AIR QUALITY CRITERIA POLLUTANT EMISSIONS INVENTORY
TASK 2.8
WORKING PAPER – DOCUMENTATION OF ASSUMPTIONS

The emissions inventory was developed for Seattle-Tacoma International Airport (the Airport) sources using the FAA's EDMS Version 5.1.4.1. The purpose of the inventory was to identify existing conditions emissions of criteria pollutants as part of the Sustainable Airport Master Plan (SAMP) and to serve as a baseline for considering various strategies to achieve the Port of Seattle's air quality goals and objective. EDMS was used, as at the time the study began, it was the FAA's state-of-the-art emissions model and is required when assessing aviation emission sources at Airports.[1] It recognized by the U.S. Environmental Protection Agency (USEPA) as the preferred tool for modeling aircraft emissions.

EDMS was used to estimate emissions from non-road mobile sources, such as, aircraft engines, auxiliary power units, ground support equipment, ground access vehicles, training fires, and stationary sources, such as generators, commercial kitchens, cooling towers, boilers, and bulk liquid storage tanks. For this evaluation, detailed airport activity characteristics were collected to model each of these sources. Relative to what is typically the dominant airport source (aircraft), data was collected and incorporated into EDMS details on types of aircraft, engine combinations, number of landing and takeoffs (LTOs), and the operating time in each of the LTOs modes (takeoff, climbout, taxi-idle, startup, and approach).

The purpose of this paper is to supplement the Protocol document that was prepared before the analysis was initiated, but documenting the assumptions that produced the results to be used as the existing conditions in the SAMP.

1. METHODOLOGY

LeighFisher (LFA) collected data concerning each of the airport sources for inclusion in the EDMS model. This data reflects the sources of emissions and the general activity associated with those sources (such as number of sources, engines, fuel types, and run times). EDMS has an internal database of emission factors for Airport pollutant sources for most criteria air pollutants. These emission factors are typically in units of mass per unit of time or distance (e.g., grams/ second, or grams/mile). The EDMS database of emission factors reflects differences in emissions based on fuel type, fuel burn, engine power load, manufacture year, and manufacturer, among many other characteristics.

These emission factors are used by EDMS to calculate a total estimated emission inventory for a specified time period by multiplying the emission factor for the particular source, by the operating time, distance traveled, or number of events input by the user. The result is the estimated total emissions for each source group and ultimately total estimated emissions for the study period.

Airport-specific information, such as latitude and longitude coordinates of the official Airport Reference Point (ARP) and elevation of the ARP above sea level are provided within the EDMS structure for each of the National Plan of Integrated Airport (NPIAS) airports. All other Airport-specific information must be collected

[1] After initiation of the SAMP, the FAA released the Aviation Environmental Design Tool (AEDT) Version 2b for use in preparing airport air quality analyses. Because the study was scoped for EDMS, and initiated before the release of AEDT, EDMS was used. It is anticipated that the two models would produce similar results.

and manually entered into the program. EDMS, however, includes default information for some conditions. Where default data was used in this analysis, it is noted.

To estimate emissions from aircraft sources, a series of data inputs is needed, which include number of aircraft operations, aircraft operations by fleet mix, aircraft engine type equipage, and aircraft operating times.

Standard weather data includes mixing height and temperature as discussed below.

Mixing Height

The mixing height is the height of vertical mixing of the atmosphere and particles above the ground. Warm air at the surface of the Earth rises at a given rate. As long as the air is warmer than the ambient temperature, it will continue to rise. However, once the air cools, it slows down and eventually stops rising. It is at this junction that determines the mixing height. The default mixing height value in EDMS of 3,000 feet was used.

Temperature

Daily averages of the maximum, minimum, and mean temperatures for the annual and ozone season are the standard weather inputs for EDMS. Temperature data provided by the National Climate Data Center (NCDC), a division of National Oceanic and Atmospheric Administration were used as the EDMS temperature inputs for the emissions inventory. NCDC Climate "Normals" data were collected in 30-year increments. The period of 1981 to 2010 was used in EDMS model. The annual daily temperature was determined to be 52 degrees Fahrenheit (°F) with an average daily high temperature of 63.25 °F and an average daily low temperature of 41.65 °F.

2. EMISSION SOURCES

Emissions at the Airport were modeled for the following sources:

1. Aircraft Engines
2. Auxiliary Power Units (APUs)
3. Ground Support Equipment (GSE) including the Port's fleet vehicles
4. Stationary Sources
5. Parking Traffic
6. Roadway Traffic

It is important to note that fire training is not conducted at Sea-Tac Airport, and thus, no fire training emissions are reported.

2.1. AIRCRAFT ENGINES

Emissions from aircraft engines are related to the combustion of aircraft fuel. The emissions from the aircraft engines vary depending on the number of aircraft operations, aircraft type, engine type, and operating time in each of the modes of operation.

LFA used the following sources to obtain data on aircraft operations:

- **FAA Traffic Control Tower records** (providing total aircraft operations by FAA categories of activity).

- **Port of Seattle Airport Statistics** (https://www.portseattle.org/About/Publications/Statistics/Airport-Statistics/Pages/default.aspx providing total annual aircraft operations).
- **The Official Airline Guide (OAG)** – providing scheduled air carrier activity by company, time of day, and general aircraft type (LFA has a subscription to electronic form)
- **The Port of Seattle's Aircraft Noise & Monitoring System records** (ANOMS): provided by the Port's noise office, this data was for the period January 1, 2014 to December 31, 2014. The data contained information about each flight, time of day, airline, and aircraft.
- **FAA Aviation System Performance Metrics (ASPM)**: providing total aircraft operations by month and taxi-idle-delay time. (electronic form: https://aspm.faa.gov/apm/sys/)
- **JP Airline Fleets International** (JP Fleets), 2013-14 Edition: LFA maintains a subscription to this publication which identifies the fleet of each airline and the engines used by that company.
- For aircraft types that are not documented in JP Airline Fleet, LFA used the following sources to identify the type of aircraft and engines associated with that aircraft:
    - ***Jane's All the World's Aircraft*** annual publication: LFA maintains a subscription to Jane's.
    - ***Jane's Encyclopedia of Aviation***, 2011-2012 Edition
    - **FAA Registry** (http://registry.faa.gov/aircraftinquiry/): From the ANOMS, if aircraft were identified by the N number, and a specific engine not known, the FAA database was consulted to determine if it provided additional insight about the aircraft.

Total annual aircraft operations were obtained from the Port of Seattle Airport Statistics for 2014, which were verified by FAA's ASPM data. The records provide a breakdown of operations into the following categories:

- **Air Carrier**: An aircraft with seating capacity of more than 60 seats or a maximum payload capacity of more than 18,000 pounds carry passengers or cargo for hire or compensation
- **Air Taxi**: An aircraft designed to have a maximum seating capacity of 60 seats or less or a maximum payload capacity of 18,000 pounds or less carrying passengers or cargo for hire or compensation
- **General Aviation (GA)**: Takeoffs and landings of all civil aircraft, except those classified as air carriers or air taxis.
- Military

Table 21 lists the annual aircraft operations data reported by the Port of Seattle by category of operation.

Table 21
NUMBER OF OPERATIONS BY TYPE

OPERATION TYPE	2014 OPERATIONS	% of Annual
Air Carrier	325,425	95.6%
Air Taxi	10,813	3.2%
General Aviation	4,113	1.2%
Military	127	<0.1%
Total 2014 Operations	**340,478**	**100%**

Source: Port of Seattle, Sea-Tac International Airport Passenger, Cargo and Operations Summary for December 2014 Note: percentages may not add due to rounding.
https://www.portseattle.org/About/Publications/Statistics/Airport-Statistics/Pages/default.aspx (see December 2014 report for year to date 2014)

2.1.1.Aircraft Operation Types

Once the total number of aircraft operations were identified, LFA assigned the operations according to the aircraft fleet mix, an understanding of the various categories of activity can improve the assignment of fleet mix. From the data in **Table 21**, it was not possible to identify All-Cargo operations. Therefore, other sources of that data were to separately capture that activity and associated fleet mix. Therefore, the activity was then categorized by the following: (1) Commercial, (2) Cargo, (3) GA, and (4) Military.

To determine the number of Commercial and Cargo aircraft operations, the Port of Seattle statistics reports of annual aircraft landings for 2014 were used to determine the percent of Commercial landings versus All-Cargo landings for 2014. Using Port data, it was determined that 98.5% of aircraft landings were commercial aircraft operations, and 1.5% were all-cargo aircraft operations. Commercial and All-cargo aircraft operations include both Air Carrier and Air Taxi operations. The sum of Air Carrier and Air Taxi operations (336,238 operations, from **Table 22)** were multiplied by the respective percent of aircraft landings to determine annual Commercial and Aircraft operations.

Table 22
NUMBER OF LANDINGS BY OPERATOR TYPE

TYPE	NUMBER OF OPERATORS	NUMBER OF LANDINGS	PERCENT OF LANDINGS	TOTAL OPERATIONS
Commercial	39	164,003	98.5%	331,301
All-Cargo	17	2,444	1.5%	4,937
	Total	**166,447**		**336,238**

Source: Port of Seattle, Sea-Tac International Airport Passenger, Cargo, and Operations Summary for December 2014, and LeighFisher, 2016. (total landing by airline) May not add due to rounding

Commercial LTOs were calculated by multiplying “Total Operations” numbers by the fleet mix data provided by ANOMS. The calculated fleet mix for each operation type is provided in **Table A1-2**. Commercial aircraft

LTOs and Remain-Over-Night operations (RONs) that were used as EDMS inputs are shown in **Table A2-1**.

Cargo aircraft LTOs were organized by aircraft type and by count of cargo operations, as provided by ANOMS data to generate a fleet mix. The aircraft LTOs were calculated by multiplying the count of operations by the calculated fleet mix for each aircraft type. The calculated cargo aircraft fleet mix is provided in **Table A1-3.** Cargo aircraft LTOs that were used as EDMS inputs are shown in **Table A2-2.**

The annual LTOs for GA operations were organized by aircraft type and by count of GA operations, as provided by ANOMS to generate a fleet mix. The aircraft LTOs were calculated by multiplying the count of operations by the calculated fleet mix for each aircraft type. The calculated cargo aircraft fleet mix is provided in **Table A1-4.** GA aircraft LTOs that were used as EDMS inputs are shown in **Table A2-2**.

The annual LTOs for Military Aircraft operations were generated in the same fashion as General Aviation and Cargo aircraft LTOs were generated. There was only one operation type for Military aircraft operations. Thus, a fleet mix was not calculated. The EDMS inputs are shown in **Table A2-3.**

2.1.2.Fleet Mix

Once the annual number of aircraft operations by operation types was identified, the next step was to identify the aircraft type or fleet mix associated with those aircraft operations. The Port's ANOMS data was used as it identifies the aircraft type using a three letter code (i.e., 739 for Boeing 737-900). The ANOMS system obtains its data from the FAA's Air Traffic Control System which obtains such information from the aircraft transponder, which is used to control activity arriving to and from the Airport, and thus, is viewed as having the greatest accuracy.

LFA conducted a spot check of the ANOMS data using the OAG to verify the ANOMS data was an accurate representation by comparing the air carrier and air taxi operations. As shown in **Table A1-1**, the similar fleet mixes from the OAG and ANOMs databases provide confidence in the ANOMS data. The LFA Team decided to use the ANOMS data for the fleet mix as it contains GA and Military operations, whereas OAG does not is OAG data is limited to scheduled operations.

Table A1-3 shows the full commercial aircraft fleet mix. The GA and Military aircraft fleet mix was determined by matching ANOMS data with *Jane's Encyclopedia of Aviation (2011-2012 Edition)* to determine aircraft types that operate at the Airport. This is necessary, as for the smaller and slower performing aircraft, the transponder data/FAA Radar data captured by the ANOMS system uses broader categories of aircraft, rather than specific aircraft.

Aircraft operations were also categorized by airline, and then by aircraft types using ANOMS data to provide a more detailed and tailored fleet mix to the commercial airlines.

Summary of steps: the following steps were taken to identify aircraft operations by aircraft fleet mix:

1. Obtain number of operations by operation category: Air Carrier, Air Taxi, General Aviation, and Military (Table 2-1) (Data from Port's activity statistics page for year end 2014)
2. Downloaded each month activity statistics from the Port "Landings by Airline by Aircraft" and summarized those landings by all-cargo operators (FedEx, BX, CargoLux, etc) in order to identify the cargo operations. From this annual summary, LFA identifying a number of landings as a percentage of total landings for cargo so that these aircraft types could be identified. See spreadsheet

SEA_2014_Total_Operations.xls which was used to produce Table 2-2.

