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Development of Aircraft Emissions Inventories

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Acronym List

Acronym	**Definition**
AC	Commercial Air Carriers
ADIP	Airport Information Data Portal
AEDT	Aviation Environmental Design Tool
AETC	Aircraft Engine Type Code
AFE	Above Field Elevation
AICUZ	Air Installation Compatible Use Zone
AirToxScreen	EPA's Air Toxics Screening Assessment
APU	Auxiliary Power Unit
ASIF	AEDT Standard Input File
AT	Air Taxis
AVgas	Aviation Fuel
CAPs	Criteria Air Pollutants
CO	Carbon Monoxide
CSV	Comma Separated Values
DOT	Department of Transportation
EIB	Emission Inventory Branch
EIS	Emission Inventory System
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
GAA	General Aviation Aircraft
GSE	Ground Support Equipment
GUI	Graphical User Interface
HAPs	Hazardous Air Pollutants
HDE	Humanitarian Data Exchange
ID	Identification Number
LD	Landing(s)
LTO	Landing and Takeoff
MIL	Military aircraft
NEI	National Emission Inventory
NO_x	Nitrogen Oxide
NPIAS	National Plan of Integrated Airport Systems
OAG	Official Airline Guide
OPSNET	Operations Network
OSAP	Office of State Air Partnerships
PM	Particulate Matter
PM_{10}	Particulate Matter with a diameter of 10 micrometers (or less)

$PM_{2.5}$	Fine Particulate Matter with a diameter of 2.5 micrometers (or less)
SCC	Source Classification Codes
SQL	Structured Query Language
SLT	State/Local/Tribal agencies
SSMS	SQL Server Management Studio
T-100	Air Carrier Statistics T-100 databank
TAF	Terminal Area Forecast
TGO	Touch-and-Go
TO	Takeoff(s)
TOG	Total Organic Gases
UNC-IE	University of North Carolina at Chapel Hill's Institute for the Environment
XML	Extensible Markup Language

1 Executive Summary

The Emissions Inventory Branch (EIB) at the United States Environmental Protection Agency's (EPA) Office of State Air Partnerships (OSAP) triennially produces the National Emission Inventory (NEI). The NEI compiles comprehensive emissions data for criteria air pollutants (CAPs) and hazardous air pollutants (HAPs) for mobile, point, and nonpoint sources. The types of mobile sources include aviation, marine vessels, locomotive engines on railroads, on-road vehicles and off-roadway (i.e., nonroad) engines. Emissions data are needed by state, Tribal, and local agencies to evaluate emissions trends and to compare emissions between geographic areas. The NEI is also used as a basis for various EPA air quality modeling and regulatory analyses. The Emission Inventory System (EIS) is used to collect and distribute emissions inventory information for the NEI. EPA uses the data in the NEI to develop national emissions modeling platforms that support air quality modeling studies. These studies support both regulatory and non-regulatory analyses and often require data representing years outside of the triennial NEIs, including years in the future.

The University of North Carolina at Chapel Hill's Institute for the Environment (UNC-IE) estimated emissions of the aircraft sector for both CAPs and HAPs for the 2023 NEI. These data will be used to support air quality modeling activities, regulatory initiatives, state implementation plans and programs, and airport-related emissions studies.

The emissions associated with airport activities are attributed to the following sources with associated source classification codes (SCC):

- Military (SCC: 2275001000)
- Commercial Aviation (SCC: 2275020000)
- General Aviation
    - Piston driven (SCC: 2275050011)
    - Turbine driven (SCC: 2275050012)
- Air Taxis
    - Piston driven (SCC: 2275060011)
    - Turbine driven (SCC: 2275060012)
- Auxiliary Power Units (APUs) (SCC: 2275070000)
- Ground Support Equipment (GSEs)
    - Gasoline-fueled (SCC: 2265008005)
    - Diesel-fueled (SCC: 2270008005)

To estimate emissions from these sources, activity data for the year 2023 provided by states and Tribes were compiled and supplemented with publicly available 2023 activity data as described in Section 3. Two approaches were used to estimate emissions from the compiled activity data. For activity that included aircraft-specific data, UNC-IE used the Federal Aviation Administration's (FAA) Aviation Environmental Design Tool (AEDT) [1] to estimate emissions (Method 1). If such detailed data were not available, UNC-IE used generic emission factors in combination with estimates of activity by different aircraft types (i.e., air taxis, general aviation, and military aircraft) to calculate emissions (Method 2). Additional information on the methodology used is included in Chapter 3 of this document.

Table 1-1 summarizes the total activity in terms of landing and takeoff (LTO) cycles for the current year analysis (2023) compared to the two previous inventory totals by SCC code. Percentages colored in red highlight negative changes. Overall, LTOs increased in 2023 over previous inventory years, with 6% more LTOs than in 2017 and 20% more LTOs than in 2020, a year when air travel was greatly reduced due to the COVID-19 pandemic. Documentation from 2020 [2] indicated that 2017 activity was a combination of 2017 aircraft-specific and 2014 generic data. Touch-and-Go (TGO) operations are not included. LTOs are estimated by dividing total operations by two and rounding to the nearest whole number.

Table 1-1. A Comparison of 2023 LTOs with 2017 and 2020 LTOs.

		LTOs			**Percent Difference**	
SCC	**SCC Description**	**2017**	**2020**	**2023**	**2023 v 2017**	**2023 v 2020**
2275001000	Military Aircraft: All Types	4,034,228	3,693,002	3,746,300	-7%	1%
2275020000	Commercial Aircraft: All Types	7,822,548	5,304,089	8,672,156	11%	63%
2275050011	General Aviation, Piston	27,945,914	22,432,799	31,501,623	13%	40%
2275050012	General Aviation, Turbine	12,059,215	15,671,335	12,569,531	4%	-20%
2275060011	Air Taxi, Piston	992,378	490,315	454,752	-54%	-7%
2275060012	Air Taxi, Turbine	4,569,582	3,233,536	4,142,061	-9%	28%
	TOTAL	57,423,865	50,825,076	61,086,423	6%	20%

Despite increases in air travel over the previous two inventory years, CAPs emissions for the 2023 inventory did not necessarily increase when compared to previous years. Table 1-2 summarizes total emissions by pollutant and compares 2023 emissions to those in previous inventories. Percentages colored in red highlight negative changes. Updated AEDT emissions estimates due to model updates in AEDT can lead to changes in emissions over time. However, it is likely that much of the difference could be due to differences in modeling methodology between 2023 and previous inventory years. Most notably, the selection of airframe and engines to use in AEDT modeling can impact emissions estimates, particularly at large airports. Differences among SCC categories year-over-year can also be due to changes in how equipment are assigned to SCCs for that inventory (more information on this is available in Section 3.3). Overall, these findings demonstrate that aircraft and airport-related emissions are impacted by the increase in air travel over time, solidifying the critical need to continue documenting the impacts of aircraft emissions on overall air quality, though improvements in aircraft engines can help to offset increases in air travel.

Table 1-2. A comparison of total annual emissions from all airports for CAPs for 2023, 2020, and 2017.

	Emissions (Tons)			**Percent Difference**	
Pollutant Name	**2017**	**2020**	**2023**	**2023 v 2017**	**2023 v 2020**
Carbon Monoxide	499,888	338,307	427,633	-14%	26%
Lead	225	176	246	9%	40%
Nitrogen Oxides	134,333	85,900	140,420	5%	63%
PM10 Primary (Filt + Cond)	10,172	8,684	10,181	0%	17%
PM2.5 Primary (Filt + Cond)	8,909	7,693	8,860	-1%	15%
Sulfur Dioxide	16,821	9,359	15,019	-11%	60%
Volatile Organic Compounds	56,676	52,040	42,492	-25%	-18%

2 Introduction

2.1 Purpose and Objectives

UNC-IE responded to U.S. EPA Task Order (TO) PR-OAR-24-00559 issued under the Blanket Purchase Agreement contract 68HERD21A002. TO PR-OAR-24-00559, titled "Development of Aircraft Emissions Inventories," is directed towards supporting and improving air quality models and tools used by partners in and outside of EPA for regulatory and research applications. This report documents procedures used to estimate 2023 aviation emissions and is a deliverable under this task order.

To develop comprehensive inventories for the aircraft source category, UNC-IE conducted the following tasks:

- Matched Emissions Inventory System (EIS) airport entries with publicly available airport data and AEDT airport tables
- Created an updated Aircraft Engine Type Code (AETC) table to assign default SCC codes to airframe/engine combinations
- Compiled aircraft operations data from several publicly available Federal Aviation Administration (FAA) data sources including the following:
    - For aircraft specific data: 2023 T-100 dataset [3]
    - For generic aircraft data: 2023 Terminal Area Forecast (TAF) data [4], 2023 Operations Network (OPSNET) [5], 2023 data for all airports found in the Airport Information Data Portal (ADIP), formerly referred to as the Airport Master Record (form 5010) data [6], and 2023-2027 National Plan of Integrated Airport Systems (NPIAS) airports [7]
- Shared aircraft operations data with states to allow for feedback, corrections, and comments
- Reviewed and post-processed state-, local-, and Tribe-submitted 2023 aircraft operations data
- Created AEDT Standard Input Files (ASIFs) based on post-processed operations data
- Calculated emission estimates using the best available operations data
- Checked emissions outputs for completeness, validity, and congruity with previous-year estimates and ensured that all operations from operating airports in the input files had corresponding emissions in the inventory
- Summarized activity and emissions data

It should be noted that the engine-specific factors used in the AEDT model were derived from testing data used to certify the engines and account for U.S. and international emissions standards at the time of manufacture. For more information about the AEDT model and how engine-specific emissions factors were developed, please see the AEDT website and model documentation [1].

