnings and advisories necessary to ensure safe operation, and will not engage in any activity that generates FOD. Although the AEP is the only individual(s) permitted to drive airport vehicle(s), all other personnel are required to have an understanding of the airfield markings, signage, warnings and advisories.

5. POTENTIAL HAZARDS

This section of the HASSP identifies the potential health and safety hazards associated with GSE fleet and activity surveys to be performed at the Airport, and evaluates the risks to personnel. During field observations at the Airport, there is potential for personnel to be exposed to: chemical, physical, and biological hazards. These are discussed in detail below.

Chemical Hazards

In airports the main sources of air pollution are exhaust from aircraft engines, aircraft auxiliary power units (APU), other combustion engines (e.g., vehicles, handling and loading equipment etc.), vapor emissions from refueling aircraft, and larger dust particles from brakes, tires, asphalt, soil etc. Personnel working in close proximity to these types of sources may be exposed to a complex mixture of pollutants by incidental skin exposure, eye contact or inhalation.

The main pollutants of concern can be divided into: petroleum hydrocarbons; polycyclic aromatic hydrocarbons (PAHs); volatile organic compounds (VOCs); inorganic gases like sulfur dioxide (SO_2), carbon monoxide (CO), and nitrogen dioxide (NO_2); and particulate matter (PM).

Petroleum Hydrocarbon

Hydrocarbon fuels (including gasoline, diesel fuel and jet fuel) are complex mixtures of hydrocarbons and additives. The constituents of hydrocarbon fuels possess a range of vapor pressures. For highly volatile components, chronic exposures or exposures to a high concentration may cause unconsciousness, coma, and possible death from respiratory failure. Exposure to low concentrations of vapor may produce flushing of the face, slurred speech, and mental confusion. Fuels are also irritating to the skin, and may cause drying and dermatitis as a result of prolonged contact.

Various components and additives of the fuels can themselves present significant additional hazards. The aromatic compounds BTEX are of the main concern in relation to fieldwork activi-

[3] The AOA includes aircraft movement areas, aircraft parking areas, loading ramps, and safety areas, for use by regulated aircraft, and any adjacent areas (e.g., general aviation areas). Encompasses the runways, taxiways, aprons and other areas of the airport intended to be used by aircraft for taxiing, takeoff, landing, maneuvering, and parking. This area does not include the secured area.

ties. However, some additives used for performance enhancement (e.g., methyl tert-butyl ether - MTBE), oxygenation (e.g., alcohols and MTBE) and water scavenging (e.g., ethylene glycol methyl ether - EGME) can also present significant hazards as a result of prolonged inhalation or skin exposure. Tetra-ethyl and tetra-methyl lead, both of which have been identified as carcinogens and present moderate skin contact hazards, are added to aviation gasoline for anti-knock control.

There are no set limits for petroleum hydrocarbons; however, gasoline guidelines may be used instead. Both the OSHA permissible exposure limits (PELs) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) for gasoline are 300 parts per million (ppm).

Material safety data sheets (MSDS) for these chemical substances are provided as **Exhibit A-2** to this HASSP.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are produced during combustion events due to inadequate oxidation of fuel. PAHs in the pure state are yellowish crystalline solids. They are found in coal tar and in products of incomplete combustion. These chemicals have varying degrees of potency for causing cancer, with benzo(a)pyrene being among the most potent (in low concentrations). Benzo(a)pyrene is often used as an indicator compound for PAH pollution. In airports PAHs are mainly produced due to incomplete combustion in aircraft and diesel engines. PAHs will exist bound to particulate matter and as gases in the exhaust gas. Some significant PAH compounds include:

- Anthracene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(d,e,f)phenanthrene
- Chrysene
- Fluoranthene
- Fluorene
- Indeno(1,2,3,c,d)pyrene

MSDS for the primary chemical substances are provided as **Exhibit A-2** to this HASSP.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are a very large group of organic compounds mainly present as gases. Some VOCs (e.g., benzene), are carcinogenic while others (e.g., aldehydes, can cause irritation of eyes and airways. In airports VOCs mainly originate from fuel vaporized during fueling and unburned or partly burned fuel in the exhaust gas. Some VOCs will be bound to particulate matter in exhaust gas. Aldehydes are also formed by photochemical reactions in the surrounding air.

Inorganic Gases

Sulfur dioxide (SO_2) is a colorless gas also with a strong characteristic odor. SO_2 is emitted into the atmosphere by both natural processes and by man-made sources such as the combustion of sulfur-containing fuels and sulfuric acid manufacturing. When combined with other substances in the air, SO_2 can precipitate out as rain, fog, snow, or dry particles (commonly referred to as "acid rain"). Sulfate particles are a major cause of reduced visibility in many areas of the United States. Aircraft engines are a key source of SO_2 in airports. The inhalation of elevated concentrations of SO_2 can cause irritation of the mucous membranes, bronchial damage, and can exacerbate pre-existing respiratory diseases such as asthma, bronchitis, and emphysema.

Carbon monoxide (CO) is a colorless, odorless, tasteless gas that is a product of incomplete combustion of organic materials. In the ambient environment, it may temporarily accumulate into localized "hot-spots," especially in calm weather conditions and in the wintertime when CO forms easily and is chemically most stable. CO can be absorbed by the lungs and react with hemoglobin to reduce the oxygen-carrying capacity of the blood. At elevated concentrations CO can have cardiovascular and central nervous system effects.

Nitrogen dioxide (NO_2) is a reddish-brown to dark brown gas with an irritating odor. NO_2, nitric oxide (NO), and the nitrate radical (NO_3) are collectively called oxides of nitrogen (NO_x). These three compounds are interrelated, often changing from one form to another in chemical reactions. The principal man-made source of NO_x is fuel combustion in motor vehicles and power plants with aircraft also contributing. NO_2 emissions from these sources are highest during high-temperature combustion conditions. Reactions of NO_x with other chemicals (such as VOCs) can lead to ozone formation and acidic precipitation. Additionally, secondary PM can be formed within the atmosphere from precursor gases, such as NO_x, through gas-phase photochemical reactions or through liquid phase reactions in clouds and fog droplets. In humans, NO_2 can be a lung irritant capable of producing pulmonary edema at high concentrations and can lead to other respiratory illnesses such as bronchitis and pneumonia.

Particulate Matter

Particulate matter (PM) is made up of small solid particles and liquid droplets suspended or settling out of the atmosphere. PM consists of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. PM can be formed from both natural and man-made sources including forest fires and wind erosion over exposed soils (i.e., fugitive dust); the incineration of solid wastes; and as an exhaust product from the internal combustion engine. Of growing concerns are the effects of PM on visibility and the potential impairment to human health by small PM (i.e., ultrafine particle emissions or PM0.1). The regulatory standards for PM are segregated by sizes: less than or equal to 10 micrometers (denoted PM_{10}) and less than or equal to 2.5 micrometers (denoted $PM_{2.5}$).

Assessment of Exposure Hazards

Inhalation – Inhalation of chemical hazards will be greatly minimized through use of administrative controls and PPE such as air respirators.

Skin Contact – Direct contact of chemical hazards to skin will be minimized through use of administrative controls, and dermal protective equipment.

Eye Contact – Direct eye contact with chemical hazards will be minimized through the use of eye protective gear such as safety glasses.

Personnel will minimize exposure hazards by conducting all data collection at sufficient distance from the exhaust areas of aircrafts engines, GSE and/or vehicle engines.

For list of air contaminants and their representative permissible exposure limits (PELs) refer to 29 CFR §1910.1000 Table Z-1 and Z-2. Personnel's exposure to any substance listed in Tables Z-1 and Z-2 shall be limited in accordance with the requirements of 29 CFR §1910.1000.

First aid measures relevant to the chemical substances mentioned are described in the respective MSDS provided as **Exhibit A-2** to this HASSP.

Physical Hazards

Aside from adhering to all regulations, signs, markings and advisories discussed in the preceding sections, awareness of the physical surroundings is critical, and to increase visibility a safety vest will be required at all times when conducting data collection outside of a vehicle. Caution will be needed to protect from jet blast or jet engine ingestion if engines are running, including securing loose articles of clothing. Personnel will be mindful of the status of aircraft engine rotational lights which will be illuminated if an aircraft engine is running. Additionally, all markings noting restricted areas around an engine will be identified to prevent engine suction.

Furthermore, during field observations at the Airport, there is potential for personnel to be exposed to physical hazards such as slips, trips, falls, and heat/cold stress as well as noise and ultraviolet (UV) radiation as described below.

Slips, Trips, and Falls

Slips, trips & falls can happen anywhere while performing fieldwork and can result in falls, injuries, possibly disability or death. For instance, in the event field observations occur near glycol application areas, recommended PPE and/or gear includes waterproof clothing, waterproof shoes, and eye protection. In and around the deiced aircraft the ramp will become more hazardous, because GSE have a reduced ability to stop and personnel in the area may be more prone to slip-and-falls.

The physical hazards associated with slips, trips and falls are detailed in **Table 3**.