3. The commercial aircraft fleet mix was determined by multiplying the Commercial “Total Operations” number in Table 2-2 with the % fleet mix from Table A1-2 (ANOMS fleet mix “% of fleet”).
4. Because APU use differs for aircraft assigned to a gate versus a remain overnight (RON) position, commercial aircraft that would use a RON were identified. RON use was estimated per carrier based on spreadsheet (SEA_2014_PCAirData.xls). This distribution of operations is shown in Table A2-1.
5. The Cargo aircraft fleet mix was calculated by multiplying the Cargo “Total Operations” number in Table 2-2 with the ANOMS fleet mix.
6. The General Aviation Fleet and Military mix was calculated by multiplying the number of GA operations by the ANOMS fleet mix for GA operations.

2.1.3.Aircraft Engine Types

To assign engine types to each operation, LFA used the 2013-2014 edition of JP Fleets, which contains engine type information for each airline, air taxi, large non-commercial government, and corporate operator. If an aircraft category/airline/aircraft type operating at the Airport is found to have more than one engine type match in JP Fleets, the LFA Team assigned an engine type based on the proportional distribution of known engine types for that aircraft category/airline/aircraft type operating at the Airport.

For example, as shown in **Table A1-3** for an American Airlines (AA) flight with a Boeing 737-900, the data from JP Fleets indicate that there are two engine types used approximately 50% of the time: CFM CFM56-7B24 and CFM CFM56-7B27. The ANOMS data indicates that this flight represents 12% of the fleet. Thus, it is considered that there is one AA operation type with a Boeing 737-900 and a CFM CFM56-7B24 engine representing 6% of the fleet (half of the 12%), and another AA operation type with a Boeing 737-900 and a CFM CFM56-7B27 representing 6% of the fleet.

2.1.4.Aircraft Operating Times

Figure 1 below illustrates the modes of the LTO Cycle. There are six phases of the aircraft landing-takeoff (LTO) cycle that can be classified as either ground mode or the airborne mode. The ground mode includes taxi-in, taxi-out, and startup. The airborne mode includes takeoff, climb out, and approach.

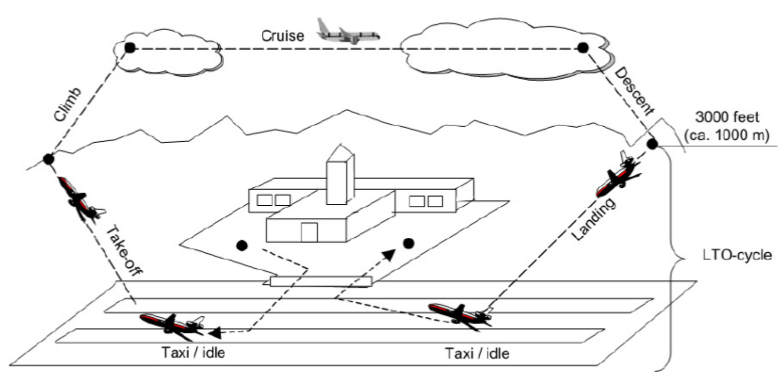

FIGURE 1 - ILLUSTRATION OF THE LTO CYCLE

EDMS default times were used for: takeoff, climbout, approach, and startup. For Taxi-Idle-delay, data from the ASPM was used for 2014. Whereas the default data in EDMS is 26 minutes (taxi-in/out combined), the

ASPM data for Sea-Tac showed: 21.51 minutes as taxi-in and out.[2]

2.2.AUXILIARY POWER UNITS

Emissions generated by auxiliary power units (APUs) occur when an aircraft is taxiing from the runway and/or parked: (1) at the gate, (2) at a cargo ramp, and (3) at a maintenance ramp or hangar. To acquire the most accurate information for use in estimating aircraft APU emissions, LFA collected data from the Port on the availability of electric ground power units (GPUs) and pre-conditioned air (PCA) units at each of the Passenger gates. All Passenger gates at the Airport have available ground power and PCA, and thus are not required to use APUs during the substantial portion of their time at the gate.

Because of this variability, APU usage times were determined by airline-specific factors, using data collected by Port staff. The Port data resulted in the following APU use times:

1. *Alaska Airlines, Horizon Air, Southwest Airlines, United Airlines:* APUs are used 7 minutes per operation, or 3.5 minutes per arrival or departure.
2. *Delta Airlines, U.S. Airways, Virgin America, JetBlue Airways, EVA Air:* APUs are used for 50% of OAG-scheduled gate occupancy time.
3. *All other airlines not indicated above:* APUs are used for 100% of the OAG-schedule gate occupancy time (i.e., APUs are never turned off as aircraft are not connected to ground power and PCA units).

To determine actual gate occupancy times, LFA used proprietary software for flight linking based on OAG schedules, which provides substantially more accurate gate use time values than EDMS default values. These APU usage times were assumed to apply to RON operations.

The default EDMS APU type for each Commercial and Cargo aircraft type were used and *Jane's All the World's Aircraft* will be used as a cross reference to verify if there are any aircraft with no APU features.

GA and Military aircrafts typically do not occupy passenger gates, but the aircrafts may be equipped with APUs. Because default EDMS APU assignments are not available for the GA and Military aircraft types, the APU with the lowest horsepower rating was selected. For GA and Military aircrafts, the GTCP 36-100 and the GTCP 85 (200 HP) APUs were selected, respectively. EDMS default APU operating times of 90 minutes per operation were used.

The list of APU usage times for Commercial, Cargo, General Aviation and Military operations are given in **Tables A2-4 through A2-7** respectively.

2.3.GROUND SUPPORT EQUIPMENT

Ground support equipment (GSE) encompasses all equipment that is needed to service aircraft and the airport on the ground during a normal turn- around and generally includes the following primary types of equipment:

- **Baggage Tractors** transfer passenger baggage and some cargo to/from gates. The baggage

[2] FAA ASPM data for the year 2014. https://aspm.faa.gov/apm/sys/ (see spreadsheet – (2014 ASPM Data.xls)

tractor is the most recognizable type of GSE at an airport. These vehicles are used to transport luggage, mail, and cargo between an aircraft and the airport terminal and/or processing/sorting facilities.

- **Belt Loaders** load and unload baggage and cargo into/from an aircraft.
- **Provision Trucks**, or catering trucks, are used to deliver food, drinks, and other supplies to aircraft while on the ground. These trucks tend to be powered by large diesel engines and have lifts in the back to move the storage compartment to the height of the aircraft. These trucks are also usually owned by airlines and/or flight kitchens.
- **Pushback Tractors** maneuver aircraft away from (i.e., out of) gates. Although an aircraft's engines are capable of moving an aircraft in reverse, this is not typically done for aircraft with jet engines due to the resulting "jet blast" that would occur on the ramp.
- **Deicer Trucks** spray hot liquid on to aircraft in inclement weather to remove ice buildup and prevent future accumulation of ice. These trucks typically have: (1) an engine on the front that is used to move the truck and run pumps and lifts, and (2) a rear engine that heats the deicing liquid. Deicing trucks typically carry a 2,000-gallon tank of deicing liquid, and a 100- to 110-gallon diesel fuel tank to run for an eight to 10 hour shift.
- **Lavatory Trucks** and motorized carts are used by airlines to remove restroom waste from aircraft.

It is important to note that this emissions inventory does not list GSE that operate on electric power, as electric GSE are considered to have no criteria pollutant emissions.

Table A2-8 lists the GSE assumptions used in EDMS including GSE type, fuel type, year (age) and population units. The EDMS default values for GSE annual operating times, load factors, and engine horsepower ratings were used.

2.3.1.Modeling Approach

EDMS offers two methods for estimation of GSE emissions, (1) an activity-based method, or (2) a population-based method. With the activity-based method, the model assigns levels of GSE activity per aircraft operation for each aircraft specified in the model. This approach quantifies emissions based on the number of aircraft operations and the GSE typical for each aircraft. In the population-based method, an inventory of equipment is developed and linked with annual hours of usage to calculate an emissions inventory from hourly emissions factors. A population-based method, which provides for a more rigorous and accurate approach to estimating GSE emissions, was used for estimating all GSE at the Airport.

For Port owned GSE which service the airport (also called fleet vehicles), the inventory was provided by Port staff. For non-Port owned GSE, the inventory was provided using data from the Airport Cooperative Research Program (ACRP) field survey in 2012.[3] If any parameter data such as age or fuel type was unavailable, the average or most common parameter was used. If operating data was not available, either EDMS defaults or professional assumptions based on airline industry standards were used.

2.3.2.Modeling Parameters

The following are parameters used as inputs to model GSE-related emissions:

- **Age** refers to the number of years the GSE has been in use since the year it was manufactured.

3 ACRP 02-16: *Airport Ground Support Equipment (GSE) Emission Reduction Strategies, Inventory and Tutorial* (2012) as documented in ACRP Report 78 http://www.trb.org/Main/Blurbs/168172.aspx

Documenting the age of the GSE is important because, as the equipment gets older, the engine can degrade and emit more pollutants. Stricter emission standards over the years have greatly reduced emissions and older equipment was typically manufactured under less stringent emission standards. Additionally, older vehicles are not equipped with up-to-date emission control technologies. If the age of the equipment was unknown, the default EDMS value was used which employs a distribution of ages based on national usage patterns.

- **Horsepower** refers to the power rating of the engine. Generally, as the horsepower increases, the amount of emissions increases. The EDMS default value was used.
- **Average Vehicle Speed** for GSE modeled as on-road vehicles were assigned the default average speed of 10 mph. No off-road GSE were modeled in this inventory.
- **Load Factor**, given as a percentage, refers to the time-weighted average of engine use relative to full power. The EDMS default value was used.
- **Operating Time** refers to the annual utilization time or mileage of the equipment. The EDMS default values were used or the values were derived from known operational data.
- **Fuel Type**: refers to the type of fuel used to operate the equipment. Virtually all GSE are powered by gasoline, diesel, or electric. As noted, emissions from electric-powered GSE were not included in this emissions inventory.

2.4.STATIONARY SOURCES

On-Airport stationary sources of emissions included in this emissions inventory are:

- Generators
- Boilers

These stationary sources are a small percentage of the overall Airport emissions inventory and are unlikely to change significantly from year-to-year. The Port provided run-time hours, horsepower ratings of the generators, and estimated energy used by boilers.

The following are parameters used for modeling boiler-related stationary source emissions:

- **Fuel Type**: refers to the type of fuel used. Boilers are assumed to use natural gas.
- **Type of boiler** refers to the construction of boiler for its intended use (i.e., residential furnace, wall-fired boiler, or tangential boiler), capacity of the boiler (in British Thermal Units (BTU) per hour), and controls for emissions. It is assumed that all boilers are wall-fired with a capacity of less than 100 million BTU per hour and no emissions controls (uncontrolled).
- **1000^3 of cubic meters used**, or million cubic meters used, refers to the energy used by the boiler. The Port provided annual energy usage for boilers in 2014 in therms, which was converted to million cubic meters of natural gas.

The following are parameters used for modeling generator-related stationary source emissions:

- **Fuel Type**: Diesel was chosen for all generator stationary sources.
- **Hours Operated**: The annual run-hours for generators were provided by the Port.
- **Horsepower** is the power rating of the generator's engine. Horsepower ratings for each generator were provided by the Port, and were used to override EDMS default horsepower ratings. It is important to note that EDMS does not allow horsepower rating inputs larger than 1000 HP. Thus, for many generator sources, the horsepower rating was divided in half or in thirds, and were entered into EDMS two or three times, respectively, in order to simulate the emissions of a generator with a

horsepower rating greater than 1000 HP. A generator inventory list is provided in **Table A15**.

The EDMS inputs for boilers and generators are provided in **Tables A2-9 and A2-10**, respectively.

2.5.PARKING TRAFFIC

Vehicular traffic at the only on-Airport multi-story parking garage, "Main Garage", was modeled. The emissions were modeled in EDMS assuming vehicular traffic consisted of gasoline-powered light duty vehicles, which include automobiles, sport utility vehicles, and pickup trucks. LFA also used Vissim,[4] a traffic modeling tool, to model traffic flows and obtain assumptions for average vehicle speed, distance travelled, idle time, and traffic volumes. The Vissim data ensured that the data used in the emissions inventory was consistent with that used in other parts of the traffic analysis for the SAMP.