Section 3.1 of this report identifies the national and state activity data sources included in this study. Section 3.4 describes each activity data source that was used to compile the 2023 activity dataset. This section also documents any assumptions or adjustments that were made to facilitate the development of the activity dataset. Section 3.5 summarizes the emissions estimation methodology used to develop the

2023 airport inventory. Section 4 provides summary tables for criteria pollutants and key takeaways. Section 5 discusses suggestions for future inventory development. The full dataset of CAP and HAP emissions associated with 2023 airport activities are included in the database files that accompany this report.

2.2 Background

Airport activities are considered as point sources (facilities) in the calculation of emissions and for the EPA's EIS. The aircraft source category includes all aircraft types used for public, private, and military purposes. The emissions associated with airport activities are attributed to the following source categories, each with an associated SCC:

- Military (SCC: 2275001000)
- Commercial Aviation (SCC: 2275020000)
- General Aviation
  - Piston driven (SCC: 2275050011)
  - Turbine driven (SCC: 2275050012)
- Air Taxis
  - Piston driven (SCC: 2275060011)
  - Turbine driven (SCC: 2275060012)
- Auxiliary Power Units (APUs) (SCC: 2275070000)
- Ground Support Equipment (GSEs)
  - Gasoline-fueled (SCC: 2265008005)
  - Diesel-fueled (SCC: 2270008005)

Commercial aircraft (AC) transport passengers, freight, or both, and tend to be larger aircraft that use jet engines. Commercial aircraft can carry between 61 and 800 passengers and typically serve regular routes between larger airports. Air taxis (AT), which are also considered to be commercial aircraft, are usually smaller aircraft (60 passengers or less) that can either serve regular routes or can operate on a more limited basis compared to larger commercial aircraft. TAF defines air taxis as "airport operations performed by aircraft with 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" [8]. General aviation aircraft (GAA) includes most other aircraft used for recreational flying and personal transportation. Smaller aircraft that support business travel, even those with jet engines, are also included in the GAA category. The AT and GAA fleet include both jet, turbine, and propeller-driven aircraft. Most of the AT and GAA fleet are comprised of piston- (or propeller-) driven aircraft, though these aircraft types also include smaller business jets, turboprops, and helicopters equipped with piston or turboshaft engines. Military aircraft (MIL) comprise a wide range of aircraft types such as training aircraft, fighter jets, helicopters, and jet- and propeller-driven cargo planes of varying sizes. However, only one generic emission factor is used for all military aircraft.

Aircraft emissions included in the NEI are associated with an aircraft's landing and takeoff (LTO) cycle (Figure 2-1), and typically, there are higher emissions associated with takeoff than with landing. For commercial aircraft, the cycle begins when the aircraft approaches the airport on its descent from cruising altitude, then lands and taxis to the gate, where it idles during passenger deplaning. The cycle continues as the aircraft idles during passenger boarding, taxis back onto the runway, takes off, and ascends (or climbs out) to cruising altitude. GAA and military aircraft have a similar LTO cycle but with different activities occurring while the aircraft is on the ground. During each mode of operation, an aircraft engine operates at a specific power setting and fuel consumption rate for a given aircraft make and model, and AEDT can calculate emissions on a specified flight path by multiplying emission factors for each operating mode for each specific aircraft engine and the typical period of time the aircraft is operating. This study uses a single runway and flight path to represent the airport's activities. AEDT also calculates emissions for GSEs and APUs appropriate to the aircraft type and operation. This is the approach used for calculating emissions using Method 1 when operation counts by specific airframe and engine are available. Method 2, which must be applied when more specific equipment data is not available, relies upon a more generic approach that uses representative emission factors by aircraft type (i.e., air taxis, general aviation, and military aircraft) to calculate emissions. For the purposes of the NEI, airport emissions are limited to operations that occur at or below 3,000 feet above field elevation (AFE).

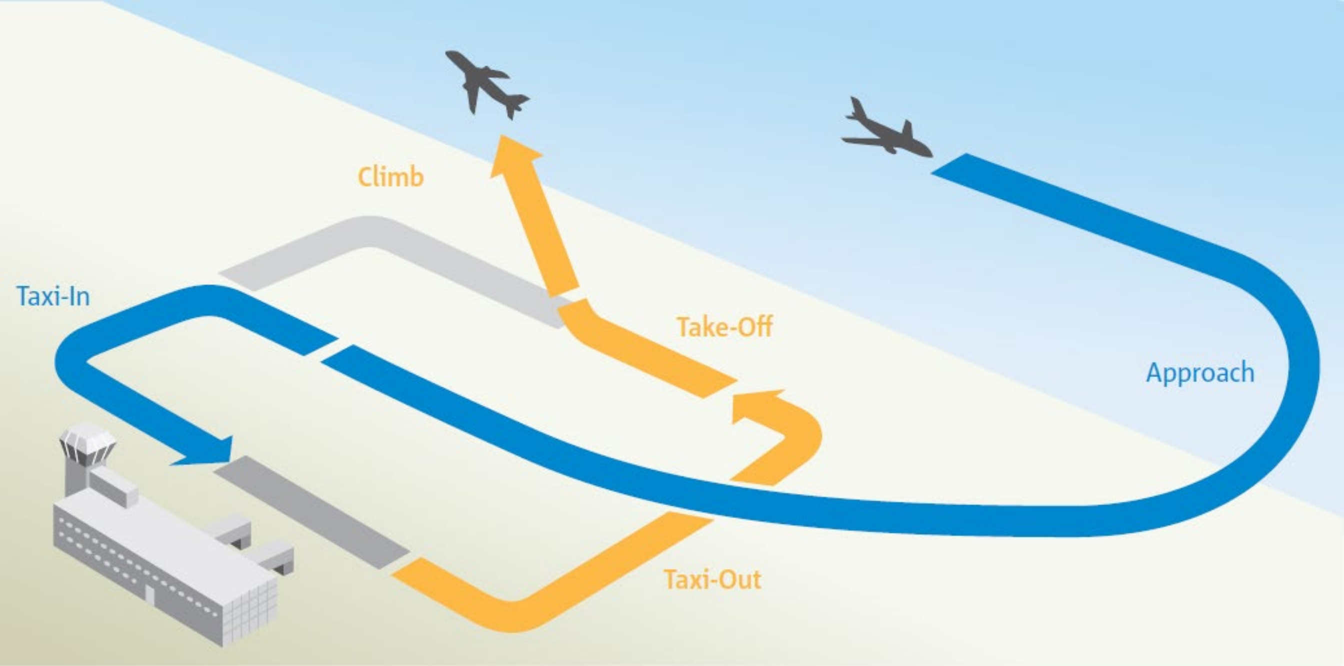

Figure 2-1. An illustration of the LTO cycle taken from figure 2.5 from the 2016 European Aviation Environmental Report [9]

Aircraft emissions can also come from Touch-and-Go (TGO) operations. AEDT defines a TGO operation as a “flight operation that begins with a level flight in the terminal control area, descends and lands on an airport runway, and then takes off immediately after landing and returns to level flight.” [10] Since TGO operations are not typically captured in publicly available datasets, they are only considered in the inventory when specifically provided by state, local, or Tribal organizations.

3 Methodology

3.1 Airport Activity Data

Free and publicly available federal data representing aviation activity for 2023 is somewhat limited in scope. Similar to previous years' emission inventory reports, aviation data are available from the 2023 Air Carrier Statistics database, also known as the T-100 (T-100) data bank [3], Terminal Area Forecast (TAF) data for 2023 (estimates) [4], 2023 Air Traffic Activity Data Systems (OPSNET) data [5], and 2023 data from the Airport Information Data Portal (ADIP) [6], formerly referred to as the Airport Master Record (form 5010) data. The T-100 data, which is produced by the US Department of Transportation's Bureau of Transportation Statistics, "contains domestic and international airline market and segment data" and includes "carrier, origin, destination, aircraft type and service class for transported passengers, freight and mail, available capacity, scheduled departures, departures performed, aircraft hours, and load factor" for airports that "are located within the boundaries of the United States and its territories" [3]. In addition, T-100 provides estimates of capacity (available seats), payload, distance traveled, and aircraft type. These additional pieces of information can be used to estimate aircraft weight and divide T-100 activity into those for AC operations and those that count as air taxi operations. As such, the T-100 data provides one of the best, freely available sources to calculate aviation emissions since the aircraft type can be aligned with the FAA's Aviation Environmental Design Tool (AEDT) software to calculate emissions from aircraft, APUs, and GSEs. Unfortunately, the T-100 data does not provide any information on engine type or aircraft age.