Table 3 – Identifying slips, trips, falls

Type	Definition	Causes
Slip	Too little friction or traction between feet (footwear) and walking/working surface, resulting in loss of balance	▪ Wet product or spills on smooth floors or walking surfaces (e.g., water, mud, grease, oil, food, blood, etc.). ▪ Dry product or spills making walking surface slippery (e.g., dusts, powders, granules, wood, and plastic wrapping). ▪ Transitioning from one surface to another ▪ Sloped walking surfaces ▪ Ramps & gang planks without skid-

		or slip-resistant surfaces ▪ Metal surfaces (e.g., platforms, sidewalk and road covers) ▪ Loose, irregular surfaces such as gravel ▪ Weather hazards
Trip	Foot or lower leg hits object and upper body continues moving, resulting in loss of balance Stepping down to lower surface & losing balance	▪ Uncovered hoses, cables, wires or extension cords across aisles or walkways ▪ Clutter, obstacles in aisles, walkway & work areas ▪ Changes in elevation or levels ▪ Unmarked steps or ramps ▪ Irregularities in walking surfaces ▪ Thresholds or gaps ▪ Damaged, non-uniform, improper or irregular steps ▪ Debris, accumulated waste materials ▪ Objects protruding from walking surface ▪ Uneven surfaces and sidewalk/curb drops
Fall	Occurs when too far off center of balance	▪ Two types: 1. Fall at same level (i.e., fall to same walking or working surface, or fall into or against objects above same surface) and 2. Fall to lower level (i.e., fall to level below walking or working surface)
Environmental Conditions Increasing Risk of Trips & Slips		▪ Poor lighting, glare, shadows ▪ Bulky PPE (includes improper footwear, loose clothing) ▪ Excess noise or temperature ▪ Fog or misty conditions ▪ Poor housekeeping ▪ Inadequate or missing signage

Heat and Cold Stress

During field observations at the Airport, personnel may be exposed to heat and cold stress, which could vary based upon work activities, PPE/clothing selection, geographical locations, and weather conditions. The guidance in **Table 4** and **Table 5** should be used in identifying and treating heat-related illnesses and cold-related injuries, respectively.

Table 4 – Identifying and Treating Heat-related Illnesses

Type of Heat-Related Illnesses	Description	First Aid
Mild Heat Strain	The mildest form of heat-related illness. Victims exhibit irritability, lethargy, and significant	▪ Provide the victim with a work break during which he/she may relax, remove any excess protective

Type of Heat-Related Illnesses	Description	First Aid
	sweating. The victim may complain of headache or nausea. This is the initial stage of overheating, and prompt action at this point may prevent more severe heat-related illness from occurring	clothing, and drink cool fluids. ▪ If an air-conditioned spot is available, this is an ideal break location. ▪ Once the victim shows improvement, he/she may resume working; however, the work pace should be moderated to prevent recurrence of the symptoms.
Heat Exhaustion	Usually begins with muscular weakness and cramping, dizziness, staggering gait, and nausea. The victim will have pale, clammy moist skin and may perspire profusely. The pulse is weak and fast and the victim may faint unless they lie down. The bowels may move involuntarily.	▪ Immediately remove the victim from the work area to a shady or cool area with good air circulation (avoid drafts or sudden chilling). ▪ Remove all protective outerwear. ▪ Call a physician. ▪ Treat the victim for shock. (Make the victim lie down, raise his or her feet 6–12 inches, and keep him or her cool by loosening all clothing). ▪ If the victim is conscious, it may be helpful to give him or her sips of water. ▪ Transport victim to a medical facility as soon as possible.
Heat Stroke	The most serious of heat illness, heat stroke represents the collapse of the body's cooling mechanisms. As a result, body temperature may rise to 104 degrees Fahrenheit or higher. As the victim progresses toward heat stroke, symptoms such as headache, dizziness, nausea can be noted, and the skin is observed to be dry, red, and hot. Sudden collapse and loss of consciousness follows quickly and death is imminent if exposure continues. Heat stroke can occur suddenly.	▪ Immediately evacuate the victim to a cool and shady area. ▪ Remove all protective outerwear and as much personal clothing as decency permits. ▪ Lay the victim on his or her back with the feet slightly elevated. ▪ Apply cold wet towels or ice bags to the head, armpits, and thighs. ▪ Sponge off the bare skin with cool water or rubbing alcohol, if available. ▪ The main objective is to cool without chilling the victim. ▪ Give no stimulants or hot drinks. ▪ Since heat stroke is a severe medical condition requiring professional medical attention, emergency medical help should be summoned immediately to provide on-site treatment of the victim and proper transport to a medical facility.

Table 5 – Identifying and Treating Cold-related Injuries

Type of Cold-Related Injuries	Description	First Aid
Hypothermia	Hypothermia occurs when the body cannot maintain a normal core temperature of 98.6 to 99.9 degrees Fahrenheit. Hypothermia can take a victim by surprise since it can occur above the freezing point. Wind, physical exhaustion and wet clothing all make a person more prone to hypothermia. Usually victims of hypothermia have the following symptoms: ▪ numbness, stiffness or pain (especially in the neck, arms and legs), ▪ poor coordination, slurred speech and drowsiness, ▪ slow, irregular breathing and heartbeat/pulse, ▪ puffiness in the face, ▪ low blood pressure, ▪ listlessness, confusion and disorientation (It is not unusual to see someone who makes little or no effort to get out of the cold or keep warm), ▪ collapse or exhaustion after rest, ▪ severe shivering, and death is a possibility.	▪ Unconscious persons with severe hypothermia should be treated aggressively by experienced medical personnel and transported to a hospital. If no pulse is detected, CPR should be administered immediately until help arrives. ▪ Remove the person out of frozen, wet or tight clothes. ▪ Rewarming the person in a warm bed or bath with warm packs, warm and dry clothes, or blankets can treat mild hypothermia in young and otherwise healthy persons. ▪ Have the victim drink something warm (if conscious) but do not give caffeine or alcohol. (Never give anything by mouth to someone who is unconscious).
Frostnip	Frostnip occurs when the face or extremities are exposed to cold wind, causing the skin to turn white. Symptoms include: firm, cold, white areas on the face, ears or extremities, peeling or blistering that may appear similar to sunburn, and mild hypersensitivity to cold persists.	▪ The frost-nipped area should be treated by rewarming the area with an unaffected hand or a warm object. Do not apply hot water.
Frostbite	Frostbite occurs when there is freezing of the skin. It can occur without hypothermia when the extremities do not receive sufficient heat from	▪ Remove restrictive clothing or jewelry near the affected area or body part ▪ Warm the frozen part and exer-

Type of Cold-Related Injuries	Description	First Aid
	central body stores because of inadequate clothing or circulation. The most vulnerable parts of the body are the nose, cheeks, ears, fingers, and toes. Damage from frostbite can be serious; scarring, tissue death, and amputation are all possible as is permanent loss of movement in the affected parts. Frostbitten areas may appear cold, hard, white, and anesthetic. On warming, area becomes blotchy, red, swollen and painful. Depending on the extent of the injury, the area may recover normally or deteriorate to gangrene.	cise it but do not walk on frostbitten feet ▪ Warm the frozen part quickly with sheets, blankets and warm water ▪ Remove wet clothing from the affected area and gently dry the affected part ▪ Place the affected part next to a warm part of the body if warm water is not available ▪ Seek medical attention immediately ▪ Don't rub the affected areas ▪ Don't break any blisters ▪ Don't drink caffeine or alcohol to treat for hypothermia or frostbite ▪ Don't re-warm the frozen tissue if tissue refreezing is a possibility ▪ Don't use hot water (use warm water only)

Noise

During field observations at the Airport, personnel may be exposed to noise. The most significant sources of noise and vibrations from airport operations are aircraft during the landing and takeoff (LTO) cycles, followed by a variety of ground operations equipment including aircraft taxiing; operation of GSE (e.g., passenger buses, mobile lounges, fuel trucks, aircraft tugs, aircraft and baggage tractors, and dolly carts); APUs; and aircraft engine testing activities in airports with aircraft maintenance activities. Other indirect sources of noise include ground vehicle traffic from access roads leading to the airport.

PPE and/or gear (such as ear plugs and/or muffs) are required to reduce the potentially deleterious exposure to aircrafts engine, GSE and/or vehicle engine noise in the apron areas.

UV Radiation

Depending on geographical location of the Airport where the GSE surveys are being performed and weather conditions, personnel may be exposed to ultraviolet (UV) radiation during fieldwork. The sun emits energy over a broad spectrum of wavelengths: visible light that you see, infrared radiation that you feel as heat, and UV radiation that you cannot see or feel. UV radiation has a shorter wavelength and higher energy than visible light. It affects human health both positively and negatively. Short exposure to UVB radiation (mostly absorbed by the ozone layer, but some does reach the earth's surface) generates vitamin D, but can also lead to sunburn depending on an individual's skin type. Fortunately the atmosphere's stratospheric ozone layer shields us from most UV radiation. What does get through the ozone layer; however, can cause skin cancer, cataracts, suppression of the immune system, and premature aging of the skin.

To protect against exposure to UV radiation, personnel will wear sunglass-type safety glasses at all times when working outdoors during daylight hours, utilize a commercial sunblock with a minimum solar protection factor (SPF) of 15, cover up and seek shade (as necessary).

Biological Hazards

Although the potential for biological hazards (such as mosquitoes, ticks, bees, and wasps) at the Airport are slim to none, care must be taken to ensure that these types of injuries are avoided.

Contact with insects can cause injury and illness to personnel. Mosquitoes can potentially carry and transmit the West Nile Virus or EEE. Ticks can transmit Lyme disease or Rocky Mountain Spotted-Fever. Bees and wasps can sting by injecting venom, which causes some individuals to experience anaphylactic shock (an extreme allergic reaction). When entering areas that provide a habitat for insects (e.g., grass areas), wear light-colored clothing, long pants and shirt, and spray exposed skin areas with a DEET-containing repellent. Keep away from high grass wherever possible. Keep your eyes and ears open for bee and wasp nests. If bitten by insects, see a doctor if there is any question of an allergic reaction.