The following inputs were used in EDMS to model emissions from Main Garage traffic:

- **Vehicle type**: Light-duty passenger vehicles, gasoline-powered. This vehicle conservatively represents the average vehicle accessing the garage, capturing SUVs, pickups, and sedans that are fueled by unleaded gasoline, diesel, or electric.
- **Average vehicle age**: 7 years. (Source: Port of Seattle)
- **Average vehicle speed**: 5 miles per hour (mph). (Source: Vissim model)
- **Vehicle idle time**: 1.5 minutes (Source: Vissim model)
- **Distance traveled** by each vehicle: 1,548.08 meters, or the equivalent of a passenger vehicle driving up four helices (curved ramps that feed each floor of the garage) in the parking structure. (Source: Vissim model)
- **Traffic volumes**: 2,085,676 vehicles annually (Source: Vissim model)

2.6. ROADWAY TRAFFIC

LFA modeled emissions from all roadway-related activity that occurs within the Airport boundary (i.e., on-Airport roadways). On-Airport roadway traffic includes emissions from all motor vehicle activities, including that of private vehicles, commercial vehicles, and Airport-operated ground transportation vehicles and access vehicles that service roadways.

The emissions inventory includes emissions from the following roadway vehicular traffic:

- Passenger cars (including rental cars)
- Taxicabs
- Limousines
- Rental shuttle/buses
- Hotel shuttles
- Parking shuttles
- Airline/Airport employee shuttles
- Charter/Public Buses
- Shared-ride Vans

[4] Vissim is a multi-modal traffic flow simulation software system used to simulate traffic conditions on roadways.

- Airporters
- Service/Delivery Vehicles

Emissions from roadway traffic are a product of traffic volumes (number of vehicles accessing the Airport), emissions factors (default EDMS emission factors were used), vehicle miles travelled (VMT), and speed. LFA used results from the Airport's Vissim model to estimate annual VMT and average speed at Airport roadways.

The Vissim model, which simulates on-Airport roadways for a 24-hour period during the Airport's peak month (July), was developed through consultation with (1) PSRC (the metropolitan planning organization for the Puget Sound Region, (2) Washington State Department of Transportation, (3) Port staff for relevant roadway traffic studies and counts and (4) daily traffic counts collected for the SAMP inventory. To convert the 24-hour VISSIM results to an estimate of annual VMT, LFA calculated total traffic volumes (as counted by traffic cameras) entering the Upper Drive, Lower Drive, and Main Garage. The volume was divided by 31 to establish an average day in July. The annual volume total was then divided by the average day in July to calculate the annual ratio. The annual ratio was multiplied by the VISSIM 24-hour results to estimate the annual VMT. Additionally, average vehicle speed was calculated from the average of two years' of simulated roadway traffic. Assumptions about the vehicle average age and fuel type were provided by Port staff.

Most of the roadway traffic was assumed to be powered by diesel or gasoline fuel. The Port specified some roadway types as powered by compressed natural gas (CNG) and propane. For CNG-powered vehicles, custom emission factors were used in place of default EDMS emission factors whereas all other fuel type emission factors assumed EDMS default. For CNG, emission factors were calculated based on the FAA's Voluntary Airport Low Emission (VALE) Technical Report,[5] which provides CNG emission factors for carbon monoxide (CO), particulate matter (PM), nitrous oxides (NOx), and nonmethane hydrocarbons (NMHC). Conversion factors to EDMS emission factor units (grams per mile) were by the USEPA, Energy Information Agency (EIA), and Department of Energy (DOE) conversion factors. Specifically, brake specific fuel consumption (BSFC) and fuel densities of gasoline,[6] fuel density of CNG,[7] and fuel economies[8] were used to calculate conversions.

Propane, or liquefied propane gas (LPG) vehicles were modeled as gasoline-powered vehicles, due to their similar emissions and limited availability of emissions comparisons between gasoline- and LPG-powered vehicles.

The results of the Vissim model and EDMS inputs are provided in **Table A2-11**. It is important to note that vehicular traffic was modeled on a *per vehicle* basis. The annualized VMT was divided by 1,000 vehicles to model emissions on a per 1,000 vehicle basis.

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5 Federal Aviation Administration, Voluntary Airport Low Emission Program Technical Report Version 7 (Revised December 2, 2010), Table 5-2

6 United States Environmental Protection Agency, EPA420-R-02-005, January 2002, Update Heavy-Duty Engine Emission Conversion Factors for MOBILE6

7 According to the EIA, CNG has a fuel density about 38% less than gasoline. https://www.eia.gov/todayinenergy/detail.cfm?id=14451

8 The US Department of Energy estimates that CNG-powered vehicles achieve approximately the same fuel economy as a conventional gasoline vehicle, http://www.afdc.energy.gov/fuels/natural_gas_basics.html

3. EMISSIONS INVENTORY FOR 2014

Table 3-1 summarizes the criteria pollutant emissions for all sources in the year 2014 at the Airport. Criteria pollutants are NO_x, volatile organic compounds (VOCs), CO, particulate matter with aerodynamic diameters equal to or less than 2.5 micrometers ($PM_{2.5}$) or 10 micrometers (PM_{10}), sulfur oxides (SO_x) and lead. Because very little AvGas, the only fuel that contains lead, is dispensed at Sea-Tac, the evaluation did not include consideration of lead emissions.

Table 31

CRITERIA POLLUTANT EMISSION INVENTORY, 2014

	SHORT TONS OF POLLUTANTS (2014)						
EMISSION SOURCE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
Aircraft Engines	1,623	242	1,329	158	8	8	3,395
APUs	72	5	48	9	22	22	149
GSE	307	78	2,292	21	20	19	2,738
Stationary Sources	17	1	12	0	22	23	34
Parking	1	2	36	0	1	1	39
Ground Transport	32	19	462	2	1	0	516
Total	**2,052**	**347**	**4,178**	**54**	**53**	**187**	**6,871**

Source: LeighFisher, 2016

APPENDIX A: SUPPORTING DATA

Table A1-1

AIRCRAFT FLEEX MIX AND DATA SOURCE COMPARISON - 2013

OAG Aircraft Type	2013 ANOMS Aircraft Type	OAG %	2013 ANOMS %
DE HAVILLAND DHC-8-400	DH8D	24.86%	25.37%
BOEING 737-800	B738	19.66%	19.57%
BOEING B-737-700LR	B737	11.32%	11.62%
BOEING B-737-900	B739	8.56%	8.43%
AIRBUS A320-100/200	A320	7.05%	7.14%
BOEING B-737-400	B734	5.99%	6.03%
BOEING B-757-200	B752	4.80%	4.95%
BOEING B-767-300	B763	1.96%	2.09%
BOEING B-737-300	B733	1.77%	1.90%
CANADAIR CRJ-700	CRJ7	1.66%	1.63%
EMBRAER 120 BRASILIA	E120	1.55%	1.55%
AIRBUS A319	A319	1.40%	1.44%
DE HAVILLAND DHC-8-300	DH8C	1.17%	1.15%
CESSNA 208	C208	1.09%	0.54%
CANADAIR CRJ-200ER	CRJ2	0.91%	0.70%
AIRBUS INDUSTRIE A321	A321	0.87%	0.80%
BOEING B-777-200/200LR/233LR	B772	0.77%	0.46%
AIRBUS INDUSTRIE A330-200	A333	0.75%	0.85%
BOEING B-757-300	B753	0.73%	0.76%
BOEING B-747-400	B744	0.64%	0.83%
DOUGLAS MD-11	MD11	0.51%	0.01%
BOEING B-747F	B77W	0.41%	0.15%
CANADAIR CRJ-900	CRJ9	0.36%	0.44%
AIRBUS A300-600	A306	0.32%	0.01%
ERJ-190 -EMBRAER 190	E190	0.32%	0.31%
DOUGLAS DC-10-30	DC10	0.21%	0.01%
BOEING B-767-200	B762	0.01%	0.00%
AIRBUS INDUSTRIE A340-300	A343	0.01%	0.01%
BOEING B-767-400	B764	0.01%	0.02%
BOEING B-737-500	B735	0.01%	0.01%
Other	Other	0.33%	1.23%

Source: Federal Aviation Administration, Airport Noise and Operations Monitoring System (ANOMS) and Official Airline Guide (OAG)

Table A12

COMMERCIAL AIRCRAFT FLEET MIX GENERATED FROM ANOMS DATA (2014)

Airline	Aircraft Type	Total
ASA	B738	11.91%
ASA	B739	8.56%
ASA	B734	5.97%
ASA	B737	4.28%
ASA	A320	0.01%
ASA	DH8D	0.01%
QXE	DH8D	23.82%
QXE	B739	0.01%
DAL	B752	2.67%
DAL	B738	1.72%
DAL	B763	1.36%
DAL	B739	0.83%
DAL	B753	0.61%
DAL	A332	0.51%
DAL	A333	0.42%
DAL	A320	0.42%
DAL	A319	0.08%
DAL	B772	0.06%
DAL	MD90	0.02%
DAL	B744	0.01%
SWA	B737	4.82%
SWA	B733	1.72%
SWA	B738	0.87%
SWA	B735	0.01%
UAL	A320	1.79%
UAL	B739	1.73%
UAL	B738	1.14%
UAL	A319	0.83%

Table A12

COMMERCIAL AIRCRAFT FLEET MIX GENERATED FROM ANOMS DATA (2014)

Airline	Aircraft Type	Total
UAL	B752	0.78%
UAL	B737	0.11%
UAL	B753	0.02%
UAL	B772	0.01%
UAL	B763	0.01%
SKW	CRJ7	3.13%
SKW	CRJ9	1.71%
SKW	E120	0.81%
SKW	CL60	0.22%
SKW	CRJ2	0.07%
AAL	B738	2.90%
AAL	B752	0.30%
CPZ	E170	2.21%
AWE	A320	1.24%
AWE	A321	0.81%
AWE	A319	0.08%
AWE	B752	0.01%
VRD	A320	0.99%
VRD	A319	0.51%
JBU	A320	1.37%
JZA	DH8C	1.12%
JZA	CRJ2	0.07%
JZA	CRJ9	0.07%
JZA	DH8D	0.01%
FFT	A320	0.53%
FFT	A319	0.28%
CFS	C208	0.63%
HAL	A332	0.42%
SCX	B738	0.18%

Table A12

COMMERCIAL AIRCRAFT FLEET MIX GENERATED FROM ANOMS DATA (2014)

Airline	Aircraft Type	Total
SCX	B737	0.16%
BAW	B772	0.14%
BAW	B744	0.13%
BAW	B77W	0.05%
ACA	E190	0.30%
KAL	B772	0.15%
KAL	B744	0.09%
KAL	B77L	0.05%
KAL	B77W	0.01%
AAR	A333	0.17%
AAR	B744	0.11%
UAE	B77W	0.17%
UAE	B77L	0.04%
ANA	B788	0.21%
EVA	B744	0.17%
EVA	B77W	0.03%
ICE	B752	0.20%
DLH	A333	0.11%
DLH	A343	0.08%
CHH	B788	0.10%
CHH	A332	0.05%
CAL	B744	0.15%
EJA	C750	0.03%
EJA	C56X	0.02%
EJA	C680	0.02%
EJA	GALX	0.01%
EJA	F2TH	0.01%
EJA	H25B	0.01%
EJA	C560	0.01%

Table A12

COMMERCIAL AIRCRAFT FLEET MIX GENERATED FROM ANOMS DATA (2014)

Airline	Aircraft Type	Total
OAE	B763	0.09%
NWA	A332	0.04%
NWA	A333	0.01%
CFG	B763	0.05%
AAY	MD83	0.01%
RPA	E190	0.01%
AMX	B738	0.004%
KFS	B722	0.001%
BSK	B738	0.001%
NRL	B732	0.001%
BOE	B763	0.0003%
TSC	B737	0.001%
SIA	A321	0.001%

Source: Federal Aviation Administration, Airport Noise and Operations Monitoring System (ANOMS).