TAF and OPSNET data do not provide separate estimates of operations (takeoffs (TO) and landings (LD)) at the same level of detail as the T-100 data. Instead, total operations are provided for general aircraft types (i.e., air carriers, air taxis, general aviation, and military). OPSNET includes actual operations at FAA-controlled facilities, while TAF includes forecasted and estimated operations, but neither data source provides enough detail to calculate emissions using AEDT. Note that TAF operations estimates are based on the federal fiscal year (October 1 to September 30), not the calendar year. For this work, UNC-IE prioritized OPSNET data over TAF data when both were available for an airport. More information on how the disparate data sources were used in estimating emissions can be found in section 3.4.

The ADIP data are populated from FAA forms used for airport infrastructure planning and include information about airport characteristics, and some records have operations for similar general aircraft types as the TAF/OPSNET. For records in the ADIP data without aircraft category, there may be estimates of different aircraft types, e.g., Single Engine Aircraft, Multi Engine Aircraft, Jet Engine Aircraft, Helicopters, etc. based at the airport, and UNC-IE assumed that all of these aircraft can be grouped as general aviation unless the airport is designated as a military airport. UNC-IE used the "MILITARY_JOINT_USE" flag as well as the "OWNERSHIP" field to look for Air Force, Army, or Navy-owned facilities to determine if the airport was military-only. Activity data from military airports were assumed to be military-related and assigned to the 2275001000 SCC. Note that ADIP aircraft operations estimates are not typically updated due to the time and costs involved. In cases where ADIP data only had counts of aircraft types, UNC-IE assumed one operation per aircraft per day for a total of 365 operations per aircraft type.

3.2 Airport Inventory

To develop the airport inventory, UNC-IE started with a table provided by the EPA that included an EIS facility identification number (EIS ID) and a series of columns with airport codes that were associated with that EIS ID in past inventories. The dataset also included a potential matching airport ID in AEDT. The EPA data, since it represents all airports used in previous inventories, contained many rows of duplicate entries for the same airport, as well as airports that were closed prior to 2023. Significant effort was involved with cleaning the data and helping the EPA identify duplicate entries.

Using this data, UNC-IE developed a crosswalk table that matched EIS IDs with 1) AEDT IDs (if present in AEDT); 2) Official Airline Guide (OAG) codes used in the T-100 data; and 3) the 3–4-character airport location identifiers used in OPSNET, TAF, and ADIP. This process uncovered several inconsistencies in airport naming conventions and examples where one dataset, like the T-100, used outdated three-character codes to refer to airports (e.g., Yuma International Airport transitioned from YUM to NYL in 2008, but it was still listed as YUM in the T-100 data). The crosswalk table developed by UNC-IE also contains Boolean fields for T-100, OPSNET, TAF, and ADIP to indicate whether or not there were airport operations for 2023 for each facility in the respective data sources. EIS facilities that did not have operations data from at least one data source were excluded from the NEI. This restriction greatly reduced the total number of airports in the inventory. While over 19,000 airports match up to one of these potential sources of activity data, only about 62% of those airports had potential activity for 2023. Facilities that were present in T-100 or ADIP but not present in the EIS data were evaluated, and if the facility was operational and could be located in GIS, it was added to the EIS database accordingly. Airports located outside of the United States, Virgin Islands, and Puerto Rico were also excluded from the inventory. UNC-IE also consulted the NPIAS dataset of 3,287 airports classified by size to confirm airport codes.

For quality assurance and to check airport locations, UNC-IE downloaded open-source airport data available from the Humanitarian Data Exchange (HDE) for the U.S.,[1] Puerto Rico,[2] and the U.S. Virgin Islands,[3]and added a field in the crosswalk table to facilitate airport matching. This dataset was useful for identifying airports that are no longer in operation.

For the 2023 NEI, 12,173 of the 19,797 airports listed in the EIS are included. The other 7,624 airports were excluded either due to lack of data; to prevent duplication; or due to possible airport closure according to the HDE dataset. Note that one airport in New Jersey that did not have activity from any of our available sources was included using operations data from the 2020 inventory at the request of the State. Point source coordinates in the EIS were not compared against coordinates in the AEDT database as part of this effort. The 12,173 airports in this inventory included airports that only had TGO activity.

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[1] https://data.humdata.org/dataset/ourairports-usa.

[2] https://data.humdata.org/dataset/ourairports-pri.

[3] https://data.humdata.org/dataset/ourairports-vir.

In the 2017 inventory, there were a total of 19,336 airports included, but the 2020 inventory only included 5,959 airports.

3.3 Aircraft Engine Type Codes (AETC)

For each inventory cycle, a mapping of airframe and engine types to SCC must be undertaken to ensure that aircraft emissions are assigned to the proper SCC code. To accomplish this, UNC-IE pulled data from AEDT 3g that combined airframes (`[FLEET].[dbo].[FLT_AIRFRAMES]`) and engines (`[FLEET].[dbo].[FLT_ENGINES]`) using the equipment table (`[FLEET].[dbo].[FLT_EQUIPMENT]`), with the assumption that AEDT 3g represented the best available repository for operational aircraft. AEDT also included categorical information about airframe size (`[FLEET].[dbo].[FLT_CAT_SIZES]`) and usage (`[FLEET].[dbo].[FLT_CAT_USAGE]`). After combining these values into a new AETC table, UNC-IE matched the AEDT airframes to T-100 airframes whenever possible. As with the airport matching process, there were often discrepancies between the airframe description in AEDT compared with the airframe description in T-100, and UNC-IE attempted to find the best available match using web-based searches whenever necessary. The AETC table was then updated with generic aircraft and engine types for each aircraft-related SCC code.

Based on feedback from officials with the Hartsfield-Jackson Atlanta International Airport Authority and Georgia Department of Natural Resources, UNC-IE updated the AETC table with a designated SCC code using AEDT designations and T-100 seat information following the approach described in Table 3-1. In the table, the designation values are as follows: M: Military, G: General Aviation, and C: Commercial, with engine types as: J: Jet, T: Turboprop, and P: Piston. It should be noted that the SCC codes assigned serve as a "best guess" and there are many examples of airframes operating in a different manner than the SCC code implies. Local airport authorities know their operations best, and UNC-IE relied on state and Tribal agencies to assign the best SCC code to their operations data during the state, local, and Tribal (SLT) agencies' data review process. The updates to the AETC table made for this inventory resulted in shifts of activity and emissions from the 2020 inventory to the current inventory.

Table 3-1. Hierarchical approach to assigning SCC codes based on AEDT designations, engine types, aircraft sizes, aircraft usage, and T-100 seats.

AEDT Designation	AEDT Engine Type	AEDT Aircraft Size	AEDT Max Seats	T-100 Seats	SCC Code
M				N/A	2275001000
M	J, T			0-60	2275050012
M	P			0-60	2275050011
G	T				2275050012
G	P				2275050011
G	J	Light, Medium			2275050012

AEDT Designation	AEDT Engine Type	AEDT Aircraft Size	AEDT Max Seats	T-100 Seats	SCC Code
G	T, J		5-60	5-60	2275060012
C			>60		2275020000
C	T, J		0-60	0-60	2275060012
C	P		0-60	0-60	2275060011
C	T	Light			2275050012
C	P	Light			2275050011
C, G	P		5-60	5-60	2275060011
C, G		Heavy, Large			2275020000

3.4 Airport Operations

3.4.1 Preparation of operations data for airports that have airframe information

T-100 data were available and matched to an EIS facility ID and AEDT airport ID for 1,304 airports. As stated previously, while T-100 operations data include airframes, they do not include engines. For this inventory, UNC-IE selected the maximum AEDT equipment ID matching the T-100 airframe, usually corresponding to newer aircraft, to provide SLT agencies with a best-guess on the equipment ID that AEDT would use in its modeling. More specifically, the largest `[EQUIP_ID]` from `([FLEET].[dbo].[FLT_EQUIPMENT])` with the airframe matching what was listed in the T-100 dataset was assigned. This may have unintentionally resulted in modeling younger aircraft with potentially newer engines, but without additional information about aircraft age or engine type available, the selection of `[EQUIP_ID]` to use in AEDT modeling is arbitrary.

For airports with T-100 data, T-100 is always considered the primary data source, and operations are presented by airframe and engine type for aircraft found in the dataset. For other aircraft-related SCCs, UNC-IE relied on total annual operations found in a secondary source, and operations were assigned using generic airframe and engine type codes. UNC-IE consulted OPSNET, TAF, and ADIP data (respectively) as secondary sources for each of these airports to determine if there was additional air taxi, general aviation activity, or military activity. For general aviation, air taxi, and military activity, UNC-IE included additional operations from those data sources, i.e., if OPSNET had air taxi operations, operations data included air taxi from T-100 plus air taxi from OPSNET (OPSNET air taxi minus air taxi T-100). The estimates for any additional air taxi, military, and general aviation operations from OPSNET, TAF, or ADIP were attributed to generic airframes representative of the generic aircraft type. More information about primary and secondary data sources can be found in section 3.4.3.