Personal Protective Equipment (PPE) and/or Gear

The purpose of PPE and/or gear is to provide a barrier, which will shield or isolate individuals from the chemical physical, and/or biological hazards that may be encountered during work activities. **Table 6** lists the minimum PPE and/or gear required during the GSE fleet and activity surveys performed at the Airport and additional PPE as deemed necessary. The specific PPE guidelines are consistent with OSHA's requirements in 29 CFR 1910.132.

Additionally, **Table 6** lists other essential items that should be carried on each transport vehicle during fieldwork.

Table 6 – PPE and Gear

Type of PPE	Description
High-visibility Safety Vest	Must have reflective tape and be visible from all sides. Must be worn at all times during fieldwork.
Footwear	No open-toe shoes and/or sandals Waterproof shoes (when necessary)
Work Uniform	No shorts/cutoff jeans/sleeveless shirts/loose or bulky clothing Waterproof clothing (when necessary)
Hearing Protection	Ear plugs and/or muffs

Cold Weather Gear (if applicable)	Warm clothing
Eyewear	Must wear sunglass-type safety glasses
Sun screen/Insect repellant (if applicable)	Must apply minimum solar protection factor (SPF) of 15 and DEET-containing repellent
Other Essential Items:	
First Aid Kit	Should be carried on each transport vehicle. The number of first aid kits and the content of each kit shall reflect the degree of isolation, the number of personnel performing fieldwork, and the hazards reasonably anticipated at the work site.
Fire Extinguisher	Should be carried on each transport vehicle.
Water	Should be carried on each transport vehicle.

Of note, each subcontractor is responsible for equipping its personnel with any required PPE and/or gear.

6. EMERGENCY ACTION PLAN

Although the potential for an emergency to occur is remote, the two major categories of emergencies that could potentially occur during fieldwork to personnel are: 1) illnesses and physical injuries (including injury-causing chemical exposure), and 2) catastrophic events (such as fire, explosion, earthquake, or chemical spill). The Airport shall have in place an Airport Emergency Plan (AEP) per the requirements of 14 CFR §139.

Prior to the start of field work, the Airport Escort shall brief field work personnel on security and safety procedures as well as the AEP, and other airport-specific emergency procedures. All personnel shall consult and adhere to airport-specific emergency action plan(s) and procedures.

Information regarding the nearest hospital (with emergency care) to the Airport is listed below. Driving directions and map to the hospital from the Airport are presented as **Exhibit A-3**.

Name of Nearest Hospital (with emergency care):

____ ____________________________________

Address/Location: ____ ____

Telephone: _________________________

7. STOP WORK AUTHORITY

All personnel have the right and duty to stop work when conditions are unsafe, and to assist in correcting these conditions. Whenever the H&SO determines that workplace conditions present an uncontrolled risk of injury or illness to personnel, immediate resolution with the appropriate supervisor shall be sought. The H&SO shall implement corrective actions so that operations may be safely resumed. Resumption of safe operations is the primary objective; however, operations shall not resume until all fieldwork personnel has concurred that workplace conditions meet acceptable safety standards.

8. PERSONNEL ACKNOWLEDGEMENT

By signing below, the undersigned acknowledges that he/she has read and reviewed the KB Environmental Inc. HASSP associated with **Task 4** (*Develop Draft Protocol for Collecting GSE Operational Data*) of ACRP 02-46: *Improving Ground Support Equipment Operational Data for Airport Emissions Modeling Amplified Work Plan (AWP)*.

The undersigned also acknowledges that he/she has been instructed in the contents of this document and understands the information pertaining to the specified work, and will comply with the provisions contained therein.

Print Name	**Signature**	**Organization**	**Date**

EXHIBIT A-1: AIRPORT SITE MAP

The Airport site map, indicating site perimeter and survey areas as well as points of entry and exit is provided below.

[Insert Map or Figure]

EXHIBIT A-2: MATERIAL SAFETY DATA SHEETS (MSDS)

[Insert MSDS]

EXHIBIT A-3: DRIVING DIRECTIONS AND MAP TO NEAREST HOSPITAL (WITH EMERGENCY CARE

[Insert Map and Directions]

[End]

APPENDIX B

Data Collection Forms and Resources

Airport GSE Operating Time Observation Form

Aircraft Type:	MD82	**Turnaround:**	☐	**Operator:**	AAL	**Date:**	7/10/2014
Apron Type:	Terminal C	**Enroute:**	☐	**Tail:**	N585	**Airport:**	DFW
Team:	B			**Time In:**	10:17:09	**Gate:**	C33
Scribe:	Joe Smith			**Time Out:**	11:10:20	**Flight:**	132

GSE		Start	Stop	Start	Stop	Start	Stop
Belt Loader							
☒ Forward	☐ Aft	10:20:01	11:02:35				
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
Baggage Tractor							
☐ Forward	☒ Aft	10:18:53	10:24:54				
☒ Forward	☐ Aft	10:20:32	10:20:53	10:25:27	10:28:31		
☒ Forward	☐ Aft	10:28:09	10:30:22				
☐ Forward	☒ Aft	11:05:05	11:08:59				
☒ Forward	☐ Aft	10:37:41	10:43:41				
☐ Forward	☒ Aft	10:56:10	11:01:30				
☐ Forward	☐ Aft						
Aircraft Tractor							
	Power In/Push Back	10:19:29	10:19:57	11:08:18	11:13:12		
	Tug In/Push Back						
Air Start							
Cabin Service Truck							
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
☐ Forward	☐ Aft						
Catering Truck							
☐ Forward	☒ Aft	10:19:19	10:38:50				
☒ Forward	☐ Aft	10:19:20	10:41:04				
☐ Forward	☐ Aft						
Air Conditioners/Heaters							
	Air Conditioner						
	Heater						
Deicer							
Forklift							
Fuel Truck							
Ground Power Unit							
Hydrant Fueling							
☐ Cart	☒ Truck	10:30:08	10:41:21				
Lavatory Service							
☐ Cart	☒ Truck	10:40:45	10:47:32				
On-road Vehicle							
☐ Pickup	☒ Van	10:39:50	10:43:10				
☐ Pickup	☐ Van						
☐ Pickup	☐ Van						
Water Service							
☐ Powered	☐ Gate						
Passenger Stairs							
Other: 400 Hz gate power		10:18:06	11:03:17				
Other: PCA		10:20:12	11:03:50				
Other:							

Notes: Pick-up truck observed to be associated with refueling activities.
Water service observed but not timed.

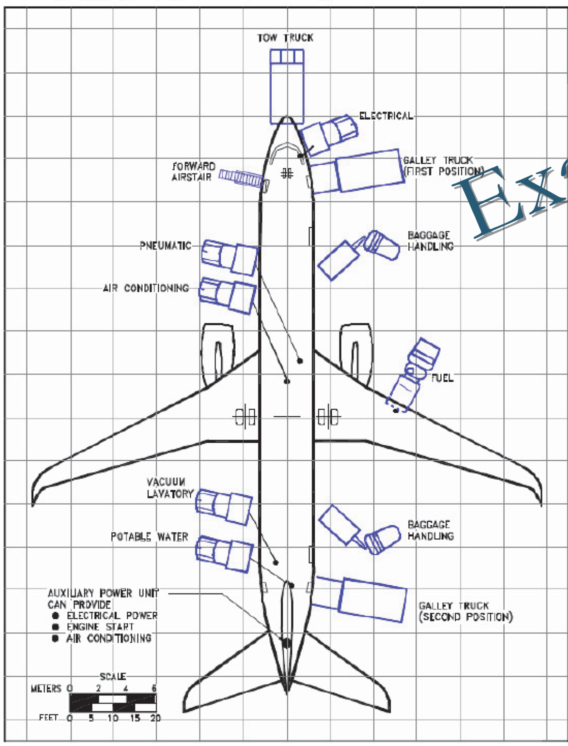
Team Sampling Itinerary

Airport: ABC						
Team:	**1**			**2**		
Airside:	**C**	**C**	**C**	**A**	**A**	**A**
Carrier:	**SWA**	**SWA**	**SWA**	**JBU**	**SIL**	**UAL**
Aircraft:	**B737**	**B733**	**B712**	**A320**	**SF34**	**A320**
Time	**Flight No. (Gate)**	**Flight No. (Gate)**	**Flight No. (Gate)**	**Flight No. (Gate)**	**Flight No. (Gate)**	**Flight No. (Gate)**
0800			**313(C30)**			
0830		**665(C38)**				
0900				**525 (A12)**		
0930	**480(C34)**				**4042(A1)**	
1000	3499(38)		**709(c42)**	2191(A14)		
1030						**360(A4)**
1100			641(C30)		**3993(A1)**	
1130		**185(C36)**		1[illegible]25(A15)		
1200	**4292(C34)**			**891(A12)**		
1230						**1656(A7)**
1300		**1432(C35)**		925(A14)		
1330			**456(C38)**		**3984(A1)**	
1400				**1447(A14)**		
1430	**206(C34)**					1593(A5)
1500					**3980(A1)**	
1530		**48(C39)**		391(A12)		**1640(A6)**
1600						
1630			**982(C38)**		**4008(A1)**	
1700		**307(C30)**		**325(A14)**		
1730						
1800					4031(A1)	**1408(A5)**

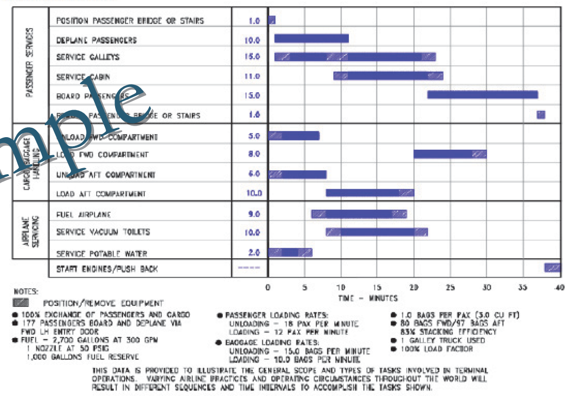
Notes: Black bold flight numbers represent the optimum sampling schedule. Red bold flight numbers represent a contingency sampling schedule in the event of missed observations.