Note: ASA = Alaska Airlines, QXE = Horizon Air, DAL = Delta Airlines, SWA = Southwest Airlines, UAL = United Airlines, SKW = SkyWest Airlines, AAL = American Airlines, CPZ = Compass Airlines, AWE = US Airways, VRD = Virgin America, JBU = JetBlue Airways, JZA = Jazz Aviation LP, FFT = Frontier Airlines, CFS = Empire Airlines, HAL = Hawaii Airlines, SCX = Sun Country Airlines, KAL = Korean Air, BAW = British Airways, ACA = Air Canada, AAR = Asiana Airlines, UAE = Emirates Airlines, ANA = All Nippon Airways, EVA = EVA Air, ICE = Iceland Air, DLH = Lufthansa, CHH = Hainan Airlines, CAL= China Airlines, OAE=Omni Air, CFG = Condor, AAY = Allegiant Air, RPA = Republic Airlines, AMX = Aeromexico, KFS = Kalitta Charters, BSK = Miami Air Internatioinal/Quest Cargo International, NRL = Nolinor Aviation, BOE = Boeing, TSC = Energjet, SIA = Singapore Airlines

Note: Data on Singapore Airlines was not provided by ANOMS. Data was provided by the Port of Seattle.

Table A12

COMMERCIAL AIRCRAFT FLEET MIX BY AIRLINE AND AIRCRAFT TYPE (2014)

AIRLINE	AIRCRAFT TYPE	ENGINE TYPE	ANOMS FLEET MIX (%)	ENGINE SPLIT	% OF FLEET
ASA	Boeing 737-890 (w)	CFM CFM56-7B24	11.9%	50%	6.0%
ASA	Boeing 737-890 (w)	CFM CFM56-7B27	11.9%	50%	6.0%
ASA	Boeing 737-990ER	CFM CFM56-7B26	8.6%	50%	4.3%
ASA	Boeing 737-990 (w)	CFM CFM56-7B24	8.6%	50%	4.3%
ASA	Boeing 737-490	CFM CFM56-3C1	6.0%	100%	6.0%
ASA	Boeing 737-790 (w)	CFM CFM56-7B22	4.3%	50%	2.2%
ASA	Boeing 737-790 (w)	CFM CFM56-7B24	4.3%	50%	2.2%
QXE	Bombardier Dash 8-402Q	PWC PW150A	23.8%	100%	23.9%
DAL	Boeing 757-232	PW PW2037	2.7%	100%	2.7%
DAL	Boeing 737-832 (w)	CFM CFM56-7B26	1.7%	100%	1.7%
DAL	Boeing 767-332	GE CF6-80A2	1.4%	40%	0.5%
DAL	Boeing 767-332ER (w)	GE CF6-80C2B6	1.4%	40%	0.5%
DAL	Boeing 767-332ER (w)	PW PW4060	1.4%	20%	0.3%
DAL	Boeing 737-990ER	CFM CFM56-7B26	0.8%	100%	0.8%
DAL	Boeing 757-351	PW PW2043	0.6%	100%	0.6%
DAL	Airbus A330-223	PW PW4168	0.5%	100%	0.5%
DAL	Airbus A330-323	PW PW4168	0.4%	100%	0.4%
DAL	Airbus A320-212	CFM CFM56-5A3	0.4%	100%	0.4%
DAL	Airbus A319-114	CFM CFM56-5A5	0.1%	100%	0.1%
DAL	Boeing 777-232ER	RR Trent 895	0.1%	100%	0.1%
DAL	McDonnell Douglas MD-90-30	IAE V2525-D5	0.0%	100%	0.0%
SWA	Boeing 737-7H4 (w)	CFM CFM56-7B22	4.8%	100%	4.8%
SWA	Boeing 737-3H4 (w)	CFM CFM56-3B1	1.7%	50%	0.9%
SWA	Boeing 737-3L9	CFM CFM56-3B2	1.7%	50%	0.9%
SWA	Boeing 737-8H4 (w)	CFM CFM56-7B26	0.9%	100%	0.9%

Table A12

COMMERCIAL AIRCRAFT FLEET MIX BY AIRLINE AND AIRCRAFT TYPE (2014)

AIRLINE	AIRCRAFT TYPE	ENGINE TYPE	ANOMS FLEET MIX (%)	ENGINE SPLIT	% OF FLEET
SWA	Boeing 737-5H4	CFM CFM56-3C1	0.0%	50%	0.0%
SWA	Boeing 737-5H4	CFM CFM56-3B1	0.0%	50%	0.0%
UAL	Airbus A320-232	IAE V2527-A5	1.8%	100%	1.8%
UAL	Boeing 737-924ER	CFM CFM56-7B26	1.7%	100%	1.7%
UAL	Boeing 737-824 (w)	CFM CFM56-7B26	1.1%	100%	1.1%
UAL	Airbus A319-131	IAE V2522-A5	0.8%	100%	0.8%
UAL	Boeing 757-222	PW PW2037	0.8%	100%	0.8%
UAL	Boeing 737-724 (w)	CFM CFM56-7B24	0.1%	100%	0.1%
UAL	Boeing 757-324 (w)	RR RB211-535E4	0.0%	100%	0.0%
UAL	Boeing 777-222ER	PW PW4090	0.0%	100%	0.0%
SKW	Bombardier CRJ-701ER	GE CF34-8C5	3.1%	100%	3.1%
SKW	Bombardier CRJ-900ER NG	GE CF34-8C5	1.7%	100%	1.7%
SKW	Embraer EMB-120 Brasilia ER	PWC PW118	0.8%	100%	0.8%
SKW	Bombardier CRJ-200LR	GE CF34-3B1	0.3%	100%	0.3%
AAL	Boeing 737-823 (w)	CFM CFM56-7B26	2.9%	100%	2.9%
AAL	Boeing 757-223 (w)	RR RB211-535E4	0.3%	100%	0.3%
CPZ	Embraer 175-LR	GE CF34-8E5	2.2%	100%	2.2%
AWE	Airbus A320-231 0317	IAE V2500-A1	1.2%	100%	1.3%
AWE	Airbus A321-231	IAE V2527-A5	0.8%	100%	0.8%
AWE	Airbus A319-112	CFM CFM56-5B6	0.1%	100%	0.1%
VRD	Airbus A320-214	CFM CFM56-5B4	1.0%	100%	1.0%
VRD	Airbus A319-112	CFM CFM56-5B6	0.5%	100%	0.5%
JBU	Airbus A320-232	IAE V2527-A5	1.4%	100%	1.4%
JZA	Bombardier Dash 8-301	PWC PW123	1.1%	100%	1.1%
JZA	Bombardier CRJ-200ER 7330	GE CF34-3B1	0.1%	100%	0.1%

Table A12

COMMERCIAL AIRCRAFT FLEET MIX BY AIRLINE AND AIRCRAFT TYPE (2014)

AIRLIN_	AIRCRAFT TYPE	ENGINE TYPE	ANOMS FLEET MIX (%)	ENGINE SPLIT	% OF FLEET
JZA	Bombardier CRJ-705LR	GE CF34-8C5	0.1%	100%	0.1%
JZA	Bombardier Dash 8-402 NextGen	PWC PW150A	0.0%	100%	0.0%
FFT	Airbus A320-214	CFM CFM56-5B4	0.5%	100%	0.5%
FFT	Airbus A319-111	CFM CFM56-5B5	0.3%	100%	0.3%
CFS	Cessna 208B Grand Super Cargomaster	PWC PT6A-114A	0.6%	100%	0.6%
HAL	Airbus A330-243	RR Trent 772B-60	0.4%	100%	0.4%
HAL	Boeing 767-33AER (w)	PW PW4060	0.0%	100%	0.0%
SCX	Boeing 737-8BK (w)	CFM CFM56-7B27	0.2%	100%	0.2%
SCX	Boeing 737-73V	CFM CFM56-7B22	0.2%	100%	0.2%
KAL	Boeing 777-2B5ER	PW PW4090	0.2%	100%	0.2%
KAL	Boeing 747-4B5F	PW PW4056	0.1%	50%	0.0%
KAL	Boeing 747-4B5ERF	PW PW4062	0.1%	50%	0.0%
KAL	Boeing 777-FB5	GE GE90-110B1	0.0%	100%	0.0%
KAL	Boeing 777-3B5ER	GE GE90-115B	0.0%	100%	0.0%
BAW	Boeing 777-236ER	GE GE90-85B	0.1%	100%	0.1%
BAW	Boeing 747-436	RR RB211-524H2	0.1%	100%	0.1%
BAW	Boeing 777-336ER	GE GE90-115B	0.1%	100%	0.1%
ACA	Embraer 190-AR	GE CF34-10E5	0.3%	100%	0.3%
AAR	Airbus A330-323	PW PW4168	0.2%	100%	0.2%
AAR	Boeing 747-446SF	GE CF6-80C2B1	0.1%	100%	0.1%
UAE	Boeing 777-31HER	GE GE90-115B	0.2%	100%	0.2%
UAE	Boeing 777-21HLR	GE GE90-110B1	0.0%	100%	0.0%
ANA	Boeing 787-8	RR Trent 1000	0.2%	100%	0.2%
EVA	Boeing 747-45E	GE CF6-80C2B1	0.2%	100%	0.2%
EVA	Boeing 777-35EER	GE GE90-115B	0.0%	100%	0.0%

Table A12

COMMERCIAL AIRCRAFT FLEET MIX BY AIRLINE AND AIRCRAFT TYPE (2014)

AIRLIN_	AIRCRAFT TYPE	ENGINE TYPE	ANOMS FLEET MIX (%)	ENGINE SPLIT	% OF FLEET
ICE	Boeing 757-208 (w)	RR RB211-535E4	0.2%	100%	0.2%
DLH	Airbus A330-343	RR Trent 772B-60	0.1%	100%	0.1%
CHH	Boeing 787-8	GE GEnx-1B64	0.1%	100%	0.1%
CHH	Airbus A330-243	RR Trent 772B-60	0.1%	100%	0.1%
CAL	Boeing 747-409F	GE CF6-80C2B1	0.1%	100%	0.1%
OAE	Boeing 767-319ER	GE CF6-80C2B6	0.1%	100%	0.1%
CFG	Boeing 767-330ER (w)	PW PW4062	0.05%	100%	0.05%
AAY	McDonnell Douglas MD-83	PW JT8D-219	0.01%	100%	0.01%
RPA	Embraer 190-AR	GE CF34-10E6	0.01%	100%	0.01%
AMX	Boeing 737-8Z9 (w)	CFM CFM56-7B27	0.004%	100%	0.004%
KFS	Boeing 727-2M7F Adv	PW JT8D-17	0.001%	100%	0.001%
BSK	Boeing 737-81Q (w)	CFM CFM56-7B26	0.001%	100%	0.001%
NRL	Boeing 737-229QC Adv	PW JT8D-15(NOR3)	0.001%	100%	0.001%
BOE	Boeing 767-33AER	GE CF6-80C2B6	0.0003%	100%	0.0003%
TSC	Boeing 737-73V (w)	CFM CFM56-7B24	0.001%	100%	0.001%
SIA	Airbus A320-214	CFM CFM56-5B4	0.001%	100%	0.001%

Source: LeighFisher; Federal Aviation Administration, Airport Noise and Operations Monitoring System (ANOMS), 2015.

Note: "% of Fleet" refers to methodology described in Section 4.3 Engine Types.

Note: ASA = Alaska Airlines, QXE = Horizon Air, DAL = Delta Airlines, SWA = Southwest Airlines, UAL = United Airlines, SKW = SkyWest Airlines, AAL = American Airlines, CPZ = Compass Airlines, AWE = US Airways, VRD = Virgin America, JBU = JetBlue Airways, JZA = Jazz Aviation LP, FFT = Frontier Airlines, CFS = Empire Airlines, HAL = Hawaii Airlines, SCX = Sun Country Airlines, KAL = Korean Air, BAW = British Airways, ACA = Air Canada, AAR = Asiana Airlines, UAE = Emirates Airlines, ANA = All Nippon Airways, EVA = EVA Air, ICE = Iceland Air, DLH = Lufthansa, CHH = Hainan Airlines, CAL= China Airlines, OAE=Omni Air, CFG = Condor, AAY = Allegiant Air, RPA = Republic Airlines, AMX = Aeromexico, KFS = Kalitta Charters, BSK = Miami Air Internatioinal/Quest Cargo International, NRL = Nolinor Aviation, BOE = Boeing, TSC = Energjet, SIA = Singapore Airlines

Table A1-3

CARGO AIRCRAFT FLEET MIX BY AIRLINE AND AIRCRAFT TYPE (2014)

AIRCRAFT TYPE	OPERATIONS	% OF FLEET
McDonnell Douglas MD-11BCF	1,487	36.9%
McDonnell Douglas MD-10-30AF	946	23.4%
Airbus A300-605R F	472	11.7%
Boeing 757-2B7SF	248	6.1%
McDonnell Douglas MD-10-30F	245	6.1%
Boeing 747-4R7F	176	4.4%
Boeing 767-3Y0ER	174	4.3%
Airbus A300-622R F	149	3.7%
Boeing 777-FS2	84	2.1%
Airbus A310-203F	22	0.5%
Boeing 767-223SF	18	0.4%
Boeing 747-222SF	14	0.3%
Total	**4,035**	

Source: LeighFisher; Federal Aviation Administration, Airport Noise and Operations Monitoring System (ANOMS), 2015.