Since none of the operations data from OPSNET, TAF, or ADIP include information about aircraft engine types, UNC-IE relied on data contained in Table 3.2 of the 2023 General Aviation and Part 135

Total Hours Flown by Actual Use by Aircraft Survey [4]. This information provides an estimate of the total hours flown by fixed wing aircraft with piston engines and all fixed wing aircraft which allowed UNC-IE to determine the nationwide ratio of piston to turbine operations for both GAA and AT operations. Table 3-2 highlights the relevant information used to calculate the piston to turbine fractions. For GAA operations, piston engines represent 72% of all activity and 28% of activity are attributed to turbine engines. For AT operations, piston engines represent only 10% of all activity with 90% of activity attributed to turbine engines. Note these totals do not include hours flown by Other, Experimental, and Special Light-sport aircraft.

Table 3-2. Piston versus total hours by aircraft type and class to determine piston/turbine fractions.

Aircraft Type	Class	Piston Hours	Total Hours	Piston (%)	Turbine (%)
Fixed Wing	GAA	15,830,087	20,865,506	76%	24%
Rotorcraft	GAA	619,914	2,006,498	31%	69%
ALL	**GAA**	**16,450,001**	**22,872,004**	**72%**	**28%**
Fixed Wing	AT	238,540	2,399,859	10%	90%
Rotorcraft	AT	23127	171,913	13%	87%
ALL	**AT**	**261,667**	**2,571,772**	**10%**	**90%**

UNC-IE used estimates of distance travelled from the T-100 data to approximate appropriate stage length values to use in AEDT modeling. AEDT uses stage length as a proxy for aircraft weight due to fuel weight with the assumption that aircraft require more fuel to travel longer distances. Heavier aircraft require more thrust and therefore burn more fuel on take-off. UNC-IE then created a lookup table using the airport facility ID, the AEDT equipment ID for the T-100 aircraft, the average distance traveled by that aircraft at that airport, and the corresponding stage length value. UNC-IE applied the appropriate stage length values to departing aircraft and used a stage length of 1 for all arrivals. Table 3-3 provides a summary of how stage length was assigned based on average distance. Table 3-4 demonstrates the impact on fuel burn and nitrogen oxide (NOx) emissions with increasing stage length for an example aircraft at John F. Kennedy International airport in New York City. All arrivals use a stage length of 1, and stage length values with “M” are meant to represent maximum distance traveled.

Table 3-3. Stage length values by average distance (nautical miles) traveled for departures.

Average Distance Traveled (nmi)	Stage Length
1 – 499	1
500 – 999	2
1000 – 1499	3
1500 – 2499	4
2500 – 3499	5

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[4] https://www.faa.gov/data_research/aviation_data_statistics/general_aviation/cy2023

Average Distance Traveled (nmi)	Stage Length
3500 – 4499	6
4500 – 5499	7
5500 – 6499	8
6500 +	M

Table 3-4. Boeing 737-800 series fuel burn and NOx emissions at stage lengths (SL) 1 through 6 at John F. Kennedy International airport.

Stage Length	Fuel Burn (Short Tons)	Difference from SL = 1	NO_x (Short Tons)	Difference from SL = 1
1	7.17E-01	-	6.28E-03	-
2	7.28E-01	1.50%	6.46E-03	2.89%
3	7.41E-01	3.22%	6.71E-03	6.44%
4	7.65E-01	6.34%	7.18E-03	12.54%
5	7.91E-01	9.33%	7.66E-03	18.03%
6	8.02E-01	10.62%	7.87E-03	20.28%

3.4.2 Preparation of operations data for airports without airframe information

Most airports in the inventory did not have operations counts in the T-100 data. For these airports, UNC-IE relied on the total operations provided by (in order) OPSNET, TAF, and ADIP. Data sources were queried for 2023, but some data sources, like ADIP, have operations estimates that may not have been updated for 2023. If the primary data source did not have operations for a given operation type, UNC-IE consulted the secondary data source for that operation type. For airports where the ADIP data was the primary source, UNC-IE queried those airports to find records with estimates of air taxi, general aviation, and military operations. For airports without these values, UNC-IE summed the counts of single engine aircraft, multi-engine aircraft, jet engine aircraft, and helicopters and assumed one operation per day per aircraft type to calculate total general aviation operations. If an airport did not have any data that could be used to estimate operations, it was excluded from the inventory. UNC-IE used the piston to turbine fractions in Table 3-2 to allocate operations between piston and turbine engines.

3.4.3 Primary and Secondary Source Determination

UNC-IE defined primary and secondary data sources for each of the representative airports using the hierarchical approach described in 3.4.1 and 3.4.2. For airports with T-100 data, T-100 is always considered the primary data source, and operations are presented by airframe and engine type for aircraft found in the dataset. Then, the secondary source is consulted to look for missing operations or different activity not represented in the T-100 data. Similarly, for airports with a primary data source of OPSNET, TAF, or ADIP, UNC-IE relied on total annual operations counts found in the primary source and then examined the secondary data source for additional operations.

Table 3-5 shows a breakdown of the number of airports by primary and secondary data source. Note that these sums do not include additional operations that were able to be modeled in AEDT that came from SLT agency inputs. Additionally, New Jersey requested that operations from 2020 were used to supplement 2023 data for two airports, KNEL and KWRI. There were operations in the T-100 data for KWRI, and UNC backfilled operations using generic aircraft to match the 2020 inventory totals for this airport. KNEL had no operations data for 2023 in our available sources, so UNC created operations to match the 2020 inventory. The "Included in Inventory" column indicates the number of airports with data that were ultimately included in the inventory. Over 100 airports were determined to either have closed or were duplicated and therefore not included in the inventory despite having operations estimates from one or more sources.

Table 3-5. Primary and secondary data sources with total counts of airports.

Priority	Primary Data Source	Secondary Source	Number of Airports	Included in Inventory
1	T-100	OPSNET	471	471
2	T-100	TAF	656	656
3	T-100	ADIP	165	165
4	T-100	N/A	13	13
5	OPSNET	TAF	54	54
6	TAF	ADIP	2,091	2,088
7	TAF	N/A	2	2
8	ADIP	N/A	8,850	8,751
	Airports with SLT-only data			1
	TOTAL with data			**12,201**
	No available data (excluded from inventory)			7,596
	TOTAL airports in EIS			**19,797**

3.4.4 State/Local/Tribal (SLT) input on operations data

For the 2023 inventory, UNC-IE built a small cloud-based web server to facilitate the sharing of comma separated value (CSV) files of operations data by SLT agency. UNC-IE developed a python script to build the operations data CSV files incorporating the methodology outlined in Section 3.4 of this document. Agency representatives were given two months to review the operations data prepared by UNC-IE for their area. The website allowed users to download operations data and then make any necessary changes offline. The user then returned to the website to upload the revised CSV file. The server applied some simple automated QA checks to ensure all necessary fields were included to preserve data integrity, and revised data was reviewed by UNC-IE to ensure compatibility. Appendix A includes the instructions that were sent to each state. Table A-1 contains a complete listing of the fields provided for SLT representatives to download, along with an explanation of the field, and an example value. Representatives from eight different states (Connecticut, Delaware, Georgia, Maryland, Maine, North Carolina, Virginia, and Washington), the District of Columbia, one local agency (Maricopa County Air Quality Department), and the District of Columbia provided revised operations data either through the website or via email. Five additional agencies requested login information but did not provide any updated operations data for UNC-IE to review. As mentioned earlier, New Jersey made requests related to using 2020 operations data for two airports after an initial draft of the inventory was shared with SLT agencies. The Commonwealth of Virginia was the only agency to provide TGO operations. UNC-IE decided to split out the TGO operations into a separate file since it requires different AEDT parameters for modeling. Table 3-6 summarizes the total number of airports in EIS compared with the total number of airports included in the 2023 inventory by state and highlights the states that responded to the data request.

Table 3-6. A comparison of the total number of active airports in EIS by state with the number of airports included in the 2023 inventory and agencies that responded to the data request.