Airport Planning Manual Terminal Servicing Guide

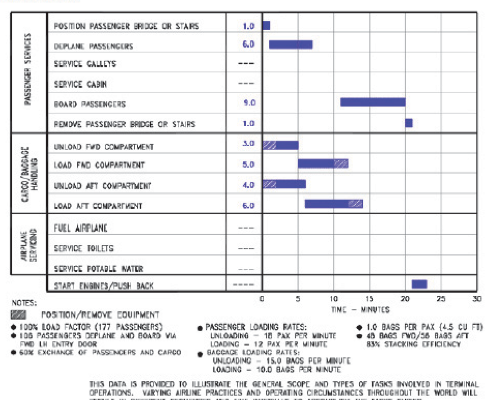
Boeing B737-900; -900ER with Winglets



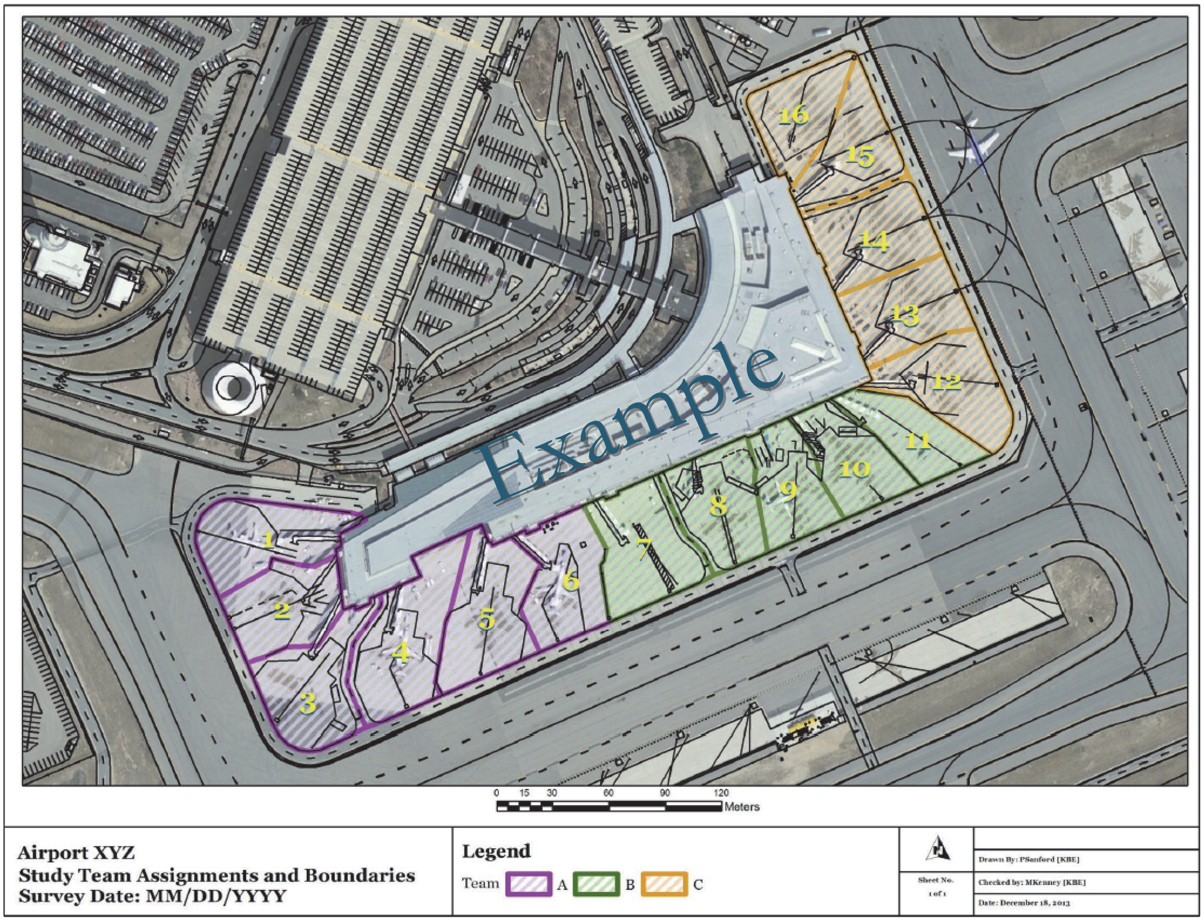
Turnaround:



Enroute:



Survey Team Gate Assignment Map



Visual Guide for Typical Apron GSE

Aircraft Tractor

Air Conditioner

Air Start

Ambulatory Transporter

Baggage Tractor

Belt Loader

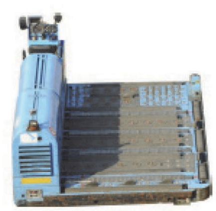
Boarding Stairs

Cabin Service Truck

Cargo Tractor

Catering Truck

Container Loader



Container Transporter

Deicer

Fork Lift

Fuel Truck

Equipment Data Plate Examples

APPENDIX C

Aircraft Size Classifications

Aircraft	EDMS Category	Usage
Wide-Body		
Aerospatiale Concorde	HCJP	P
Airbus A300B2-100 Series	HCJP	P
Airbus A300B2-200 Series	HCJP	P
Airbus A300B2-300 Series	HCJP	P
Airbus A300B4-600 Series	HCJP	P
Airbus A300B4-100 Series	HCJP	P
Airbus A300B4-200 Series	HCJP	P
Airbus A300C4-200 Series	HCJP	P
Airbus A300C4-600 Series	HCJC	C
Airbus A300F4-200 Series	HCJC	C
Airbus A300F4-600 Series	HCJC	C
Airbus A300F4-600ST Beluga	HCJC	C
Airbus A310-200 Series Freighter	HCJC	C
Airbus A310-200 Series	HCJP	P
Airbus A310-300 Series	HCJP	P
Airbus A330-200 Series Freighter	HCJC	C
Airbus A330-200 Series	HCJP	P
Airbus A330-300 Series	HCJP	P
Airbus A340-600 Series	HCJP	P
Airbus A340-200 Series	HCJP	P
Airbus A340-300 Series	HCJP	P
Airbus A340-500 Series	HCJP	P
Airbus A350-800 Series	HCJP	P
Airbus A350-900 series	HCJP	P
Airbus A380-800 Series	HCJP	P
Airbus A380-900 Series	HCJP	P
Antonov 124 Ruslan	HCJC	C
Boeing 707-100 Series	HCJP	P
Boeing 707-300 Series	HCJP	P
Boeing 747-100 Series Freighter	HCJC	C
Boeing 747-100 Series	HCJP	P
Boeing 747-100 SR	HCJP	P
Boeing 747-200 Series Freighter	HCJC	C
Boeing 747-200 Series	HCJP	P
Boeing 747-300 Series Freighter	HCJC	C
Boeing 747-300 Series	HCJP	P
Boeing 747-400 ER	HCJP	P
Boeing 747-400 Freighter	HCJC	C
Boeing 747-400 Series	HCJP	P
Boeing 747-8 Freighter	HCJC	C

Boeing 747-8	HCJP	P
Boeing 747-SP	HCJP	P
Boeing 767-200 ER	HCJP	P
Boeing 767-200 Series Freighter	HCJC	C
Boeing 767-200 Series	HCJP	P
Boeing 767-300 ER Freighter	HCJC	C
Boeing 767-300 ER	HCJP	P
Boeing 767-300 Series	HCJP	P
Boeing 767-400 ER	HCJP	P
Boeing 767-400	HCJP	P
Boeing 777-200 Series Freighter	HCJC	C
Boeing 777-200 Series	HCJP	P
Boeing 777-200-ER	HCJP	P
Boeing 777-200-LR Freighter	HCJC	C
Boeing 777-200-LR	HCJP	P
Boeing 777-300 ER	HCJP	P
Boeing 777-300 Series	HCJP	P
Boeing 787-8 Dreamliner	HCJP	P
Boeing 787-9 Dreamliner	HCJP	P
Boeing DC-10-10 Series	HCJP	P
Boeing DC-10-30 Series	HCJP	P
Boeing DC-10-30 ER	HCJP	P
Boeing DC-10-40 Series	HCJP	P
Boeing DC-8 Series 50	HCJP	P
Boeing DC-8 Series 60	HCJP	P
Boeing DC-8 Series 60 Freighter	HCJC	C
Boeing DC-8 Series 70	HCJP	P
Boeing DC-8 Series 70 Freighter	HCJC	C
Boeing MD-10-1	HCJC	C
Boeing MD-10-1 Freighter	HCJC	C
Boeing MD-10-30	HCJP	P
Boeing MD-11	HCJP	P
Boeing MD-11 Freighter	HCJC	C
Boeing MD-11-ER	HCJP	P
Ilyushin 62 Classic	HCJP	P
Ilyushin 76 Candid	HCJP	P
Ilyushin 86 Camber	HCJP	P
Ilyushin 96	HCJP	P
Ilyushin 96 Freighter	HCJC	C
Ilyushin 76 Candid Freighter	HCJC	C
Lockheed L-1011-100 Tristar	HCJP	P
Lockheed L-1011-200 Tristar	HCJP	P
Lockheed L-1011-250 Tristar	HCJP	P