Table A14

GENERAL AVIATION AIRCRAFT FLEET MIX BY AIRCRAFT TYPE (2014)

AIRCRAFT TYPE	OPERATIONS	% OF FLEET
Dassault Falcon 50	271	17.9%
Piper PA-31 Navajo	177	11.7%
Cirrus SR22	118	7.8%
Gulfstream IV-SP	79	5.2%
Cessna 172 Skyhawk	64	4.2%
Cessma 560 Citation XLS	61	4.0%
Raytheon Hawker 800	60	4.0%
Raytheon Super King Air 300	58	3.8%
Bombardier Challenger 600	45	3.0%
Cessna 550 Citation II	41	2.7%
Bombardier Challenger 300	41	2.7%
Gulfstream V-SP	39	2.6%
Pilatus PC-12	34	2.2%
Cessna 560 Citation V	33	2.2%
Cessma 680 Citation Sovereign	28	1.8%
Cessna 208 Caravan	28	1.8%
Bombardier Learjet 45	26	1.7%
Bombardier Learjet 31	26	1.7%
Dassault Falcon 2000-EX	25	1.7%
Bombardier Learjet 35A/36A	22	1.5%
Dassault Falcon 900-B	22	1.5%
Raytheon Beechjet 400	22	1.5%
Cessna 525 Citationjet	21	1.4%
Bombardier Learjet 60	18	1.2%
Piper PA-47 500TP	16	1.1%

AIRCRAFT TYPE	OPERATIONS	% OF FLEET
Israel IAI-1125 Astra	16	1.1%
Cessna 650 Citation III	15	1.0%
Embrarer EMB120 Brasilia	14	0.9%
Cessna 525 Citationjet	14	0.9%
Cessna 414	13	0.9%
Cessna 750 Citation X	13	0.9%
Convair CV-580	13	0.9%
Gulfstream G200	13	0.9%
Raytheon King Air 90	12	0.8%
Cessna 310	9	0.6%
Raytheon Beech Bonanza 36	7	0.5%
Total Operations	**1,514**	

Source: LeighFisher; Federal Aviation Administration, Airport Noise and Operations Monitoring System (ANOMS), 2015.

Table A15
GENERATOR INVENTORY (2014)

GENERATOR/PUMP	STATIONARY SOURCE	TYPE	ANNUAL OPERATING HOURS	HORSEPOWER RATING (HP)
Airfield Light 1	Generator	Diesel Fuel	122.7	2400
Airfield Light 2	Generator	Diesel Fuel	87.7	2400
Building Lights 1	Generator	Diesel Fuel	4	67
Building Lights 2	Generator	Diesel Fuel	5.2	80
Boiler 3 Generator	Generator	Diesel Fuel	1	380
Concourse A C4	Generator	Diesel Fuel	33	1341
Concourse A Fire	Generator	Diesel Fuel	3.5	240
Concourse A STEP	Generator	Diesel Fuel	2	2012
Parking Garage	Generator	Diesel Fuel	4.4	235
Pump 01	Generator	Diesel Fuel	6.8	412
Pump 02	Generator	Diesel Fuel	6.6	412
Pump 03	Generator	Diesel Fuel	2.6	412
Pump 04	Generator	Diesel Fuel	7.4	412
Pump 05	Generator	Diesel Fuel	4.5	380
Pump 07	Generator	Diesel Fuel	5.6	380
Pump 8	Generator	Diesel Fuel	4.4	380
Toll Plaza	Generator	Diesel Fuel	4.1	503
WWTP	Generator	Diesel Fuel	16.6	165

Source: Port of Seattle, 2015

APPENDIX EDMS INPUTS

Table A21

COMMERCIAL AIRCRAFT OPERATIONS INPUTS IN EDMS (2014)

EDMS ID	AIRCRAFT	ENGINE TYPES	Annual Operations	Annual RONS (2014)
COM - 01	Boeing 737-890 (w)	CFM CFM56-7B24	19,841	2,281
COM - 02	Boeing 737-890 (w)	CFM CFM56-7B27	19,841	2,281
COM - 03	Boeing 737-990ER	CFM CFM56-7B26	14,255	2,373
COM - 04	Boeing 737-990 (w)	CFM CFM56-7B24	14,255	2,190
COM - 05	Boeing 737-490	CFM CFM56-3C1	19,880	2,008
COM - 06	Boeing 737-790 (w)	CFM CFM56-7B22	7,125	365
COM - 07	Boeing 737-790 (w)	CFM CFM56-7B24	7,125	-
COM - 08	Bombardier Dash 8-402Q	PWC PW150A	79,338	-
COM - 09	Boeing 757-232	PW PW2037	8,884	730
COM - 10	Boeing 737-832 (w)	CFM CFM56-7B26	5,729	730
COM - 11	Boeing 767-332	GE CF6-80A2	1,815	146
COM - 12	Boeing 767-332ER (w)	GE CF6-80C2B6	1,815	146
COM - 13	Boeing 767-332ER (w)	PW PW4060	908	73
COM - 14	Boeing 737-990ER	CFM CFM56-7B26	2,773	1,643
COM - 15	Boeing 757-351	PW PW2043	2,032	183
COM - 16	Airbus A330-223	PW PW4168	1,715	548
COM - 17	Airbus A330-323	PW PW4168	1,397	730
COM - 18	Airbus A320-212	CFM CFM56-5A3	1,389	-
COM - 19	Airbus A319-114	CFM CFM56-5A5	252	-
COM - 20	Boeing 777-232ER	RR Trent 895	189	-
COM - 21	McDonnell Douglas MD-90-30	IAE V2525-D5	56	-
COM - 22	Boeing 737-7H4 (w)	CFM CFM56-7B22	16,040	3,285
COM - 23	Boeing 737-3H4 (w)	CFM CFM56-3B1	2,864	-
COM - 24	Boeing 737-3L9	CFM CFM56-3B2	2,864	-
COM - 25	Boeing 737-8H4 (w)	CFM CFM56-7B26	2,905	-
COM - 26	Boeing 737-5H4	CFM CFM56-3C1	13	-
COM - 27	Boeing 737-5H4	CFM CFM56-3B1	13	-

Table A21

COMMERCIAL AIRCRAFT OPERATIONS INPUTS IN EDMS (2014)

EDMS ID	AIRCRAFT	ENGINE TYPES	Annual Operations	Annual RONS (2014)
COM - 28	Airbus A320-232	IAE V2527-A5	5,975	1,825
COM - 29	Boeing 737-924ER	CFM CFM56-7B26	5,753	-
COM - 30	Boeing 737-824 (w)	CFM CFM56-7B26	3,799	183
COM - 31	Airbus A319-131	IAE V2522-A5	2,765	-
COM - 32	Boeing 757-222	PW PW2037	2,610	183
COM - 33	Boeing 737-724 (w)	CFM CFM56-7B24	357	-
COM - 34	Boeing 757-324 (w)	RR RB211-535E4	51	-
COM - 35	Boeing 777-222ER	PW PW4090	42	-
COM - 36	Bombardier CRJ-701ER	GE CF34-8C5	10,411	-
COM - 37	Bombardier CRJ-900ER NG	GE CF34-8C5	5,682	-
COM - 38	Embraer EMB-120 Brasilia ER	PWC PW118	2,685	-
COM - 39	Bombardier CRJ-200LR	GE CF34-3B1	956	-
COM - 40	Boeing 737-823 (w)	CFM CFM56-7B26	9,645	2,190
COM - 41	Boeing 757-223 (w)	RR RB211-535E4	989	365
COM - 42	Embraer 175-LR	GE CF34-8E5	7,372	-
COM - 43	Airbus A320-231 0317	IAE V2500-A1	4,143	183
COM - 44	Airbus A321-231	IAE V2527-A5	2,707	1,095
COM - 45	Airbus A319-112	CFM CFM56-5B6	257	-
COM - 46	Airbus A320-214	CFM CFM56-5B4	3,282	730
COM - 47	Airbus A319-112	CFM CFM56-5B6	1,684	-
COM - 48	Airbus A320-232	IAE V2527-A5	4,566	365
COM - 49	Bombardier Dash 8-301	PWC PW123	3,747	365
COM - 50	Bombardier CRJ-200ER 7330	GE CF34-3B1	248	-
COM - 51	Bombardier CRJ-705LR	GE CF34-8C5	244	-
COM - 52	Bombardier Dash 8-402 NextGen	PWC PW150A	30	-
COM - 53	Airbus A320-214	CFM CFM56-5B4	1,753	-
COM - 54	Airbus A319-111	CFM CFM56-5B5	933	-
COM - 55	Cessna 208B Grand Super Cargo master	PWC PT6A-114A	2,096	-
COM - 56	Airbus A330-243	RR Trent 772B-60	1,410	730
COM - 57	Boeing 767-33AER (w)	PW PW4060	14	-
COM - 58	Boeing 737-8BK (w)	CFM CFM56-7B27	595	-

Table A21

COMMERCIAL AIRCRAFT OPERATIONS INPUTS IN EDMS (2014)

EDMS ID	AIRCRAFT	ENGINE TYPES	Annual Operations	Annual RONS (2014)
COM - 59	Boeing 737-73V	CFM CFM56-7B22	546	-
COM - 60	Boeing 777-2B5ER	PW PW4090	505	-
COM - 61	Boeing 747-4B5F	PW PW4056	148	-
COM - 62	Boeing 747-4B5ERF	PW PW4062	148	-
COM - 63	Boeing 777-FB5	GE GE90-110B1	151	-
COM - 64	Boeing 777-3B5ER	GE GE90-115B	37	-
COM - 65	Boeing 777-236ER	GE GE90-85B	465	-
COM - 66	Boeing 747-436	RR RB211-524H2	420	-
COM - 67	Boeing 777-336ER	GE GE90-115B	168	-
COM - 68	Embraer 190-AR	GE CF34-10E5	1,001	-
COM - 69	Airbus A330-323	PW PW4168	572	183
COM - 70	Boeing 747-446SF	GE CF6-80C2B1	366	-
COM - 71	Boeing 777-31HER	GE GE90-115B	576	-
COM - 72	Boeing 777-21HLR	GE GE90-110B1	120	-
COM - 73	Boeing 787-8	RR Trent 1000	687	-
COM - 74	Boeing 747-45E	GE CF6-80C2B1	566	183
COM - 75	Boeing 777-35EER	GE GE90-115B	106	106
COM - 76	Boeing 757-208 (w)	RR RB211-535E4	661	-
COM - 77	Airbus A330-343	RR Trent 772B-60	378	-
COM - 78	Boeing 787-8	GE GEnx-1B64	334	-
COM - 79	Airbus A330-243	RR Trent 772B-60	171	-
COM - 80	Boeing 747-409F	GE CF6-80C2B1	483	-
COM - 81	Boeing 767-319ER	GE CF6-80C2B6	312	-
COM - 82	Boeing 767-330ER (w)	PW PW4062	155	-
COM - 83	McDonnell Douglas MD-83	PW JT8D-219	40	-
COM - 84	Embraer 190-AR	GE CF34-10E6	38	-
COM - 85	Boeing 737-8Z9 (w)	CFM CFM56-7B27	15	-
COM - 86	Boeing 727-2M7F Adv	PW JT8D-17	3	-
COM - 87	Boeing 737-81Q (w)	CFM CFM56-7B26	4	-
COM - 88	Boeing 737-229QC Adv	PW JT8D-15(NOR3)	4	-
COM - 89	Boeing 767-33AER	GE CF6-80C2B6	1	-

Table A21

COMMERCIAL AIRCRAFT OPERATIONS INPUTS IN EDMS (2014)

EDMS ID	AIRCRAFT	ENGINE TYPES	Annual Operations	Annual RONS (2014)
COM - 90	Boeing 737-73V (w)	CFM CFM56-7B24	2	-
COM - 91	Airbus A320-214	CFM CFM56-5B4	4	-
	TOTAL Commercial OPERATIONS		**331,301**	**289**

Source: LeighFisher, 2015.

Note: Remain Overnight hardstands (RONs) are a subset of total operations. To obtain the number of annual operations without RONs, "Annual RONs" were subtracted from "Annual Operations". In EDMS, an additional RON identifier was added to the "EDMS ID", e.g., "COM-01-RON" was used to indicate RON operations.