State	Airports in EIS	Airports Included	SLT Response
AK	839	636	
AL	296	168	
AR	306	187	
AZ	309	182	Maricopa County only
CA	916	458	
CO	463	278	
CT	134	43	X
DC	14	7	X
DE	43	31	X
FL	866	548	
GA	462	330	X
HI	50	24	
IA	297	186	
ID	290	233	
IL	774	394	
IN	592	321	
KS	373	284	
KY	253	146	

State	Airports in EIS	Airports Included	SLT Response
LA	492	234	
MA	236	100	
MD	216	51	X
ME	191	129	X
MI	481	332	
MN	462	301	
MO	506	308	
MS	255	156	
MT	279	230	
NC	452	329	X
ND	285	217	
NE	250	163	
NH	145	71	
NJ	301	122	X
NM	172	116	
NV	129	97	
NY	568	334	
OH	679	396	
OK	394	269	
OR	455	300	
PA	809	388	
PR	53	21	
RI	27	13	
SC	201	145	
SD	175	127	
TN	341	226	
TR	9	7	
TX	1920	1205	
UT	154	95	
VA	431	249	X
VI	7	6	
VT	88	46	
WA	552	383	X
WI	557	383	

State	Airports in EIS	Airports Included	SLT Response
WV	123	76	
WY	125	92	
TOTAL	**19797**	**12173**	

3.4.5 Final operations data

After the SLT review period ended, UNC-IE finalized operations data to use for emissions calculations through a series of Python scripts. First, UNC-IE confirmed that state edits did not result in any duplicate operations data for any given airport and that all airport characteristics, like the OAG code, were correct. Next, UNC-IE checked to ensure that the state response had a valid AEDT equipment ID. If an equipment ID was missing, UNC-IE attempted to assign the value using the airframe and, if included, the engine model provided in the state response. In the event of any conflicts, UNC-IE used the table of AEDT equipment and AETC codes as discussed in Section 3.3 to provide a valid equipment ID. Then, UNC-IE checked for equipment that could not be run in AEDT due to a lack of an AEDT profile. AEDT profiles provide the software with the information required to calculate emissions for the flight cycle. This profile check was conducted on both the LTO files and the TGO files. For any operations without an AEDT profile, substitute equipment from similar equipment was assigned instead. Note that some military aircraft that employ vertical takeoff and landing cannot be modeled in AEDT at this time. Operations with those aircraft were changed to use generic military emissions calculations. See Appendix E for a complete listing of substitute equipment used. Lastly, UNC-IE checked for state-provided taxi-in and taxi-out durations. AEDT taxi-time defaults were used in lieu of missing state reported estimates.

AEDT has a limited set of profiles for modeling TGO operations. Many of the TGO operations provided by VA were for aircraft that did not have a profile available in AEDT. As a result, only 17,012 of the 47,488 TGO operations reported by VA were available to model using AEDT. Furthermore, because the generic emission factors provided by the EPA are for LTO cycles, it is not possible to use generic emission factors to calculate emissions from TGO operations outside of AEDT. These operations were not included in this inventory. The final operations data used for the modeling can be found in Appendix B.

After several rounds of emissions inventory development and a draft version of the inventory was shared with SLT agencies, several important edits were made. First, New Jersey responded with edits, and Connecticut requested five small airports be removed. Second, several additional airports that had initially been included in the inventory were subsequently found to be closed. Third, the previous draft inventories used a different approach to determine the nationwide ratio of piston to turbine operations for both GAA and AT operations. The previous approach used data provided by the FAA for the fraction of activity by engine type at various airport sizes from 2021. This data provided information about the percent of total operations by jet, turboprop, turboshaft, and piston aircraft for airports classified by their planning capacity. After further EPA analysis of the methodology, the EPA decided that the approach should be revised to use the approach described in Section 3.4.1 instead. As a result, the final allocation of generic activity for GAA and AT flights is different than the allocation shared with and reviewed by SLT agencies, except in cases when the SLT agency responded with specific changes to operations estimates and provided comments to indicate the change. In these cases (specifically for CT, DE, and DC), the allocation of piston to turbine operations was left per STL agency inputs.

3.5 Emissions Calculations

3.5.1 AEDT Modeling to Calculate Emissions from Aircraft, GSE, and APUs

Given the large number of airports to be modeled using AEDT, UNC-IE developed a script-based approach to automate the 1) creation of AEDT Standard Input Files (ASIFs) and 2) utilize AEDT's command line tools to create, import, and run studies. ASIFs are based on the Extensible Markup Language (XML) and formatted based on information provided in AEDT's ASIF Reference [11]. Data from SLT responses were supplemented with other sources of data to generate ASIFs for each airport, organized by state and Tribal area. Key operations data in the ASIFs included: airframe model, engine code, taxi-in/taxi-out times (minutes), and operations divided evenly into arrivals and departures. In cases where the total operations was an odd number, an extra arrival was used to ensure that the sum of the arrivals and departures was equal to the total operations. The ASIF creation process also queried the AEDT database to ensure the tool's preferred airport code was used, to determine a primary runway, to select a default AEDT profile to use, and to determine aircraft wing type (fixed or rotary). If a runway was not present in the AEDT-provided airport layout, a custom runway using a length of 6,000' and width of 150' for fixed wing aircraft was implemented. The ASIF also requires coordinates for the runway ends. For airports with runway pairings in AEDT (runways are named based on the direction of approach, and AEDT often had both in the database), UNC-IE used the starting coordinates of the paired runway as the end coordinate. For example, if the goal is to model runway 01L, UNC looked for runway 19R in AEDT, and if found, it used the starting coordinates of 19R to quickly approximate the end coordinates for 01L. For runways without pairs in AEDT, or for custom runways, UNC-IE calculated an endpoint based on the length and bearing of the runway.

Many airports reported helicopter activity, but often a helipad or 'helicopter-runway' did not exist in the AEDT airport layout. In these cases, a custom runway designated "HUNC1" with a length and width of 200 feet at the airport location was generated. Custom track nodes were also created to help AEDT define the flight path and understand necessary operation modes to use. Each custom track assumed an 8,000 feet square around the airport and calculated track nodes at 45 and 225 degrees from the airport location.

After ASIFs were created for all operations data, UNC-IE developed a Python script that utilized AEDT's command line tools to import the ASIFs and run AEDT. Note that AEDT does not provide a command line tool to define metric results prior to a study run. To keep the process automated and avoid the necessity of using the AEDT Graphical User Interface (GUI), UNC-IE used Microsoft's SQL Server Management Studio (SSMS) and SQL Server Profiler tool to record the queries executed in the study database and then implemented them into the script. The script looped through each state and Tribal directory to import and then run each ASIF. A progress table on the SQL Server database was used to track the processing. For each airport and each step of the processing, the progress table was updated to indicate whether each step had been completed successfully. After AEDT was run for the airport, the script also queried the segment emissions table (`[RSLT_EMISSIONS_SEGMENT]`) to sum NOx emissions to check for non-zero emissions, indicating a successful run. The progress table included fields to identify the state, airport, and study name to facilitate retrieval of results. After all airports had been run to completion, UNC-IE compared some results in the `[RSLT_EMISSIONS_SEGMENT]` tables with the AEDT GUI-based results in the emissions report to ensure congruity. Note that while lead is included as a pollutant in the `[RSLT_EMISSIONS_SEGMENT]` table, all values were null, so lead emissions were estimated using a different approach outside of AEDT (See Section 3.5.3).

3.5.1.1 Limitations with Script-based AEDT Modeling

In total, 1,309 studies (including 6 for TGO operations) for 1,304 different airports were successfully run in AEDT. The emissions results are contained in the `RSLT_EMISSIONS_SEGMENT` table for each study. However, startup emissions, GSE emissions, APU emissions, and emissions from Hazardous Air Pollutants (HAPs) are not contained in this table. These emissions can only be seen when the final emissions report is loaded in the GUI. UNC-IE followed guidance in AEDT documentation and received technical support from U.S. Department of Transportation (DOT) Volpe Center staff to develop a scripted approach for calculating these emissions. For HAPs, the total organic gases (TOG) value along with associated engine and fuel mass fractions provided by AEDT were used to derive emissions estimates. Furthermore, AEDT does not calculate PM_{10} or $PM_{2.5}$ emissions from APUs or from aircraft by default. To calculate PM_{10} or $PM_{2.5}$ emissions from APUs, UNC-IE set the emissions equal to the emissions provided by the "PM" column. To calculate PM_{10} or $PM_{2.5}$ emissions from aircraft, UNC-IE set the emissions equal to the "TPM" (Total PM) column. This approach assumes that all of the particulate matter emitted by aircraft is smaller than 2.5 micrometers in diameter. UNC-IE compared the results generated by the AEDT GUI in the emissions summary table with script-based results for several airports to ensure consistency and accuracy.

3.5.2 Modeling to calculate emissions using generic emissions factors

For airports with activity without airframe information, UNC-IE followed the Method 2 approach used in previous NEI inventories. This approach relies on generic emission factors (Table 3-7) developed by the EPA [12] to calculate emissions for SCCs related to general aviation, air taxi, and military activity depending on the operations in the secondary source (OPSNET, TAF, or ADIP) for each airport using the following equation:

$$E_{ixj} = LTO_i \times FR_x \times EF_{ij} \tag{1}$$

Where:

E_{ixj} = Emission estimate for aircraft type i equipped with engine type x and pollutant j (short tons/year)

LTO_i = Annual count of LTO cycles for aircraft type i

FR_x = Fraction of LTOs equipped with engine type x

EF_{ij} = Generic emission factor for aircraft type i equipped with engine type x and pollutant j (tons/LTO)

i = Aircraft type (i.e., air taxi, general aviation, and military)

x = Engine type (i.e., jet or turboprop, and piston engine)

j = Criteria pollutant j

Note that the approach above uses Landings and Take-offs (LTOs), not individual operations. As such, UNC-IE divided the total operations by two before performing the calculation, which assumed that total operations can be evenly split between TO and LD. To determine FR_x, UNC-IE used the fractions presented in Table 3-2. A complete listing of generic emissions factors is available in Appendix C.