Lockheed L-1011 Tristar	HCJP	P
Lockheed L-1011-1 Tristar	HCJP	P
Lockheed L-1011-500 Tristar	HCJP	P
Narrow-Body		
Aero Spacelines Super Guppy	LCTC	C
Aerospatiale Caravelle 10	LCJP	P
Aerospatiale Caravelle 12	LCJP	P
Airbus A318-100 Series	LCJP	P
Airbus A319-100 Series	LCJP	P
Airbus A319-100 X/LR	LCJP	P
Airbus A320-100 Series	LCJP	P
Airbus A320-200 Series	LCJP	P
Airbus A321-100 Series	LCJP	P
Airbus A321-200 Series	LCJP	P
Antonov 140	LCTP	P
Antonov 148	LCJP	P
Antonov 24 Coke	LCTP	P
ATR 72-200	LCTP	P
ATR 72-500	LCTP	P
Avro RJ-100	LCJP	P
Avro RJ-70	LCJP	P
Avro RJ-85	LCJP	P
BAC 1-1 1 300/400	LCJP	P
BAC 1-11 475	LCJP	P
BAE 146-100	LCJP	P
BAE 146-200	LCJP	P
BAE 146-200 QT Quiet Trader	LCJC	C
BAE 146-300	LCJP	P
BAE 146-300 QT Quiet Trader	LCJC	C
BAE 146-100 QT Quiet Trader	LCJC	C
BAE 146-RJ115	LCJP	P
BAE 146-RJ70	LCJP	P
BAE 146-RJ85	LCJP	P
BAE 146-RJl OO	LCJP	P
BAE Jetstream 61 ATP	LCTP	P
Boeing 737-400 Series	LCJP	P
Boeing DC-9-40 Series	LCJP	P
Boeing 717-200 Series	LCJP	P
Boeing 720	LCJP	P
Boeing 727-100 Series	LCJP	P
Boeing 727-200 Series	LCJP	P
Boeing 727-200 Series Freighter	LCJC	C
Boeing 727-200 Series Super 27	LCJP	P

Boeing 737- 100 Series	LCJP	P
Boeing 737-200 Series	LCJP	P
Boeing 737-200 Series Freighter	LCJC	C
Boeing 737-300 Series	LCJP	P
Boeing 737-300 Series Freighter	LCJC	C
Boeing 737-400 Series Freighter	LCJC	C
Boeing 737-500 Series	LCJP	P
Boeing 737-600 Series	LCJP	P
Boeing 737-700 Series	LCJP	P
Boeing 737-800 Series	LCJP	P
Boeing 737-800 Short Field Package-Next	LCJP	P
Boeing 737-800 with winglets	LCJP	P
Boeing 737-900 Series	LCJP	P
Boeing 737-900-ER	LCJP	P
Boeing 757-200 Series Freighter	LCJC	C
Boeing 757-200 Series	LCJP	P
Boeing 757-300 Series	LCJP	P
Boeing Business Jet (BBJ)	LGJB	B
Boeing Business Jet II	LGJB	B
Boeing DC-6	LCTP	P
Boeing DC-9-10 Series	LCJP	P
Boeing DC-9-10 Series Freighter	LCJC	C
Boeing DC-9-20 Series	LCJP	P
Boeing DC-9-30 Series	LCJP	P
Boeing DC-9-40 Series Freighter	LCJC	C
Boeing DC-9-50 Series	LCJP	P
Boeing MD-81	LCJP	P
Boeing MD-82	LCJP	P
Boeing MD-83	LCJP	P
Boeing MD-87	LCJP	P
Boeing MD-88	LCJP	P
Boeing MD-90	LCJP	P
Bombardier Challenger 604	LGJB	B
Bombardier Challenger 300	LGJB	B
Bombardier Challenger 600	LGJB	B
Bombardier Challenger 601	LGJB	B
Bombardier CL -415	LGTO	O
Bombardier CRJ-100	LCJP	P
Bombardier CRJ-100-LR	LCJP	P
Bombardier CRJ-200	LCJP	P
Bombardier CRJ-200-ER	LCJP	P
Bombardier CRJ-200-LR	LCJP	P

Bombardier CRJ-400	LCJP	P
Bombardier CRJ-400-LR	LCJP	P
Bombardier CRJ-700	LCJP	P
Bombardier CRJ-700-ER	LCJP	P
Bombardier CRJ-700-LR	LCJP	P
Bombardier CRJ-705-LR	LCJP	P
Bombardier CRJ-900	LCJP	P
Bombardier CRJ-900-ER	LCJP	P
Bombardier de Havilland Dash 8 Q300	LCTP	P
Bombardier de Havilland Dash 8 Q400	LCTP	P
Bombardier Global Express 5000	LCJB	B
Bombardier Global Express	LCJB	B
Convair CV-440	LCPP	P
Convair CV-580	LCTP	P
Convair CV-640	LCTP	P
Dassault Mercure 100	LCJP	P
de Havilland DHC-7 Dash 7	LCTP	P
Embraer ERJ135	LCJP	P
Embraer ERJ135 Legacy Business	LCJB	B
Embraer ERJ135-ER	LCJP	P
Embraer ERJ135-LR	LCJP	P
Embraer ERJ140	LCJP	P
Embraer ERJ140-LR	LCJP	P
Embraer ERJ145	LCJP	P
Embraer ERJ145-EP	LCJP	P
Embraer ERJ145-LR	LCJP	P
Embraer ERJ145-LU	LCJP	P
Embraer ERJ145-MP	LCJP	P
Embraer ERJ145-XR	LCJP	P
Embraer ERJ170	LCJP	P
Embraer ERJ170-AR	LCJP	P
Embraer ERJ170-LR	LCJP	P
Embraer ERJ175-AR	LCJP	P
Embraer ERJ175-LR	LCJP	P
Embraer ERJ17S	LCJP	P
Embraer ERJ190	LCJP	P
Embraer ERJ190-AR	LCJP	P
Embraer ERJ190-LR	LCJP	P
Embraer ERJ195	LCJP	P
Embraer ERJ195-AR	LCJP	P
Embraer ERJ195-LR	LCJP	P
Embraer Legacy	LCJB	B

EmbraerERJ145-ER	LCJP	P
EmbraerERJ145-EU	LCJP	P
Fairchild Hiller FH-227	LCTP	P
Falcon 7X	LGJB	B
Fokker F27-600 Series	LCTC	C
Fokker F27-100 Series	LCTP	P
Fokker F27-200 Series	LCTP	P
Fokker F27-300 Series	LCTP	P
Fokker F27-400 Series	LCTP	P
Fokker F27-500 Series	LCTP	P
Fokker F27-700 Series	LCTC	C
Fokker F28-1000 Series	LCJP	P
Fokker F28-2000 Series	LCJP	P
Fokker F28-3000 Series	LCJP	P
Fokker F28-4000 Series	LCJP	P
Fokker F70	LCJB	B
Fokker F50	LCTP	P
Fokker F100	LCJP	P
Gulfstream 11-8	LCJP	P
Gulfstream G280	LCJB	B
Gulfstream G300	LCJP	P
Gulfstream G350	LCJP	P
Gulfstream G400	LCJP	P
Gulfstream G450	LGJB	B
Gulfstream G500	LCJP	P
Gulfstream G550	LGJB	B
Gulfstream G650	LCJB	B
Gulfstream II	LCJP	P
Gulfstream II-SP	LCJP	P
Gulfstream IV-SP	LCJP	P
Gulfstream VSP	LGJB	B
Hawker HS748-1	LCTP	P
Hawker HS748-2	LCTP	P
Hawker HS748-2A	LCTP	P
Hawker HS748-2B	LCTP	P
Ilyushin 114	LCTB	B
Ilyushin 18 Clam	LCTP	P
Lockheed L-1329 Jetstar II	LGJB	B
Lockheed L-1329 Jetstar I	LGJB	B
Lockheed L-188 Electra	LCTP	P
Martin WB-57F Canberra	LGJO	O
NAMC YS-11-100 Series	LCTP	P
NAMC YS-11A-200 Series	LCTP	P

NAMC YS-11A-300 Series	LCTP	P
NAMC YS-11A-400 Series	LCTP	P
NAMC YS-11A-500 Series	LCTP	P
NAMC YS-11A-600 Series	LCTP	P
NAMC YS-11A-700 Series	LCTP	P
Raytheon Hawker 900	LGJB	B
Raytheon Hawker 900XP	LCJB	B
Saab 2000	LCTP	P
SAC 1-11 200	LCJP	P
SAC 1-11 500	LCJP	P
Shorts SC5 Belfast	LCTC	C
Sukhoi Superjet 100-95 (RRJ-95)	LCJP	P
Tupolev 134 Crusty	LCJP	P
Tupolev 154 Careless	LCJP	P
Tupolev 204 Freighter	LCJC	C
Tupolev Tu-330	LCJP	P
Tupolev204	LCJP	P
Vickers Vanguard	LCTC	C
Xian Yunshuji Y-7	LCTP	P
Yakovlev 42 Clobber	LCJP	P
Small-Body		
3Xtrim 3X47 Ultra	SGPP	P
3Xtrim 3X55 Trener	SGPP	P
Aerospatiale N 262	SCTP	P
Aerospatiale SN 601 Corvette	SGJB	B
Aerostar PA-60	SGPB	B
Air Tractor 802	SGTO	O
Air Tractor AT-502	SGTO	O
Air Tractor AT-5028	SGTO	O
Air Tractor AT-502A	SGTO	O
Air Tractor AT-602	SGTO	O
American Jet Hustler 400 A	SGTB	B
Antonov AN28 Cash	SCTC	C
ATR 42-200	SCTP	P
ATR 42-300	SCTP	P
ATR 42-320	SCTP	P
ATR 42-400	SCTP	P
ATR 42-500	SCTP	P
Aviat Husky A1B	SGPP	P
Ayres S2R-T34 Turbo-Thrush	SGTO	O
Ayres Turbo-Thrush T-65	SGTO	O
BAE Jetstream 1	SCTP	P
BAE Jetstream 200 Series	SCTP	P