Table A22
CARGO AIRCRAFT OPERATIONS INPUTS IN EDMS (2014)

EDMS ID	AIRCRAFT TYPE	ENGINE TYPE	ANNUAL OPERATIONS (2014)
CARGO - 01	McDonnell Douglas MD-11BCF	PW PW4460	1,820
CARGO - 02	McDonnell Douglas MD-10-30AF	GE CF6-50C2	1,157
CARGO - 03	Airbus A300-605R F	GE CF6-80C2A5	578
CARGO - 04	Boeing 757-2B7SF	RR RB211-535E4	303
CARGO - 05	McDonnell Douglas MD-10-30F	GE CF6-50C2	300
CARGO - 06	Boeing 747-4R7F	RR RB211-524H2	215
CARGO - 07	Boeing 767-3Y0ER	GE CF6-80C2B6	213
CARGO - 08	Airbus A300-622R F	PW PW4158	182
CARGO - 09	Boeing 777-FS2	GE GE90-110B1	103
CARGO - 10	Airbus A310-203F	GE CF6-80A3	27
CARGO - 11	Boeing 767-223SF	GE CF6-80A2	22
CARGO - 12	Boeing 747-222SF	PW JT9D-7R4G2	17
	TOTAL CARGO OPERATIONS		**4,937**

Source: LeighFisher, 2015.

Table A22

GENERAL AVIATION AND MILITARY AIRCRAFT OPERATIONS INPUTS IN EDMS (2014)

EDMS ID	AIRCRAFT TYPE	ENGINE TYPE	ANNUAL OPERATIONS (2014)
MIL - 01	Bombardier Global Express	BR700-710A2-20	**127**
TOTAL Military Operations			
GA - 01	Dassault Falcon 50	TFE731-3	736
GA - 02	Piper PA-31 Navajo	TIO-540-J2B2	481
GA - 03	Cirrus SR22	TIO-540-J2B2	321
GA - 04	Gulfstream IV-SP	TAY 611-8C	215
GA - 05	Cessna 172 Skyhawk	IO-320-D1AD	174
GA - 06	Cessma 560 Citation XLS	JT15D-5, -5A, -5B	166
GA - 07	Raytheon Hawker 800	TFE731-3	163
GA - 08	Raytheon Super King Air 300	PT6A-60A	158
GA - 09	Bombardier Challenger 600	CF34-3B	122
GA - 10	Cessna 550 Citation II	PW530	111
GA - 11	Bombardier Challenger 300	AS907-1-1A	111
GA - 12	Gulfstream V-SP	BR700-710C4-11	106
GA - 13	Pilatus PC-12	PT6A-67B	92
GA - 14	Cessna 560 Citation V	PW530	90
GA - 15	Cessma 680 Citation Sovereign	PW306B	76
GA - 16	Cessna 208 Caravan	PT6A0-114A	76
GA - 17	Bombardier Learjet 45	TFE731-2-2B	71
GA - 18	Bombardier Learjet 31	TFE731-2-2B	71
GA - 19	Dassault Falcon 2000-EX	PW308C	68
GA - 20	Bombardier Learjet 35A/36A	TFE731-2/2A	60
GA - 21	Dassault Falcon 900-B	TFE731-3	60
GA - 22	Raytheon Beechjet 400	JT15D-5, -5A, -5B	60
GA - 23	Cessna 525 Citationjet	JT15D-1 SERIES	57
GA - 24	Bombardier Learjet 60	PW306A	49
GA - 25	Piper PA-47 500TP	PT6A-42	43
GA - 26	Israel IAI-1125 Astra	TFE731-2/2A	43

EDMS ID	AIRCRAFT TYPE	ENGINE TYPE	ANNUAL OPERATIONS (2014)
GA - 27	Cessna 650 Citation III	TFE731-3	41
GA - 28	Embrarer EMB120 Brasilia	PW 118	38
GA - 29	Cessna 525 Citationjet	JT15D-1 SERIES	38
GA - 30	Cessna 414	TIO-540-J2B2	35
GA - 31	Cessna 750 Citation X	AE3007C TYPE 2	35
GA - 32	Convair CV-580	501D22A	35
GA - 33	Gulfstream G200	PW306A	35
GA - 34	Raytheon King Air 90	PT6A-135A	33
GA - 35	Cessna 310	TIO-540-J2B2	24
GA - 36	Raytheon Beech Bonanza 36	TIO-540-J2B2	19
TOTAL General Aviation Operations			**4,113**

Source: Leigh Fisher, July 2016

Table A23

COMMERCIAL AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	AIRLINE	OAG GATE OCCUPANCY TIME (MINUTES)	ADJUSTED APU USAGE PER OPERATION (MINUTES)
COM - 01	Alaska Airlines = AS / ASA	45	7
COM - 02	Alaska Airlines = AS / ASA	45	7
COM - 03	Alaska Airlines = AS / ASA	50	7
COM - 04	Alaska Airlines = AS / ASA	45	7
COM - 05	Alaska Airlines = AS / ASA	40	7
COM - 06	Alaska Airlines = AS / ASA	40	7
COM - 07	Alaska Airlines = AS / ASA	40	7
COM - 08	Horizon Air = QX / QXE	30	7
COM - 09	Delta Air Lines = DL / DAL	50	25
COM - 10	Delta Air Lines = DL / DAL	40	20
COM - 11	Delta Air Lines = DL / DAL	61	30.5
COM - 12	Delta Air Lines = DL / DAL	105	52.5
COM - 13	Delta Air Lines = DL / DAL	105	52.5
COM - 14	Delta Air Lines = DL / DAL	51	25.5
COM - 15	Delta Air Lines = DL / DAL	71	35.5
COM - 16	Delta Air Lines = DL / DAL	165	82.5
COM - 17	Delta Air Lines = DL / DAL	120	60
COM - 18	Delta Air Lines = DL / DAL	40	20
COM - 19	Delta Air Lines = DL / DAL	40	20
COM - 20	Delta Air Lines = DL / DAL	240	120
COM - 21	Delta Air Lines = DL / DAL	30	15
COM - 22	Southwest Airlines = SWA	25	7
COM - 23	Southwest Airlines = SWA	30	7
COM - 24	Southwest Airlines = SWA	30	7
COM - 25	Southwest Airlines = SWA	45	7
COM - 26	Southwest Airlines = SWA	30	7

Table A23

COMMERCIAL AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	AIRLINE	OAG GATE OCCUPANCY TIME (MINUTES)	ADJUSTED APU USAGE PER OPERATION (MINUTES)
COM - 27	Southwest Airlines = SWA	30	7
COM - 28	United Airlines = UA / UAL	45	7
COM - 29	United Airlines = UA / UAL	50	7
COM - 30	United Airlines = UA / UAL	45	7
COM - 31	United Airlines = UA / UAL	40	7
COM - 32	United Airlines = UA / UAL	50	7
COM - 33	United Airlines = UA / UAL	41	7
COM - 34	United Airlines = UA / UAL	50	7
COM - 35	United Airlines = UA / UAL	100	7
COM - 36	SkyWest Airlines = OO / SKW	0	0
COM - 37	SkyWest Airlines = OO / SKW	0	0
COM - 38	SkyWest Airlines = OO / SKW	25	25
COM - 39	SkyWest Airlines = OO / SKW	0	0
COM - 40	American Airlines = AA / AAL	50	50
COM - 41	American Airlines = AA / AAL	60	60
COM - 42	Compass Airlines = CP / CPZ	0	0
COM - 43	US Airways = US / AWE	50	25
COM - 44	US Airways = US / AWE	61	30.5
COM - 45	US Airways = US / AWE	50	25
COM - 46	Virgin America = VX / VRD	45	22.5
COM - 47	Virgin America = VX / VRD	40	20
COM - 48	JetBlue Airways = B6 / JBU	45	22.5
COM - 49	Jazz Aviation LP= QK / JZA	28	28
COM - 50	Jazz Aviation LP= QK / JZA	0	0
COM - 51	Jazz Aviation LP= QK / JZA	0	0
COM - 52	Jazz Aviation LP= QK / JZA	28	28
COM - 53	Frontier Airlines = F9 / FFT	45	45

Table A23

COMMERCIAL AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	AIRLINE	OAG GATE OCCUPANCY TIME (MINUTES)	ADJUSTED APU USAGE PER OPERATION (MINUTES)
COM - 54	Frontier Airlines = F9 / FFT	45	45
COM - 55	Empire Airlines = EM / CFS	0	0
COM - 56	Hawaiian Airlines = HA / HAL	120	120
COM - 57	Hawaiian Airlines = HA / HAL	560	560
COM - 58	Sun Country Airlines = SY / SCX	52	52
COM - 59	Sun Country Airlines = SY / SCX	47	47
COM - 60	Korean Air = KE / KAL	100	100
COM - 61	Korean Air = KE / KAL	100	100
COM - 62	Korean Air = KE / KAL	100	100
COM - 63	Korean Air = KE / KAL	100	100
COM - 64	Korean Air = KE / KAL	100	100
COM - 65	British Airways = BA / BAW	125	125
COM - 66	British Airways = BA / BAW	140	140
COM - 67	British Airways = BA / BAW	125	125
COM - 68	Air Canada = AC / ACA	0	0
COM - 69	Asiana Airlines = OZ / AAR	120	120
COM - 70	Asiana Airlines = OZ / AAR	120	120
COM - 71	Emirates Airline = EK / UAE	290	290
COM - 72	Emirates Airline = EK / UAE	290	290
COM - 73	All Nippon Airways = NH / ANA	120	120
COM - 74	EVA Air = BR / EVA (aka EVA Airways Corp)	120	60
COM - 75	EVA Air = BR / EVA (aka EVA Airways Corp)	120	60
COM - 76	Icelandair = FI / ICE	600	600
COM - 77	Lufthansa = LH / DLH	115	115
COM - 78	Hainan Airlines = HU / CHH	145	145
COM - 79	Hainan Airlines = HU / CHH	145	145
COM - 80	China Airlines = CI / CAL	100	100

Table A23

COMMERCIAL AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	AIRLINE	OAG GATE OCCUPANCY TIME (MINUTES)	ADJUSTED APU USAGE PER OPERATION (MINUTES)
COM - 81	Omni Air International = OY / OAE	125	125
COM - 82	Condor = DE / CFG	125	125
COM - 83	Allegiant Air = G4 / AAY	40	40
COM - 84	Republic Airlines = RW / RPA	0	0
COM - 85	Aeromexico = AM / AMX	40	40
COM - 86	Kalitta Charters = KFS	30	30
COM - 87	Miami Air International = BSK	40	40
COM - 88	Nolinor Aviation = NRL	40	40
COM - 89	Boeing	100	100
COM - 90	Enerjet = ENJ	40	40
COM - 91	Singapore	40	40

Source: LeighFisher, 2015   *Note EDMS default time is 26 minutes.*

Table A24

CARGO AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	AIRLINE	APU USAGE PER OPERATION (MINUTES)
CARGO - 01	FedEx	180
CARGO - 02	FedEx	180
CARGO - 03	FedEx	180
CARGO - 04	FedEx	180
CARGO - 05	FedEx	180
CARGO - 06	FedEx	180
CARGO - 07	FedEx	180
CARGO - 08	FedEx	180
CARGO - 09	FedEx	180

CARGO - 10	FedEx	180
CARGO - 11	FedEx	180
CARGO - 12	FedEx	180

Source: LeighFisher, 2015

Table A25

GENERAL AVIATION AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	APU TYPE	APU USAGE PER OPERATION (MINUTES)
GA - 01	GTCP 36-100	90
GA - 02	-	0
GA - 03	-	0
GA - 04	GTCP 36-100	90
GA - 05	-	0
GA - 06	-	0
GA - 07	GTCP 36-100	90
GA - 08	-	0
GA - 09	GTCP 36-100	90
GA - 10	-	0
GA - 11	-	0
GA - 12	-	0
GA - 13	-	0
GA - 14	-	0
GA - 15	-	0
GA - 16	-	0
GA - 17	-	0
GA - 18	-	0
GA - 19	GTCP 36-100	90
GA - 20	-	0
GA - 21	GTCP 36-100	90
GA - 22	-	0
GA - 23	-	0
GA - 24	-	0
GA - 25	-	0

GA - 26	-	0
GA - 27	-	0
GA - 28	GTCP 36-100	90
GA - 29	-	0
GA - 30	-	0
GA - 31	-	0
GA - 32	-	0
GA - 33	GTCP 36-100	90
GA - 34	-	0
GA - 35	-	0
GA - 36	-	0