Table 3-7. Generic emissions factors used for CAPs (pounds per LTO).

SCC	Description	CO	LEAD	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
2275001000	Military	25.96	-	22.34	1.39	1.36	2.11	10.87
2275020000	Commercial	22.38	-	18.58	1.08	1.05	1.78	6.16
2275050011	GA Piston	12.01	0.02	0.07	0.24	0.16	0.01	0.15
2275050012	GA Turbine	9.58	-	0.32	0.24	0.23	0.07	0.69
2275060011	Air Taxi Piston	28.14	0.02	0.16	0.60	0.42	0.02	0.17
2275060012	Air Taxi Turbine	3.61	-	0.78	0.60	0.59	0.16	1.01

3.5.3 In-flight Lead Emissions

Aircraft with piston engines use AVgas which, unlike traditional jet fuel, contains lead. While AEDT 3g has functionality to calculate lead emissions, it did not generate non-zero lead emissions estimates for any piston-powered aircraft modeled by UNC-IE. AEDT 3g also did not generate any lead emissions from APU or GSE associated with these aircraft. As a result, UNC-IE used the generic emissions factors (Method 2) to estimate lead emissions from LTO operations for all piston-powered aircraft. To calculate in-flight lead emissions, or the lead emissions associated with operations above 3,000 feet, UNC-IE used the approach outlined in the U.S. EPA's "Lead Emissions from the Use of Leaded Aviation Gasoline in the United States" [13]. UNC-IE first calculated the nationwide total fuel used by piston aircraft. This was 224,979,700 gallons based on information provided in Table 5.1 of the 2023 General Aviation and Part 135 Total Fuel Consumed and Average Fuel Consumption Rate by Aircraft Type summary [5]. UNC-IE did not include fuel used by aircraft categorized as "Other aircraft", "Experimental", or "Special Light-sport". UNC-IE then used the total lead emissions from LTO operations as calculated using Method 2 to estimate the fraction of total lead emissions each state contributed as a proxy for state fuel

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[5] https://www.faa.gov/data_research/aviation_data_statistics/general_aviation/cy2023

consumption. Finally, UNC-IE used the following formula to calculate total in-flight lead emissions in tons for each state. Note that in-flight lead emissions are aggregated to the state or Tribe level rather than reported at the airport.

$$IF_{pb} = (SC \times FC \times LC \times Rt \times CF) - LTO_{pb} \tag{2}$$

where:

IF_{pb} = Inflight lead estimates (tons of lead/year)
SC = State Contribution, or fraction of total lead emissions from each state
FC = Total 2023 aviation gas fuel consumption (gallons/year)
LC = Lead content of aviation gas (2.12 g lead/gallon of fuel)
Rt = Adjustment for lead retention rate of 5% equates to 0.95 Rt factor equation
CF = Conversion factor g to short ton (907200)
LTO_{pb} = Total lead emissions from GAA and AT use of aviation fuel (AVgas) associated with LTO activities (tons of lead/year) from each state

The total in-flight lead emissions for the inventory using this approach was 253.84 tons/year. The nationwide total lead calculated for LTO operations is 245.62 tons/year. Total lead emissions for all operations at all altitudes from aircraft is 499.46 tons/year. Note that AEDT 4a, released in January 2026, provides support to calculate lead emissions[6], and future inventories can leverage that capability for operations with known airframes.

3.6 Quality Assurance (QA) Steps

UNC-IE conducted rigorous QA on the emissions results. This was a multi-faceted approach that included checks to ensure that

- all aircraft activity as represented by the operations data was represented in calculated emissions;
- any SLT edits carried through to the final emissions summary;
- emissions calculated by AEDT were properly assigned to the Emissions Inventory System (EIS) facility;
- emissions were not accidentally duplicated; and
- scripted results matched results found in GUI-generated reports.

In addition, UNC-IE compared 2023 emissions results against previous years' emissions to ensure that 2023 calculations seemed reasonable. Figure 4-1 (below) shows the contribution by different SCCs to the total annual airport emissions in tons for CAPs for 2023 compared to previous inventories in 2020 and 2017. Differences between years for given pollutants can come from differences in data availability, the amount that generic emission factors were used in the inventory preparation, and differences in AEDT calculations due to differences in versions, equipment modeled, and evolution of the software

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[6] https://aedt.faa.gov/4a_information.aspx

itself. However, differences in SCC contributions to PM_{10} and $PM_{2.5}$ are minor and show consistency throughout the inventory years.

4 Summary of Airport Emissions

Table 4-1 summarizes the non-zero total annual emissions for both CAPs and HAPs from all airports in the inventory for 2017, 2020, and 2023. For a full listing of emissions by SCC code for all pollutants, please see Appendix D. Figure 4-1 shows how different SCCs contributed to CAPs emissions in 2023 compared to the previous two inventories in 2017 and 2020. It shows that military operations continue to be a primary source sector contributor for VOC and commercial operations are a primary contributor to NO_x emissions. Since virtually all of the commercial aircraft emissions are calculated by AEDT 3g, changes in the percent contribution of different source sectors over time by pollutant are likely due to changes in AEDT versions and are influenced heavily by AEDT input data. For reference, the 2020 inventory used AEDT version 3d, while the 2017 inventory used AEDT version 2d.

Table 4-1. Total annual emissions of CAPs and HAPs from all airports for 2017, 2020, and 2023.

Pollutant Name	Code	2017 Emissions (Tons)	2020 Emissions (Tons)	2023 Emissions (Tons)
Carbon Monoxide	CO	499,888	338,307	427,633
Lead	7439921	225	176	246
Nitrogen Oxides	NOX	134,333	85,900	140,420
PM10 Primary (Filt + Cond)	PM10-PRI	10,172	8,684	10,181
PM2.5 Primary (Filt + Cond)	PM25-PRI	8,909	7,693	8,860
Sulfur Dioxide	SO2	16,821	9,359	15,019
Volatile Organic Compounds	VOC	56,676	52,040	42,492
1-Methylnaphthalene	90120	1.70	0.03	1.00
1,3-Butadiene	106990	881.49	617.02	702.00
2-Methylnaphthalene	91576	104.33	72.77	81.69
2,2,4-Trimethylpentane	540841	14.53	7.40	11.38
Acenaphthene	83329	2.66	2.17	2.81
Acenaphthylene	208968	15.02	12.23	15.83
Acetaldehyde	75070	2,188.35	1,522.38	1,722.75
Acrolein	107028	1,241.93	866.39	977.42

Pollutant Name	Code	2017 Emissions (Tons)	2020 Emissions (Tons)	2023 Emissions (Tons)
Anthracene	120127	3.10	2.52	3.27
Benz[a]Anthracene	56553	0.37	0.30	0.39
Benzene	71432	977.15	680.94	801.70
Benzo[a]Pyrene	50328	0.37	0.30	0.39
Benzo[b]Fluoranthene	205992	0.44	0.36	0.46
Benzo[g,h,i,]Perylene	191242	0.95	0.77	1.00
Benzo[k]Fluoranthene	207089	0.44	0.36	0.46
Carbon Dioxide	CO2	29,619,242	28,413,566	40,538,901
Chrysene	218019	0.37	0.30	0.39
Cumene	98828	1.50	1.06	1.19
Dibenzo(a,h)Anthracene	53703	0.00	0.01	0.00
Ethyl Benzene	100414	134.08	93.10	117.11
Fluoranthene	206440	3.32	2.71	3.50
Fluorene	86737	5.51	4.48	5.80
Formaldehyde	50000	6,331.34	4,406.26	4,995.23
Hexane	110543	30.76	15.28	29.10
Indeno[1,2,3-c,d]Pyrene	193395	0.29	0.24	0.31
Methanol	67561	914.17	637.61	715.83
Naphthalene	91203	617.41	470.09	577.82
Phenanthrene	85018	9.27	7.58	9.77
Phenol	108952	367.68	256.46	285.49
Propionaldehyde	123386	374.55	258.10	292.27
Styrene	100425	165.90	116.47	133.62
Toluene	108883	636.46	450.56	584.31
Xylenes (Mixed Isomers)	1330207	178.36	225.68	288.76
m-Xylene	108383	72.56	0.38	9.77
o-Xylene	95476	84.86	58.64	71.02
p-Xylene	106423	58.66	0.00	0.00