BAE Jetstream 31	SCTP	P
BAE Jetstream 32	SCTP	P
BAE Jetstream 32-EP	SCTP	P
BAE Jetstream 41	SCTP	P
Boeing DC-3	SCPP	P
Boeing Stearman PT-17/A75N1	SGPP	P
Bombardier Challenger 602	SGJP	P
Bombardier de Havilland Dash 8 Q100	SCTP	P
Bombardier de Havilland Dash 8 Q200	SCTP	P
Bombardier Learjet 23	SGJB	B
Bombardier Learjet 24	SGJB	B
Bombardier Learjet 24-XR	SGJB	B
Bombardier Learjet 25	SGJB	B
Bombardier Learjet 25-XR	SGJB	B
Bombardier Learjet 28	SGJB	B
Bombardier Learjet 29	SGJB	B
Bombardier Learjet 31	SGJB	B
Bombardier Learjet 35	SGJB	B
Bombardier Learjet 36	SGJB	B
Bombardier Learjet 40	SGJB	B
Bombardier Learjet 45	SGJB	B
Bombardier Learjet 45-XR	SGJB	B
Bombardier Learjet 55	SGJB	B
Bombardier Learjet 60	SGJB	B
Britten-Norman BN-2 Islander	SGTP	P
Britten-Norman BN-2A Mk III Trislander	SGTP	P
CASA 212-100 Series	SCTP	P
CASA 212-200 Series	SCTP	P
CASA 212-300 Series	SCTP	P
CASA 212-400 Series	SCTP	P
CASA CN-235-100	SCTP	P
CASA CN-235-200	SCTP	P
CASA CN-235-300	SCTP	P
Cessna 150 Series	SGPP	P
Cessna 172 Skyhawk	SGPP	P
Cessna 182	SGPP	P
Cessna 206	SGPP	P
Cessna 208 Caravan	SGTB	B
Cessna 210 Centurion	SGPP	P
Cessna 310	SGPP	P
Cessna 337 Skymaster	SGPB	B

Cessna 404 Titan II	SGPB	B
Cessna 414	SGPB	B
Cessna 421 Golden Eagle	SGPB	B
Cessna 425 Conquest I	SGTP	P
Cessna 441 Conquest II	SGTP	P
Cessna 500 Citation I	SGJB	B
Cessna 501 Citation ISP	SGJB	B
Cessna 525 CitationJet	SGJB	B
Cessna 550 Citation II	SGJB	B
Cessna 551 Citation llSP	SGJB	B
Cessna 560 Citation Excel	SGJB	B
Cessna 560 Citation V	SGJB	B
Cessna 560 Citation XLS	SGJB	B
Cessna 650 Citation Ill	SGJB	B
Cessna 680 Citation Sovereign	SGJB	B
Cessna 750 Citation X	SGJB	B
Cessna S550 Citation S/11	SGJB	B
Cessna340	SGPB	B
Cessna402	SGPB	B
Cirrus SR20	SGPP	P
Cirrus SR22	SGPP	P
Dassault Falcon 10	SGJB	B
Dassault Falcon 100	SGJB	B
Dassault Falcon 200	SGJB	B
Dassault Falcon 2000	SGJB	B
Dassault Falcon 2000-EX	SGJB	B
Dassault Falcon 20-C	SGJB	B
Dassault Falcon 20-D	SGJB	B
Dassault Falcon 20-E	SGJB	B
Dassault Falcon 20-F	SGJB	B
Dassault Falcon 20-G	SGJB	B
Dassault Falcon 50	SGJB	B
Dassault Falcon 50-EX	SGJB	B
Dassault Falcon 900	SGJB	B
Dassault Falcon 900-B	SGJB	B
Dassault Falcon 900-C	SGJB	B
Dassault Falcon 900-EX	SGJB	B
de Havilland DHC-2 Mk III Beaver	SGPP	P
de Havilland DHC-3 Otter	SGPP	P
de Havilland DHC-6-100 Twin Otter	SCTP	P
de Havilland DHC-6-200 Twin Otter	SCTP	P
de Havilland DHC-6-300 Twin Otter	SCTP	P

de Havilland DHC-8-100	SCTP	P
de Havilland DHC-8-200	SCTP	P
de Havilland DHC-8-300	SCTP	P
Dornier 128 Skyservant	SCTP	P
Dornier 228-100 Series	SCTP	P
Dornier 228-200 Series	SCTP	P
Dornier 328 Jet	SCJP	P
Dornier 328-100 Series	SCTP	P
EADS Socata TB-10 Tobago	SGPP	P
EADS Socata TB-20 Trinidad	SGPO	O
EADS Socata TB-9 Tampico	SGPP	P
EADS Socata TBM-700	SGTP	P
EADS Socata TBM-850	SCTB	B
Eclipse 500	SCJB	B
Embraer EMB120 Brasilia	SCTP	P
Embraer EMB110 Bandeirante	SCTP	P
Equator P-550 Turbo	SGTB	B
Fairchild SA-226-T Merlin III	SCTP	P
Fairchild SA-226-TC Metro II	SCTP	P
Fairchild SA-227-AC Metro III	SCTP	P
Fairchild SA-227-AT Expediter	SCTC	C
Fairchild SA-26-T Merlin II	SCTP	P
Falcon 900DX	SGJB	B
Fokker (VFW) 614	SCJP	P
Grumman G-21G Goose	SCTP	P
Grumman G-73 Mallard	SGTP	P
Gulfstream G150	SGJB	B
Gulfstream G200	SGJB	B
Gulfstream GlOO	SGJB	B
Gulfstream I	SCTB	B
Harbin Y-12	SCTP	P
Hawker HS-125 Series 1	SGJB	B
Hawker HS-125 Series 3	SGJB	B
Hawker HS-125 Series 400	SGJB	B
Hawker HS-125 Series 600	SGJB	B
Hawker HS-125 Series 700	SGJB	B
Israel IAl-1121 Commodore	SGJB	B
Israel IAl-1123	SGPC	C
Israel IAl-1124 Westwind I	SGJB	B
Israel IAl-1124-A Westwind II	SGJB	B
Israel IAl-1125Astra	SGJB	B
Israel IAl-1126 Galaxy	SGJB	B

Lancair 360	SGPP	P
Let 420 Tubolet	SCTP	P
Let410	SCTP	P
Let410-UVP	SCTP	P
Maule MT-7-235	SGTO	O
Mitsubishi MU- 300 Diamond	SGJB	B
Mitsubishi MU-2	SGTP	P
Mooney M20-K	SGPP	P
Neiva NE-821 Caraja	SGTB	B
Partenavia P68 Victor	SGPP	P
Piaggio P180 Avanti	SGTP	P
Pilatus PC- 12	SGTP	P
Pilatus Turbo Trainer PC-9	SGTO	O
Piper PA-23 Apache/Aztec	SGPB	B
Piper PA-24 Comanche	SGPP	P
Piper PA-27 Aztec	SGPP	P
Piper PA-28 Cherokee Series	SGPP	P
Piper PA-30 Twin Comanche	SGPP	P
Piper PA-31 Navajo	SGPB	B
Piper PA-31 T Cheyenne	SGTB	B
Piper PA-32 Cherokee Six	SGPP	P
Piper PA-34 Seneca	SGPB	B
Piper PA46-TP Meridian	SGTB	B
Piper PA-42 Cheyenne Series	SGTB	B
Piper PA-46 500TP	SGTB	B
PZL M-28 Skytruck	SCTC	C
Rans S7S	SGPP	P
Raytheon Beech Baron 58	SGPB	B
Raytheon Beech 18	SGTP	P
Raytheon Beech 1900-0	SCTP	P
Raytheon Beech 1900-C	SCTP	P
Raytheon Beech 55 Baron	SGPB	B
Raytheon Beech 60 Duke	SGPP	P
Raytheon Beech 99	SCTP	P
Raytheon Beech Bonanza 36	SGPB	B
Raytheon Beech D17S Staggeiwing	SGPP	P
Raytheon Beechjet 400	SGJB	B
Raytheon Hawker 4000 Horizon	SGJB	B
Raytheon Hawker 800	SGJB	B
Raytheon King Air 100	SGTB	B
Raytheon King Air 90	SGTB	B
Raytheon Premier I	SGJB	B
Raytheon Starship 2000	SGTB	B

Raytheon Super King Air 200	SCTP	P
Raytheon Super King Air 300	SCTP	P
Reims-Cessna 406 Caravan II	SCTP	P
Robin R 2160 Alpha Sport	SGPP	P
Robin R 3000	SGPP	P
RobinDR400	SGPP	P
Rockwell 1121 Jet Commander	SCJP	P
Rockwell 1121A Jet Commander-A	SCJP	P
Rockwell 1121B Jet Commander-B	SCJP	P
Rockwell Commander 500	SGPP	P
Rockwell Commander 680	SGPP	P
Rockwell Commander 690	SGPP	P
Rockwell Commander 700	SGPP	P
Rockwell Commander 980/ 1000	SCTB	B
Rockwell Sabreliner 40	SCJP	P
Rockwell Sabreliner 50	SCJP	P
Rockwell Sabreliner 60	SCJP	P
Rockwell Sabreliner 65	SCJP	P
Rockwell Sabreliner 75	SCJP	P
Rockwell Sabreliner 80	SGJB	B
Ryan Navion B	SGPP	P
Ryan Navion F	SGPP	P
Ryan ST3KR	SGPP	P
Saab 340-A	SCTP	P
Saab 340-B	SCTP	P
Saab 340-B-Plus	SCTP	P
Shorts 330 SCTP	SCTP	P
Shorts 330-200 Series	SCTP	P
Shorts 330-100 Series	SCTP	P
Shorts 360-100 Series	SCTP	P
Shorts 360-200 Series	SCTP	P
Shorts 360-300 Series	SCTP	P
Shorts Skyvan SC7-3-1	SCTP	P
Shorts Skyvan SC7-3-2	SCTP	P
Shorts Skyvan SC7-3A- 1	SCTP	P
SIAI-Marchetti SF-600 Canguro	SGTP	P
Spencer S-12 Air Car	SGPP	P
Yakovlev 40 Codlino	SCJP	P