Source: LeighFisher, 2015

Table A26

MILITARY AIRCRAFT APU USAGE INPUTS IN EDMS (2014)

EDMS ID	APU TYPE	APU USAGE PER OPERATION (MINUTES)
MIL - 01	GTCP 85 (200 HP)	90

Source: LeighFisher, 2015

Table A27

GSE MODELING INPUTS IN EDMS

EDMS ID	GSE TYPE	EDMS GSE TYPE	FUEL TYPE	MANUFACTURING YEAR	POPULATION (UNITS)
AC-1	Air Heater	Air Conditioner	Diesel	1998	3
AC-2	Air Heater	Air Conditioner	Diesel	1999	1
AC-3	Air Heater	Air Conditioner	Diesel	2000	1
AC-4	Air Heater	Air Conditioner	Diesel	2004	1
AC-5	Air Heater	Air Conditioner	Gasoline (Modeled as Diesel)	2007	1
AC-6	Air Heater	Air Conditioner	Diesel	2008	4
AC-7	Air Heater	Air Conditioner	Diesel	2003	28
AS-1	Air Start	Air Start	Gasoline	1997	1
AS-2	Air Start	Air Start	Diesel	1997	13
AS-3	Air Start	Air Start	Diesel	1992	1
AS-4	Air Start	Air Start	Diesel	1995	1
AS-5	Air Start	Air Start	Diesel	1997	1
AS-6	Air Start	Air Start	Diesel	1998	1
AS-7	Air Start	Air Start	Diesel	2001	1
AS-8	Air Start	Air Start	Diesel	2002	1
AS-9	Air Start	Air Start	Diesel	2003	1
AS-10	Air Start	Air Start	Diesel	2006	1
AS-11	Air Start	Air Start	Diesel	1986	1
AS-12	Air Start	Air Start	Diesel	1990	1
AT-1	Aircraft Tractor	Aircraft Tractor	Gasoline	1995	1
AT-2	Aircraft Tractor	Aircraft Tractor	Diesel	1985	1
AT-3	Aircraft Tractor	Aircraft Tractor	Diesel	1987	1
AT-4	Aircraft Tractor	Aircraft Tractor	Diesel	1988	1
AT-5	Aircraft Tractor	Aircraft Tractor	Diesel	1989	1
AT-6	Aircraft Tractor	Aircraft Tractor	Diesel	1990	1
AT-7	Aircraft Tractor	Aircraft Tractor	Diesel	1991	1

Table A27

GSE MODELING INPUTS IN EDMS

EDMS ID	GSE TYPE	EDMS GSE TYPE	FUEL TYPE	MANUFACTURING YEAR	POPULATION (UNITS)
AT-8	Aircraft Tractor	Aircraft Tractor	Diesel	1993	1
AT-9	Aircraft Tractor	Aircraft Tractor	Diesel	1994	1
AT-10	Aircraft Tractor	Aircraft Tractor	Diesel	1998	1
AT-11	Aircraft Tractor	Aircraft Tractor	Diesel	2000	1
AT-12	Aircraft Tractor	Aircraft Tractor	Diesel	2001	2
AT-13	Aircraft Tractor	Aircraft Tractor	Diesel	2005	1
AT-14	Aircraft Tractor	Aircraft Tractor	Diesel	2008	1
AT-15	Aircraft Tractor	Aircraft Tractor	Diesel	1995	46
BT-1	Baggage Tractors	Baggage Tractors	Gasoline	1998	37
BT-2	Baggage Tractors	Baggage Tractors	Gasoline	1986	2
BT-3	Baggage Tractors	Baggage Tractors	Gasoline	2001	1
BT-4	Baggage Tractors	Baggage Tractors	Gasoline	2002	1
BT-5	Baggage Tractors	Baggage Tractors	Gasoline	2003	1
BT-6	Baggage Tractors	Baggage Tractors	Gasoline	2007	1
BT-7	Baggage Tractors	Baggage Tractors	Gasoline	2009	6
BT-8	Baggage Tractors	Baggage Tractors	Diesel	1998	33
BT-9	Baggage Tractors	Baggage Tractors	Diesel	1985	3
BT-10	Baggage Tractors	Baggage Tractors	Diesel	1993	3
BT-11	Baggage Tractors	Baggage Tractors	Diesel	1998	2
BT-12	Baggage Tractors	Baggage Tractors	Diesel	1999	4
BT-13	Baggage Tractors	Baggage Tractors	Diesel	2000	1
BT-14	Baggage Tractors	Baggage Tractors	Diesel	2001	1
BT-15	Baggage Tractors	Baggage Tractors	Diesel	2002	1
BT-16	Baggage Tractors	Baggage Tractors	Diesel	2004	1
BT-17	Baggage Tractors	Baggage Tractors	Diesel	2005	2
BT-18	Baggage Tractors	Baggage Tractors	Diesel	2006	3

Table A27

GSE MODELING INPUTS IN EDMS

EDMS ID	GSE TYPE	EDMS GSE TYPE	FUEL TYPE	MANUFACTURING YEAR	POPULATION (UNITS)
BT-19	Baggage Tractors	Baggage Tractors	Diesel	1999	18
BL-1	Belt Loader	Belt Loader	Gasoline	2001	22
BL-2	Belt Loader	Belt Loader	Gasoline	1990	1
BL-3	Belt Loader	Belt Loader	Gasoline	1991	1
BL-4	Belt Loader	Belt Loader	Gasoline	1998	1
BL-5	Belt Loader	Belt Loader	Gasoline	2000	6
BL-6	Belt Loader	Belt Loader	Gasoline	2002	2
BL-7	Belt Loader	Belt Loader	Gasoline	2003	2
BL-8	Belt Loader	Belt Loader	Gasoline	2005	1
BL-9	Belt Loader	Belt Loader	Gasoline	2006	1
BL-10	Belt Loader	Belt Loader	Diesel	2001	29
BL-11	Belt Loader	Belt Loader	Diesel	2007	6
BL-12	Belt Loader	Belt Loader	Diesel	2009	1
BL-13	Belt Loader	Belt Loader	Propane	2001	1
BL-14	Belt Loader	Belt Loader	Propane	1999	3
CST-1	Cabin Service/Catering Truck	Cabin Service Truck	Gasoline	2000	3
CST-2	Cabin Service/Catering Truck	Cabin Service Truck	Gasoline	1994	1
CST-3	Cabin Service/Catering Truck	Cabin Service Truck	Diesel	2000	11
CST-4	Cabin Service/Catering Truck	Cabin Service Truck	Diesel	2006	1
CL-1	Cargo Loader	Cargo Loader	Diesel	1998	21
CL-2	Cargo Loader	Cargo Loader	Diesel	1987	1
CL-3	Cargo Loader	Cargo Loader	Diesel	1991	1
CL-4	Cargo Loader	Cargo Loader	Diesel	1992	1
CL-5	Cargo Loader	Cargo Loader	Diesel	1993	1
CL-6	Cargo Loader	Cargo Loader	Diesel	1994	2
CL-7	Cargo Loader	Cargo Loader	Diesel	1995	1

Table A27
GSE MODELING INPUTS IN EDMS

EDMS ID	GSE TYPE	EDMS GSE TYPE	FUEL TYPE	MANUFACTURING YEAR	POPULATION (UNITS)
CL-8	Cargo Loader	Cargo Loader	Diesel	1997	1
CL-9	Cargo Loader	Cargo Loader	Diesel	1999	1
CL-10	Cargo Loader	Cargo Loader	Diesel	2000	8
CL-11	Cargo Loader	Cargo Loader	Diesel	2001	1
CL-12	Cargo Loader	Cargo Loader	Diesel	2002	2
CL-13	Cargo Loader	Cargo Loader	Diesel	2004	1
CL-14	Cargo Loader	Cargo Loader	Diesel	2006	3
CL-15	Cargo Loader	Cargo Loader	Diesel	2007	2
CL-16	Cargo Loader	Cargo Loader	Gasoline	1998	7
CL-17	Cargo Loader	Cargo Loader	Propane	1998	1
DT-1	Deicing Truck	Deicing Truck	Diesel (Modeled as Gasoline)	1991	32
DT-2	Deicing Truck	Deicing Truck	Diesel (Modeled as Gasoline)	1982	1
DT-3	Deicing Truck	Deicing Truck	Diesel (Modeled as Gasoline)	1989	1
DT-4	Deicing Truck	Deicing Truck	Diesel (Modeled as Gasoline)	1993	1
DT-5	Deicing Truck	Deicing Truck	Gasoline	1991	4
DT-6	Deicing Truck	Deicing Truck	Gasoline	1997	1
DT-7	Deicing Truck	Deicing Truck	Gasoline	1986	1
DT-8	Deicing Truck	Deicing Truck	Gasoline	1996	1
DT-9	Deicing Truck	Deicing Truck	Gasoline	1997	1
FL-1	Forklift	Forklift	Diesel	1998	5
FL-2	Forklift	Forklift	Propane	1998	13
FT-1	Fuel Truck	Fuel Truck	Diesel	1995	1
FT-2	Fuel Truck	Fuel Truck	Diesel	1997	21
FT-3	Fuel Truck	Fuel Truck	Diesel	1998	1
LT-1	Lavatory Truck	Lavatory Truck	Diesel	1994	7

Table A27
GSE MODELING INPUTS IN EDMS

EDMS ID	GSE TYPE	EDMS GSE TYPE	FUEL TYPE	MANUFACTURING YEAR	POPULATION (UNITS)
LT-2	Lavatory Truck	Lavatory Truck	Gasoline	1994	13
L-1	Lift	Lift	Diesel	2001	20
L-2	Lift	Lift	Gasoline	1996	1
L-3	Lift	Lift	Gasoline	2000	1
L-4	Lift	Lift	Gasoline	2001	2
L-5	Lift	Lift	Gasoline	2006	1
L-6	Lift	Lift	Propane	2001	2
LC-1	Light Cart/Light Stand	Other	Diesel	2014	11
LC-2	Light Cart/Light Stand	Other	Gasoline	2014	1
PS-1	Passenger Stairs	Passenger Stand	Diesel	2001	1
PS-2	Passenger Stairs	Passenger Stand	Diesel	2007	1
PS-3	Passenger Stairs	Passenger Stand	Diesel	2011	1
PS-4	Passenger Stairs	Passenger Stand	Diesel	1998	4
PS-5	Passenger Stairs	Passenger Stand	Diesel	1971	1
PS-6	Passenger Stairs	Passenger Stand	Gasoline	1998	4
PS-7	Passenger Stairs	Passenger Stand	Propane	1998	1
UC-1	Utility Cart	Cart	Diesel (Modeled as Gasoline)	2014	12
UC-2	Utility Cart	Cart	Propane (Modeled as Gasoline)	2014	3
GPU-1	Ground Power Unit	Ground Power Unit	Diesel	2001	36
GPU-2	Ground Power Unit	Ground Power Unit	Diesel	1987	1
GPU-3	Ground Power Unit	Ground Power Unit	Diesel	1988	2
GPU-4	Ground Power Unit	Ground Power Unit	Diesel	1996	1
GPU-5	Ground Power Unit	Ground Power Unit	Diesel	1999	2
GPU-6	Ground Power Unit	Ground Power Unit	Diesel	2000	2
GPU-7	Ground Power Unit	Ground Power Unit	Diesel	2001	1
GPU-8	Ground Power Unit	Ground Power Unit	Diesel	2004	2

Table A27

GSE MODELING INPUTS IN EDMS

EDMS ID	GSE TYPE	EDMS GSE TYPE	FUEL TYPE	MANUFACTURING YEAR	POPULATION (UNITS)
GPU-9	Ground Power Unit	Ground Power Unit	Diesel	2008	6
GPU-10	Ground Power Unit	Ground Power Unit	Diesel	2011	1
GPU-11	Ground Power Unit	Ground Power Unit	Gasoline	2001	1
MT-1	Other Airfield Support/Box Truck/Water Truck	Service Truck	Diesel	2002	1
MT-2	Maintenance Truck; Other Airfield Support/Box Truck/ Water Truck	Service Truck	Diesel	2005	26
MT-3	Other Airfield Support/Box Truck/Water Truck	Service Truck	Diesel	2008	1
MT-4	Other Airfield Support/Box Truck/Water Truck	Service Truck	Gasoline	2005	5
MT-5	Other Airfield Support/Box Truck/Water Truck	Service Truck	Natural Gas	2005	1
MT-6	Other Airfield Support/Box Truck/Water Truck	Service Truck	Propane	2005	2

- Age: EDMS default values were used.
- Horsepower: EDMS default values were used.
- Average Vehicle Speed for GSE modeled were assigned the default average speed of 10 mph.
- Load Factor: the EDMS default values were used.
- Operating Time: EDMS default values were used.