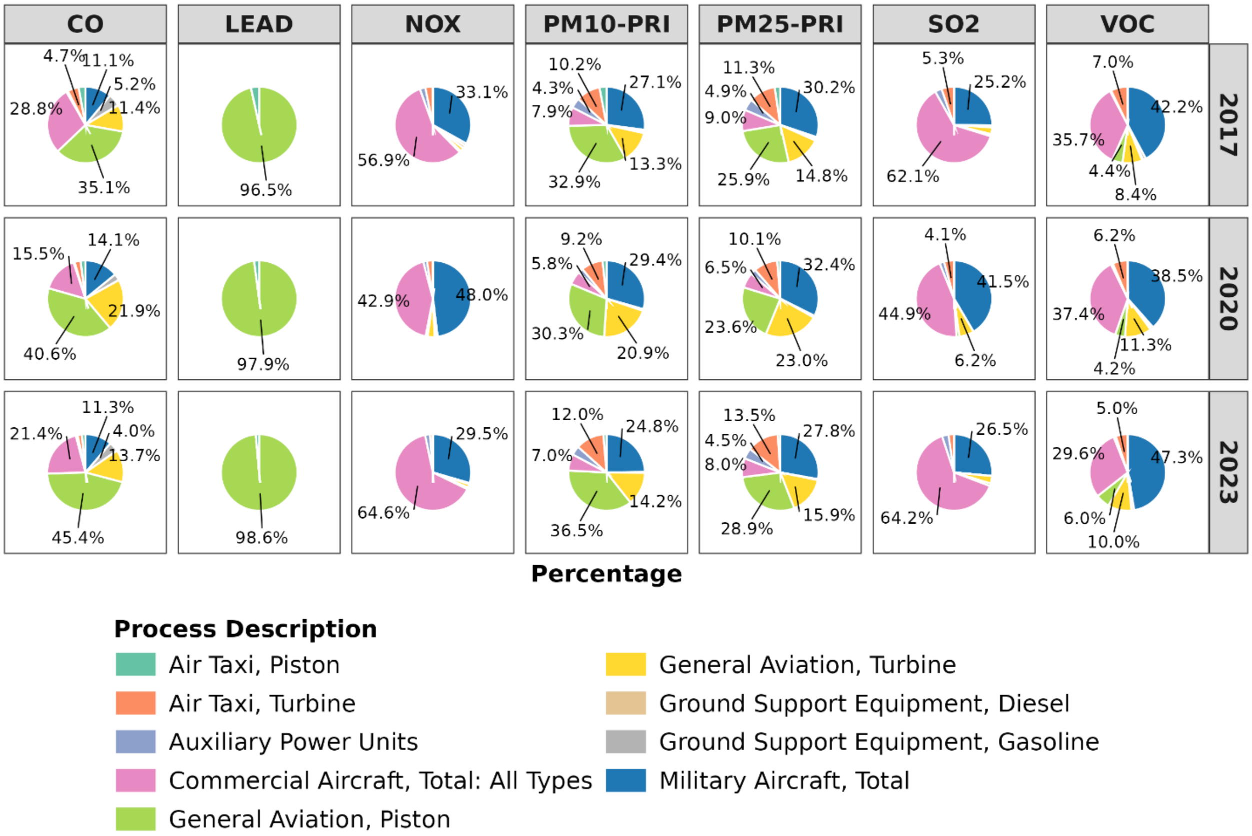

Figure 4-1. Total Annual Airport Emissions (tons) by SCC Descriptions for CAPs for 2023 Compared to Previous Inventories

Table 4-2 shows the overall emissions factors by SCC when averaged over all airports as calculated by dividing the sum of AEDT emissions using Method 1 by the total LTOs modeled for each SCC. Average VOC emissions factors from military aircraft also tend to be higher in AEDT results compared to other SCCs. Given that the differences between the average overall emissions factors as calculated by AEDT for 2023 activity and the default generic emissions factors in Table 3-7 are substantial, a review of the generic emissions factors used for all SCCs may be warranted. Note that there were no operations for SCC 2275060011 in the operations modeled by AEDT. A complete listing of generic emissions factors is available in Appendix C.

Table 4-2. Average overall emissions factors by SCC based solely on AEDT output (pounds per LTO) for typical LTO cycle modeling (does not include TGO operations).

		Pollutant						
SCC	**Description**	**CO**	**CO2**	**NOx**	**PM10-PRI**	**PM2.5-PRI**	**SO2**	**VOC**
2275001000	Military	18.34	2,171.17	5.53	0.08	0.08	0.91	6.66
2275020000	Commercial	21.10	5,289.53	20.91	0.16	0.16	2.23	2.89
2275050011	GA Piston	63.53	162.41	0.03	0.04	0.04	0.07	1.94
2275050012	GA Turbine	2.10	303.04	0.55	0.01	0.01	0.13	0.31
2275060012	Air Taxi Turbine	7.30	822.37	1.57	0.03	0.03	0.35	1.60

Table 4-3 shows the total CAPs emissions for the top 10 airports by 2023 volume in alphabetical order. This figure highlights how large airports contribute a significant percentage of nationwide emissions except for lead.

Table 4-3. Top 10 large commercial airport CAP emissions and their contribution (%) to total nationwide emissions.

Airport	**CO**	**LEAD**	**NOX**	**PM10-PRI**	**PM25-PRI**	**SO2**	**VOC**
KATL	5,334.5	0.0	4,963.4	59.7	59.6	528.0	517.4
KCLT	2,741.3	0.1	2,170.2	39.9	38.7	236.9	358.9
KDEN	4,158.2	0.0	2,769.4	46.4	45.7	315.2	425.7
KDFW	4,846.4	0.0	3,885.2	48.6	48.4	426.5	581.8
KIAH	3,375.4	0.0	2,223.9	36.2	35.6	267.0	385.8
KJFK	5,727.9	0.0	5,152.2	52.6	52.3	508.2	750.1
KLAS	3,092.4	0.2	2,403.9	53.8	51.9	246.4	322.5
KLAX	4,151.8	0.0	4,928.5	50.6	50.2	425.0	509.2
KORD	5,113.0	0.1	4,009.3	67.0	65.9	430.7	550.2
KPHX	2,469.6	0.1	1,973.7	29.0	28.5	209.1	267.7
TOTAL	41,010.5	0.6	34,479.7	483.8	476.7	3,593.0	4,669.4
Nationwide Total	427,583	246	140,421	10,181	8,860	15,019	42,493
Contribution	9.59%	0.23%	24.55%	4.75%	5.38%	23.92%	10.99%

Figure 4-2 and Figure 4-3 show the total CAPs emissions by arrival/departure and operating mode as defined by AEDT respectively, for three different sized airports: KATL (Atlanta Hartsfield-Jackson, Georgia), the busiest airport in the world; KABQ (Albuquerque, New Mexico), a medium-sized airport; and KLBC, a small commercial airport in Long Beach, California. These figures demonstrate the degree to which different engine thrust parameters can affect emissions and highlight the difficulties in using a single generic emissions factor for a given SCC code when airframe-specific data is not available. Note that plots for lead were omitted, because AEDT does not calculate any lead emissions by default.