Usage Key: P = Passenger, C = Cargo/Transport, H = Helicopter (removed), B = Business, A = Attack/Combat (removed), O= Other

APPENDIX D

Technical Support for the Derivation of Revised AEDT Defaults

Table D-1 Average TIM for each GSE Equipment by Aircraft Size Category and Study Project: Passenger Aircraft

Category (# Obs ACRP/# Obs Other)	GSE	AEDT TIM	Optional	# of Obs in Surveys per study****	Weighted Ave	Final Rec. Notes	GSE Surveys								
							ACRP				Previous Studies				KM Chng
							MIN	AVE	MAX	SD	MIN	AVE	MAX	SD	AVE
Heavy/Wide-Bodied 8	Aircraft Tractor	8		0/6/11	12	Weighted average: OTHER (10) and KM Chng (13)	Not Observed				6	10	17	4	13
	Baggage Trac-tor***	120		0/7/11	53	Weighted average: OTHER (32) and KM Chng (67) GATE ONLY, FINAL REC NEEDS TO account for time it takes to travel to load-ing/unloading area.	Not Observed				10	32	90	27	67
	Belt Loader	35		0/7/11	42	Weighted average: OTHER (37) and KM Chng (45)	Not Observed				4	37	83	37	45
	Cabin Service/ Catering Truck*	28		0/6/11	28	OTHER average. KM Chng (87) too high so was removed; also removed 2 minute time from OTHER	Not Observed				7	28	51	12	87

Category (# Obs ACRP/# Obs Other)	GSE	AEDT TIM	Optional	# of Obs in Surveys per study****	Weighted Ave	Final Rec. Notes	GSE Surveys								
							ACRP				Previous Studies				KM Chng
							MIN	AVE	MAX	SD	MIN	AVE	MAX	SD	AVE
	Cargo/ Container Loader	80		0/5/11	50	Weighted Average: OTHER(46) and KM Chng (52)	Not Observed				16	46	102	36	52
	Lavatory Cart/ Truck	25		0/3/11	17	Weighted Average: OTHER(8) and KM Chng (19); removed 2 minute time from OTHER	Not Observed				6	8	9	2	19
	Air Condi-tioner	30	Y	0/0/0	Not Observed	N/A	Not Observed								
	Air Start	7	Y	0/0/0	Not Observed	N/A	Not Observed								
	APU***	26	Y	0/5/0	25	OTHER Average GATE ONLY, FINAL REC NEEDS TO Include Taxi-in/taxi-out	Not Observed				8	25	52	18	Not Observed
	*Fuel/ Hydrant Truck	20	Y	0/2/11	37	Weighted Average: OTHER(27) and KM Chng (39)	Not Observed				24	27	30	4	39

Category (# Obs ACRP/# Obs Other)	GSE	AEDT TIM	Optional	# of Obs in Surveys per study****	Weighted Ave	Final Rec. Notes	GSE Surveys								
							ACRP				Previous Studies				KM Chng
							MIN	AVE	MAX	SD	MIN	AVE	MAX	SD	AVE
	Service Truck**	15	Y	0/2/0	11	OTHER average	Not Observed				4	11	25	12	Not Observed
	Water Service	12	Y	0/0/0	5	Not Observed for Wide-Bodied; This number was derived from Narrow-Bodied	Not Observed								
Narrow-Bodied 99	Aircraft Tractor	7		49/45/41	7	Weighted average: ACRP (6), OTHER (6) and KM Chng (8)	2	6	24	4	3	6	18	15	8
	Baggage Trac-tor***	61		52/48/41	28	Weighted average: ACRP(29), OTHER (29) and KM Chng (28) GATE ONLY, FINAL REC NEEDS TO BE HIGHER (see comment above)	5	27	98	17	5	29	96	21	28
	Belt Loader	41		52/46/41	47	Weighted average: ACRP (60), OTHER (51) and KM Chng (31)	3	55	117	30	7	51	109	26	31

Category (# Obs ACRP/# Obs Other)	GSE	AEDT TIM	Optional	# of Obs in Surveys per study****	Weighted Ave	Final Rec. Notes	GSE Surveys								
							ACRP				Previous Studies				KM Chng
							MIN	AVE	MAX	SD	MIN	AVE	MAX	SD	AVE
Narrow-Bodied 99	Cabin Service/ Catering Truck*	17		35/37/41	21	Weighted average: ACRP (22), OTHER (26) and KM Chng (15)	7	21	46	9	4	26	51	12	15
	Air Condi-tioner	30	Y	1/20	41	Weighted Average: ACRP (44) & OTHER (39)	44	44	44	--	29	39	49	15	Not Observed
	Air Start	7	Y	0/0/0	Not Observed	N/A	Not Observed								
	APU***	26	Y	0/30/0	15	OTHER Average GATE ONLY, FINAL REC NEEDS TO BE HIGHER (see comment above)	Not Observed				3	15	44	10	Not Observed
	Fuel/ Hydrant Truck*	14	Y	30/25/41	17	Weighted average: ACRP (18), OTHER (14) and KM Chng (18)	4	18	37	8	5	14	40	8	18

Category (# Obs ACRP/# Obs Other)	GSE	AEDT TIM	Optional	# of Obs in Surveys per study****	Weighted Ave	Final Rec. Notes	GSE Surveys								
							ACRP				Previous Studies				KM Chng
							MIN	AVE	MAX	SD	MIN	AVE	MAX	SD	AVE
	GPU	40	Y	3/4/0	35	Weighted Average of ACRP (54) and OTHER (26)	44	47	64	16	19	26	30	5	Not Observed
	Lavatory Cart/ Truck	14		37/26/41	8	Weighted Average of ACRP (7) and OTHER (8)	2	8	24	5	2	8	17	4	10
	Service Truck**	14	Y	16/5/0	9	Weighted Average of ACRP (10) and OTHER (7)	2	10	20	5	2	7	13	4	Not Observed
	Water Service	12	Y	8/1/0	5	Weighted Average of ACRP (4) and OTHER (5)	2	4	13	4	5	5	5	--	Not Observed
Light/Small-bodied 12	Aircraft Tractor	5		2/0/18	9	Weighted Average: ACRP(6) and KM Chng (9)	4	6	8	3	Not Observed				9
	Baggage Trac-tor***	27		2/4/18	13	Weighted Average: ACRP(15) and KM Chng (13) GATE ONLY, FINAL REC NEEDS TO BE HIGHER (see comment above)	11	15	20	6	2	4	6	2	13

Category (# Obs ACRP/# Obs Other)	GSE	AEDT TIM	Optional	# of Obs in Surveys per study****	Weighted Ave	Final Rec. Notes	GSE Surveys								
							ACRP				Previous Studies				KM Chng
							MIN	AVE	MAX	SD	MIN	AVE	MAX	SD	AVE
Light/Small-bodied 12	Belt Loader	23		2/0/18	22	Weighted Average: ACRP(36) and KM Chng (20)	27	36	45	12	Not Observed				20
	Cabin Service/ Catering Truck*	6		0/0/18	6	KM Chng Average	Not Observed								6
	Fuel/ Hydrant Truck *	20	Y	1/9/18	9	Weighted Average: ACRP(10), OTHER (5) and KM Chng (11)	10	10	10	--	3	5	13	3	11
	GPU	40	Y	1/1/18	35	Weighted Average: ACRP(44) and KM Chng (35)	44	44	44	--	10	10	10	--	35
	Lavatory Cart/ Truck	0	Y	1/0/18	4	Weighted Average: ACRP(2) and KM Chng (4)	2	2	2	--	Not Observed				4
	Service Truck**	11.5	Y	0/0/0	Not Observed	N/A	Not Observed								

MIN. = Minimum. MAX. = Maximum. NA = Not Applicable. Obs. = Observations. SD = Standard Deviation. TIM = Time-in-Mode. Y = Yes
Bold font = suggested default GSE fleet mix and TIM.
*Cabin service and catering trucks are separate in AEDT. Fuel and hydrant trucks are separate in EDMS. TIM represents average between the two.
**Service truck includes all service vehicles, including minivan.
***Gate only observations. Final recommendation for baggage tractors is higher (based on airport size; see Table 13) to account for the time it takes to travel to loading/unloading area. Final recommendation for APUs is higher (based on airport size; see Table 13) to account for taxi-in and taxi-out times.