Source: LeighFisher, 2015

Table A28

BOILERS - STATIONARY SOURCES EDMS INPUTS

EDMS ID	STATIONARY SOURCE	TYPE	1000^3 CUBIC METERS PER YEAR
Boil - Bus Maint.	Boiler	Natural Gas: Wall Fired Boiler, <100 Million BTU/hr, Uncontrolled	59.22
Boil - Central Plant	Boiler	Natural Gas: Wall Fired Boiler, <100 Million BTU/hr, Uncontrolled	8,015.16
Boil - Dist. Center	Boiler	Natural Gas: Residential Furnace	16.14
Boil - Fire Dept.	Boiler	Natural Gas: Wall Fired Boiler, <100 Million BTU/hr, Uncontrolled	76.60
Boil - Fleet Maint.	Boiler	Natural Gas: Wall Fired Boiler, <100 Million BTU/hr, Uncontrolled	144.86
Boil - Learn Center	Boiler	Natural Gas: Residential Furnace	23.78
Boil - Pumphouse	Boiler	Natural Gas: Residential Furnace	3.50

EDMS ID	STATIONARY SOURCE	TYPE	1000^3 CUBIC METERS PER YEAR

Source: LeighFisher, 2015

Table A29

GENERATORS - STATIONARY SOURCES EDMS INPUTS (2014)

GENERATOR/ PUMP	EDMS ID	STATIONARY SOURCE	TYPE	ANNUAL OPERATING HOURS	HORSEPOWER RATING (HP)
Airfield Light 1	Gen - Airfld Light 1	Generator	Diesel Fuel	122.7	2,400
Airfield Light 2	Gen - Airfld Light 1	Generator	Diesel Fuel	122.7	2,400
Building Lights 1	Gen - Airfld Light 1	Generator	Diesel Fuel	122.7	2,400
Building Lights 2	Gen - Airfld Light 2	Generator	Diesel Fuel	87.7	2,400
Boiler 3 Generator	Gen - Airfld Light 2	Generator	Diesel Fuel	87.7	2,400
Concourse A C4	Gen - Airfld Light 2	Generator	Diesel Fuel	87.7	2,400
Concourse A Fire	Gen - Bldg Lights 1	Generator	Diesel Fuel	4	67
Concourse A STEP	Gen - Bldg Lights 2	Generator	Diesel Fuel	5.2	80
Parking Garage	Gen - Boiler 3	Generator	Diesel Fuel	1	380
Pump 01	Gen - Conc A C4	Generator	Diesel Fuel	33	1,341
Pump 02	Gen - Conc A C4 (2)	Generator	Diesel Fuel	33	1,341
Pump 03	Gen - Conc A Fire	Generator	Diesel Fuel	3.5	240
Pump 04	Gen - Conc A STEP	Generator	Diesel Fuel	2	2012
Pump 05	Gen - Conc A STEP	Generator	Diesel Fuel	2	2012
Pump 07	Gen - Parking Garage	Generator	Diesel Fuel	4.4	235
Pump 8	Gen - Pump 01	Generator	Diesel Fuel	6.8	412
Toll Plaza	Gen - Pump 02	Generator	Diesel Fuel	6.6	412
WWTP	Gen - Pump 03	Generator	Diesel Fuel	2.6	412
GENERATOR/PUMP	Gen - Pump 04	Generator	Diesel Fuel	7.4	412
Airfield Light 1	Gen - Pump 05	Generator	Diesel Fuel	4.5	380
Airfield Light 2	Gen - Pump 07	Generator	Diesel Fuel	5.6	380
Building Lights 1	Gen - Pump 8	Generator	Diesel Fuel	4.4	380
Building Lights 2	Gen - Toll Plaza	Generator	Diesel Fuel	4.1	503
Boiler 3 Generator	Gen - WWTP	Generator	Diesel Fuel	16.6	165

Source: LeighFisher, 2015

Table A210

ROADWAY TRAFFIC EDMS INPUTS (2014)

EDMS ID	EDMS VEHICLE CLASS	MANUFACTURED YEAR	FUEL TYPE	AVERAGE SPEED (MPH)	VMT PER 1,000 VEHICLES
01 Passenger Cars	Light Duty Vehicles (Passenger	2007	Gasoline	30	54,065
02 Taxicabs	Light Duty Vehicles (Passenger	2010	Gasoline	30	6,773
03 Limousines	Light Duty Trucks 1	2008	Gasoline	30	4,027
04 Rental Shuttles	Class 3 Heavy Duty Vehicles	2004	CNG	15	1,199
05 Hotel Shuttles	Class 3 Heavy Duty Vehicles	2004	Gasoline	15	3,486
06 Parking Shuttles	Class 3 Heavy Duty Vehicles	2004	Gasoline	15	5,179
07 Charter/Cruises	Class 3 Heavy Duty Vehicles	1999	Diesel	30	87.42
08 Shared Van (Diesel)	Light Duty trucks 3	2009	Diesel	25	57
09 Shared Van (LPG)	Light Duty trucks 3	2004	Propane	25	517
10 Airporters	Class 3 Heavy Duty Vehicles	1999	Diesel	30	146
11 Airline Shuttles	Class 3 Heavy Duty Vehicles	1999	CNG	20	563
12 Serv Delivery	Class 3 Heavy Duty Vehicles	2004	CNG	20	235

Note: VMT is vehicle miles travelled.

Source: LeighFisher, 2015

APPENDIX: EMISSIONS BY SOURCE

This section provides detailed emissions for each source type:

- Auxiliary Power Units
- Ground Support Equipment
- Stationary Sources
- Parking Traffic
- Roadway Traffic

Table A31
AIRCRAFT ENGINE EMISSIONS BY ARRIVALS/DEPARTURES AND REMAIN-OVER-NIGHTS

	SHORT TONS OF POLLUTANTS (2014)						
EMISSION SOURCE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
Aircraft Engines	**1,623**	**242**	**1,329**	**158**	**22**	**22**	**3,395**
Arrivals/Departures	1,435	224	1,208	141	20	20	3,047
RONs	188	18	121	17	2	2	348

Note: APUs = Auxiliary Power Units; RON = Remain-Over-Night
Numbers may not add up to due rounding.

Source: LeighFisher, 2016

Table A32
AUXILIARY POWER UNITS EMISSIONS BY ARRIVALS/DEPARTURES AND REMAIN-OVER-NIGHTS

	SHORT TONS OF POLLUTANTS (2014)						
EMISSION SOURCE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
APUs (Total)	**72**	**5**	**48**	**9**	**8**	**8**	**149**
Arrivals/Departures	65	4	44	8	8	8	136
RONs	7	0	3	1	1	1	13

Note: APUs = Auxiliary Power Units; RON = Remain-Over-Night
Numbers may not add up due to rounding.

Source: LeighFisher, 2016

Table A33
AUXILIARY POWER UNIT EMISSIONS BY AIRLINE

	SHORT TONS OF POLLUTANTS (2014)						
AIRLINE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
Alaska Airlines	261	28	174	25	3	3	**494**
Horizon Air	0	0	0	0	0	0	**0**
Delta Airlines	349	36	287	33	4	4	**713**
Southwest Airlines	182	21	126	17	2	2	**351**
United Airlines	136	15	86	12	2	2	**254**
SkyWest Airlines	0	0	2	0	0	0	**3**
American Airlines	23	2	14	2	0	0	**42**
Compass Airlines	0	0	1	0	0	0	**1**
US Airways	57	3	25	5	1	1	**92**
Virgin America	24	2	24	2	0	0	**53**
JetBlue Airways	11	0	4	1	0	0	**17**
Jazz Aviation	29	68	146	9	2	2	**256**
Frontier Airlines	12	3	14	1	0	0	**31**
Empire Airlines	0	0	0	0	0	0	**0**
Hawaiian Airlines	10	1	6	1	0	0	**18**
Sun Country Airlines	5	1	4	0	0	0	**10**
Korean Airlines	40	3	33	5	1	1	**81**
British Airways	58	9	45	5	1	1	**118**
Air Canada	15	2	14	2	0	0	**34**
Asiana Airlines	42	4	48	4	0	0	**100**
Emirates Airlines	13	1	16	2	0	0	**33**
Nippon Airways	0	0	1	0	0	0	**1**
EVA Air	3	0	2	0	0	0	**5**
Iceland Air	2	1	2	0	0	0	**5**
Lufthansa	0	0	0	0	0	0	**0**
Hainan Airlines	0	0	1	0	0	0	**1**
China Airlines	0	0	0	0	0	0	**0**
Omni Air International	13	0	3	1	0	0	**18**

Condor	11	2	14	1	0	0	**29**
Allegiant Air	0	0	0	0	0	0	**0**
Republic Airlines	9	0	5	1	0	0	**16**
Aeromexico	4	1	4	0	0	0	**10**
Kalitta Charters	0	0	0	0	0	0	**0**
Miami Air International	4	0	1	0	0	0	**6**
Nolinor Aviation	32	5	29	3	0	0	**69**
Boeing	4	0	2	0	0	0	**6**
Enerjet	112	10	61	10	1	1	**195**
Singapore	0	0	0	0	0	0	**0**
Total	**1,463**	**222**	**1,195**	**143**	**20**	**20**	**3,063**

Note: Numbers may not add up due to rounding.

Source: LeighFisher, 2016

Table A34

GROUND SUPPORT EQUIPMENT EMISSIONS BY EQUIPMENT TYPE

	SHORT TONS OF POLLUTANTS (2014)						
GSE TYPE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
Air Conditioner	33	1	12	0	2	2	**494**
Air Start	21	2	38	0	1	1	**0**
Aircraft Tractor	0	0	0	0	0	0	**713**
Baggage Tractor	51	19	594	5	4	4	**351**
Belt Loader	28	12	399	3	2	1	**254**
Cabin Service Truck	19	5	168	1	1	1	**3**
Cargo Loader	19	4	83	1	2	2	**42**
Cart	0	0	2	0	0	0	**1**
Deicer	32	22	780	7	0	0	**92**
Fork Lift	3	1	13	0	0	0	**53**
Fuel Truck	3	0	1	0	0	0	**17**
Ground Power Unit	76	7	77	1	6	6	**256**
Lavatory Truck	8	2	66	1	1	0	**31**
Lift	4	1	23	0	0	0	**0**
Other	4	1	8	0	0	0	**18**
Passenger Stand	1	0	7	0	0	0	**10**
Service Truck	6	1	22	0	0	0	**81**
Total	**307**	**78**	**2,292**	**19**	**21**	**20**	**3,063**

Note: GSE = Ground Support Equipment
Numbers may not add up due to rounding.

Source: LeighFisher, 2016

Table A35
STATIONARY SOURCE EMISSIONS BY SOURCE TYPE

	SHORT TONS OF POLLUTANTS (2014)						
STATIONARY SOURCE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
Boiler	14	1	12	0	1	1	**29**
Generator	3	0	1	0	0	0	**5**
Total	17	1	12	1	1	0	**34**

Numbers may not add up due to rounding.

Source: LeighFisher, 2016

Table A36
ROADWAY TRAFFIC EMISSIONS BY SOURCE TYPE

	SHORT TONS OF POLLUTANTS (2014)						
ROADWAY TYPE	**NO_X**	**VOC**	**CO**	**SO_X**	**PM-10**	**PM-2.5**	**TOTAL**
Airline Shuttles	0	0	1	0	0	0	**1**
Airporters	0	0	0	0	0	0	**1**
Charter/Cruises	0	0	0	0	0	0	**0**
Hotel shuttles	8	3	31	0	0	0	**46**
Limousines	1	1	23	0	0	0	**27**
Parking Shuttles	11	4	45	0	0	0	**68**
Passenger cars	8	9	290	0	1	0	**340**
Rental shuttles	0	0	2	0	0	0	**2**
Serv Delivery	0	0	0	0	0	0	**0**
Shared Van Diesel	0	0	0	0	0	0	**0**
Shared Van Propane	0	0	1	0	0	0	**1**
Taxicabs	0	1	26	0	0	0	**30**
Total	**32**	**19**	**462**	**1**	**2**	**0**	**516**

Note: GSE = Ground Support Equipment
Numbers may not add up due to rounding.

Source: LeighFisher, 2016