Table D-2
Average TIM for each GSE Equipment BY Size Category: Cargo Aircraft from Oakland Airport

EDMS Category	GSE Equipment	# of Obs	EDMS TIM	Optional?	Weighted Ave	Min	Ave	Max
Wide-bodied (9)	Aircraft Tractor	3	8		7	4	7	10
	Belt Loader	3	27		23	3	23	39
	Cargo Tractor***	9	0		29	7	29	83
	Cargo/Container Loader*	9	73		91	32	91	157
	Fuel/Hydrant Truck*	2	33		24	21	24	27
	Lavatory Truck	4	13		6	4	6	11
	Service Truck	2	12		3	2	3	4
	Air Conditioner	0	23	Y	NA	NA	NA	NA
	Air Start	0	7	Y	NA	NA	NA	NA
	Baggage Tractor	0	90	Y	NA	NA	NA	NA
	Cabin Service	0	14	Y	NA	NA	NA	NA
	Fork Lift	0	0	Y	NA	NA	NA	NA
	GPU	8	0	Y	55	18	55	99
	Water Service	0	12	Y	NA	NA	NA	NA
Narrow-bodied (2)	Aircraft Tractor	1	0		5	5	5	5
	Belt Loader	1	0		4	4	4	4
	Cargo Tractor***	2	0		13	11	13	15
	Cargo/Container Loader*	2	0	Y	47	30	47	65
	Fuel/Hydrant Truck*	1	0	Y	25	25	25	25
	GPU	2	0	Y	66	63	66	70
	Other	1	0	Y	11	11	11	11

*Cabin service and catering trucks are separate in EDMS. Fuel and hydrant trucks are separate in AEDT. TIM Represents average between the two.
**Service truck includes on-road vehicles
***Gate-only observations. Final recommendation for baggage tractors should be higher (based on airport size; see Table 12) to account for the time it takes to travel to loading/unloading area. Final recommendation for APUs should be higher (based on airport size; see Table 12) to account for taxi-in and taxi-out times.

Table D-3.
Load Factors

Equipment Type	Min HP	Max HP	EDMS		NESCAUM		Zurich		CARB		ICAO	
			HP	Load	HP2	Load3	HP4	Load5	HP6	Load7	HP8	Load9
Air Conditioner*	210	300	210 - 300	0.75	--	0.39	201	0.5	--	--	201	0.50
Air Start	425	850	425 - 850	0.90	--	0.02	201	0.5	--	--	201	0.50
Aircraft Tractor*	86	617	86 - 617	0.80	--	0.08 - 0.12	127 - 670	0.25 - 0.50	--	0.54	127 - 536	0.25
Baggage Tractor*	71	107	71 - 107	0.55	--	0.02	--	--	--	0.37	40	0.50
Belt Loader*	71	107	71 - 107	0.50	--	0.07	44	0.25	--	0.34	44	0.25
Bobtail	110	235	110 - 235	0.55	--	--	--	--	--	0.37	121	0.25
Cabin Service Truck*	71	360	71 - 360	0.53	--	--	64 - 177	0.10 - 0.75	--	--	114 - 174	0.10 - 0.25
Cargo Loader*	80	133	80 - 133	0.50	--	0.06	44 - 83	0.25	--	0.34	80	0.25
Cargo Tractor	83	107	83 - 107	0.54	--	--	71 - 80	0.25	--	0.36	40	0.25
Cart	25	25	25	0.50	--	--	--	--	--	--	--	--
Catering Truck*	71	360	71 - 360	0.53	--	--	114 - 174	0.10 - 0.25	--	--	114 - 174	0.10 - 0.25
Deicer	83	270	83 - 270	0.95	--	0.07	247	0.25	--	--	241	0.10 - 0.60
Fork Lift	54	55	54 - 55	0.30	--	0.09	40 - 161	0.25	--	0.2	40 - 134	0.25
Fuel Truck	175	420	175 - 420	0.25	--	0.08	121 - 268	0.10 -0.20	--	--	268	0.10 -0.50
Generator	107	158	107 - 158	0.82	--	--	--	--	--	--	--	--
GPU*	71	194	71 - 194	0.75	--	0.1	141 - 200	0.50	--	--	134 - 201	0.50
Hydrant Cart*	--	--	--	0.70	--	--	--	--	--	--	--	--
Hydrant Truck	235	360	235 - 360	0.70	--	--	88 - 147	0.10 -0.50	--	--	94 - 147	0.10 -0.50
Lavatory Truck*	56	360	56 - 360	0.25	--	0.14	157	0.25	--	--	161	0.25
Lift	105	132	105 - 132	0.50	--	0.27	--	--	--	0.34	94 - 161	0.25
Other	126	173	126 - 173	0.50	--	--	--	--	--	0.34	--	--
Passenger Stand	65	107	65 - 107	0.57	--	0.07	40 - 87	0.25	--	0.4	40 - 87	0.25
Service Truck	235	360	235 - 360	0.20	--	0.09	94 - 161	0.25	--	--	114 - 174	0.10 - 0.25
Sweeper	45	53	45 - 53	0.51	--	--	--	--	--	--	--	--
Water Service*	235	360	235 - 360	0.20	--	--	157	0.25	--	--	161	0.25

* Suggested default GSE fleet mix in a typical wide-bodied or narrow-bodied aircraft turnaround. Small-bodied aircraft may not use all of these GSE types in a typical turnaround.

Table D-4
GSE survey counts by type and fuel (12 airports) (source: *ACRP Report 78*)

GSE Equipment	Total	Diesel [a]	Electric	Gasoline	LPG	NG	Solar	Unk [b]
Baggage Tugs/Cargo Tugs	2,575	15.4%	16.7%	52.7%	2.8%	0.0%	0.0%	12.3%
Cars/Pickups/SUVs/Vans	1,132	4.9%	0.5%	83.9%	0.1%	0.1%	0.0%	10.5%
Belt Loaders	1,102	25.0%	14.7%	44.6%	0.5%	0.4%	0.0%	14.8%
Other	843	52.2%	4.0%	28.4%	1.5%	0.2%	0.0%	13.6%
Aircraft Tractors/Tugs	705	67.7%	11.1%	8.2%	0.0%	0.0%	0.0%	13.0%
Generators/GPUs/GPU-ACs	487	61.0%	9.9%	7.2%	0.0%	0.2%	0.0%	21.8%
Deicing Trucks	399	64.7%	0.8%	26.6%	0.0%	0.0%	0.0%	8.0%
Lifts	344	21.8%	26.2%	26.7%	5.5%	0.0%	0.0%	19.8%
Carts	330	1.2%	77.6%	5.5%	0.9%	0.0%	0.0%	14.8%
Cabin Service/Catering Trucks	320	52.2%	0.3%	15.3%	0.0%	0.0%	0.0%	32.2%
Forklifts	314	12.7%	8.6%	13.7%	44.9%	0.0%	0.0%	20.1%
Air Conditioners/ Heaters	312	76.3%	2.6%	11.5%	0.0%	0.0%	0.0%	9.6%
Cargo Loaders	281	78.6%	0.4%	7.5%	0.4%	0.0%	0.0%	13.2%
Lavatory Trucks/Lavatory Carts	177	17.5%	7.9%	59.9%	0.0%	0.6%	0.0%	14.1%
Air Start Units	160	71.9%	0.6%	2.5%	0.0%	0.0%	0.0%	25.0%
Fuel Trucks	151	64.9%	2.0%	8.6%	0.0%	0.0%	0.0%	24.5%
Light Carts/Light Stands	111	64.9%	1.8%	7.2%	0.0%	0.0%	9.0%	17.1%
Passenger Stairs	95	31.6%	1.1%	42.1%	1.1%	0.0%	0.0%	24.2%
Buses	69	21.7%	0.0%	7.2%	0.0%	55.1%	0.0%	15.9%
Hydrant Carts/Hydrant Trucks	62	61.3%	0.0%	22.6%	0.0%	0.0%	0.0%	16.1%
Maintenance Trucks	56	28.6%	0.0%	44.6%	0.0%	0.0%	0.0%	26.8%
Surveyed GSE Average	10,025	**33.5%**	**11.6%**	**37.0%**	**2.6%**	**0.5%**	**0.1%**	**14.7%**

[a]Diesel fuel types were simply identified by the color or labels on the filler cap. The research team was not able to determine whether the diesel was strictly petroleum-based or biodiesel. Diesel that is 85% to 100% biodiesel (B85-B100) is defined as an alternative fuel under DOE EPAct guidelines and is potentially eligible for grant funding under FAA's VALE Program. Therefore, note that the ratio of alternative fuels to conventional fuels (petroleum diesel and gasoline) will be understated in this table.
[b]Unk = Unknown, unable to determine during survey.

APPENDIX E

Proposed New Default TIM for Passenger Aircraft GSE Fleet Mix for Small-Sized Airports

Proposed New Default TIM for Passenger Aircraft GSE Fleet Mix for Small-Sized Airports

GSE Fleet Mix	Model Default TIM	ACRP 02-46 TIM	Proposed New Default TIM
Narrow-Body Aircraft			
Aircraft Tractor	7	8	8
Baggage Tractor***	61	17	21
Belt Loader	41	36	**36**
Cabin Service/Catering Truck*	17	11	**11**
Air Conditioner	30	NA	**NA**
Air Start	7	NA	Na
APU***	26	NA	**NA**
Fuel/Hydrant Truck*	14	18	**18**
GPU	40	32	**32**
Lavatory Truck	14	11	**11**
Service Truck**	14	NA	**NA**
Water Service	12	NA	**NA**

NA = Not Applicable. TIM = Operating Time-in-Mode.
Bold font = suggested default GSE fleet mix and TIM.
*Cabin service and catering trucks are separate in AEDT. Fuel and hydrant trucks are separate in EDMS. TIM represents average between the two.
**Service Truck includes all service vehicles, including minivan.
***Gate-only observations. Final recommendation for baggage tractors is higher (based on airport size) to account for the time it takes to travel to loading/unloading area. Final recommendation for APUs is higher (based on airport size) to account for taxi-in and taxi-out times.

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
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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ISBN 978-0-309-37493-4
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