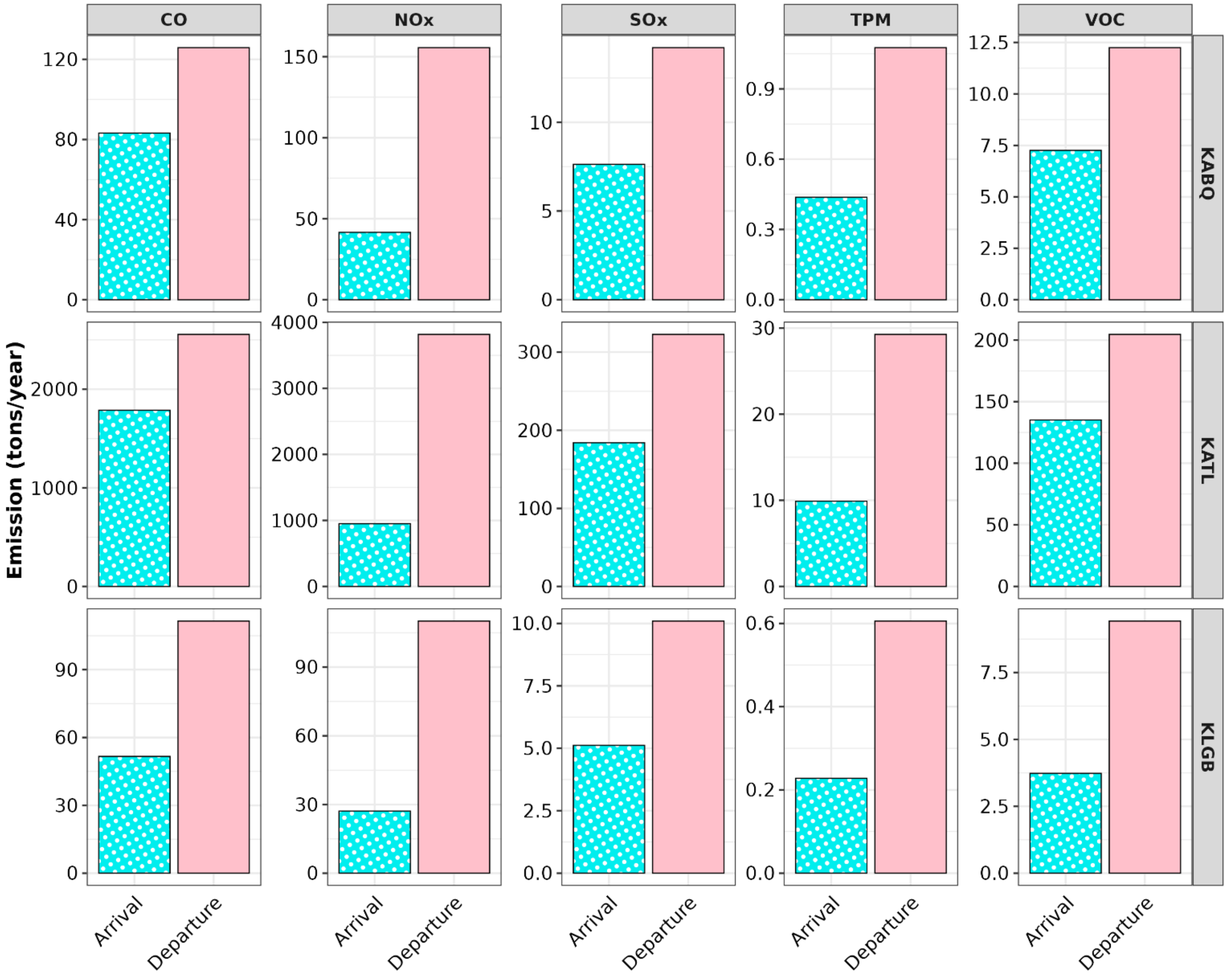

Figure 4-2. CAP emissions by arrival/departure for KABQ, KATL, and KLGB. TPM is total particulate matter.

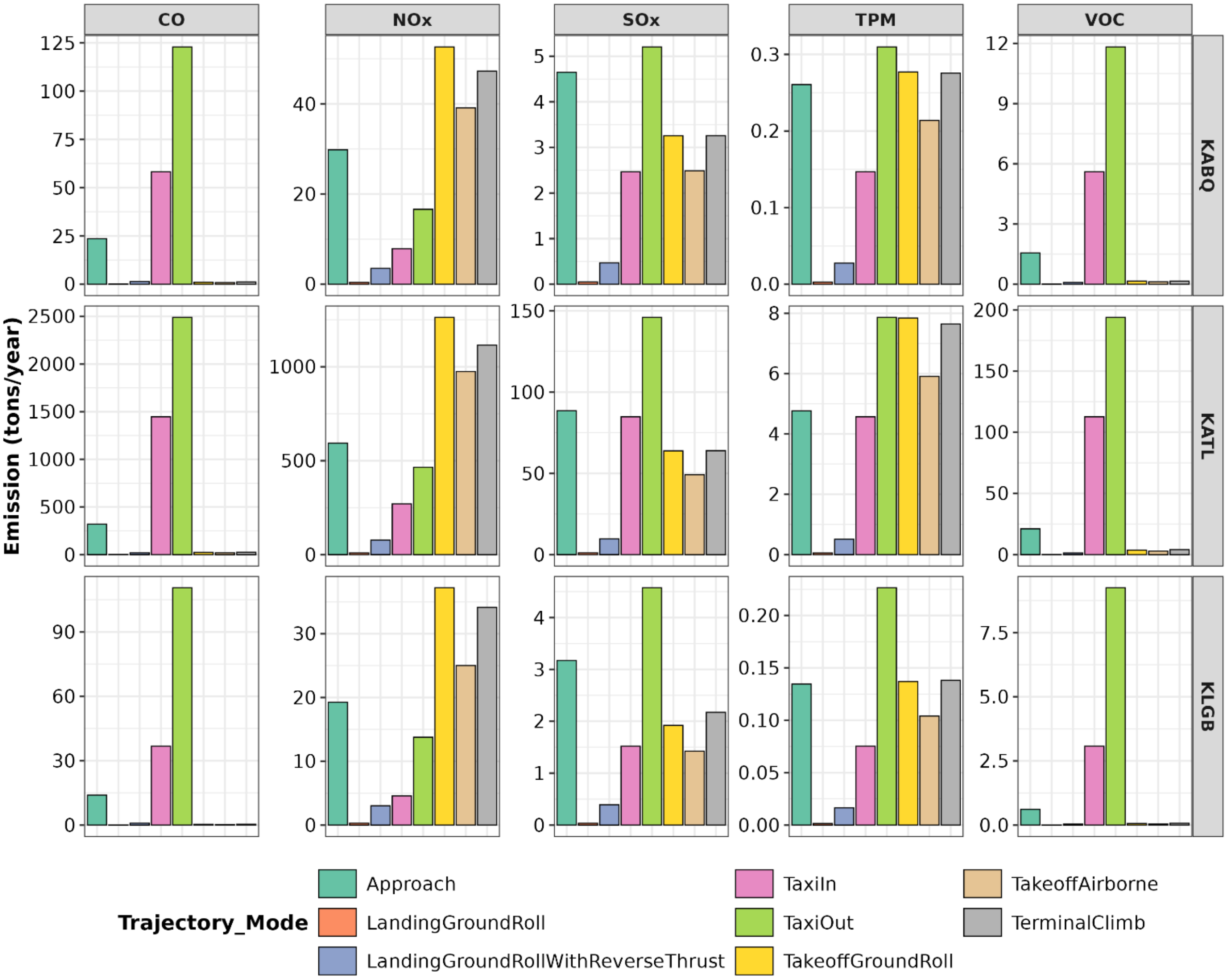

Figure 4-3. CAP emissions by AEDT mode for KABQ, KATL, and KLGB. Approach, Landing ground roll, Landing ground roll with reverse thrust, and Taxi in are associated with arrivals. Taxi out, Takeoff ground roll, Takeoff airborne, and Terminal climb are associated with departures.

5 Future Improvements

The development of the aircraft sector emissions estimates for the triennial NEI requires reliable estimates of activity at every airport, and it also requires substantial collaboration between SLT agencies, the EPA, and any outside collaborators who help put together the inventory. Given the level of effort required to assemble the activity and calculate the emissions, there are several ways that the process can be improved. These recommendations range from improvements in data sources to changes in emissions factors to changes in how the NEI assigns SCC codes. The following is a summary of some suggestions for future improvements for estimating emissions from the aircraft sector.

5.1 Data Sources

This aircraft inventory for 2023 and inventories before it have relied primarily on freely available data and SLT agencies' input. Free data sources are readily available via the web and are typically updated on an annual basis. However, as has been mentioned, there are issues with these data in terms of accuracy and usability, and some of the datasets are estimates or are outdated. Data about military operations by airframe are particularly hard to come by due to security concerns. Significant effort would be involved in trying to derive better military operations estimates. Better operations estimates may be obtained through direct contact with base commanders or through culling through Air Installation Compatible Use Zone (AICUZ) reports to identify airframes associated with the base, but the level of effort associated with those two options was greater than the scope of this project. However, it is clear that military bases are an important contributor to aircraft-related emissions, as was shown in a study in California [14].

Over the course of aircraft emissions inventory development, there are several opportunities for SLT agencies to provide input on aircraft operations. Despite efforts to revise the process of obtaining SLT agency input, less than ten states responded with any comments or edits. The lack of response is likely due to the SLT agency not having access to better data.

Substantial improvements in operations estimates could be derived by using data from commercial data providers, such as FlightAware[7] which in turn relies on Automatic Dependent Surveillance – Broadcast (ADS-B) among others. There have been limited research activities to estimate emissions from ADS-B data feeds, but this offers a rich potential for improving upon the current approaches. These datasets have the potential to provide more accurate airframe and engine information for each arrival and departure. They also have the potential to reduce or potentially eliminate the need for calculating emissions using generic emissions factors from generic aircraft types, because data may be available from many more airports, even small general aviation airports. The datasets typically use ground-based and satellite sources or transponders to collect data transmitted by aircraft during flight, so they constitute a rich dataset that could be used to more accurately model aircraft emissions below 3000 feet. Some aircraft do not have the required transponder equipment, or in the case of military aircraft, do not allow commercial providers to track it.

5.2 SCC Codes

The current SCCs try to classify emissions by the size of the aircraft along with the engine type and usage of the aircraft. This method works fairly well for most aircraft, but there are examples where airport authorities differ in their understanding of what is commercial, air taxi, or general aviation. There are also many examples of aircraft that are classified as commercial or air taxi or even general aviation that are also used by the military in a modified form. While AEDT captures some of the nuances in these

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[7] https://www.flightaware.com/about/datasources/.

military modifications in its profiles, many of the modified aircraft are not represented in AEDT's database, and as a result, substitute aircraft must be modeled. This can then lead to confusion when trying to map the emissions back to military operations. Further background research into how EIS aircraft inventory data are used may provide some important context about the necessity of using SCC codes to classify the usage of the aircraft. For instance, future versions of the EIS could limit the use of the military SCC (2275001000) to fighter jets, dedicated military transports, and other aircraft that are only used for military operations.

The current SCC system also does not distinguish between fixed wing aircraft and rotary aircraft. This makes it difficult to estimate the emissions from helicopters at any given airport. There are dozens of airports in the inventory that are actually just helipads, so dedicated SCC codes for helicopters would help to better understand the emissions sources. The addition of dedicated SCC codes for helicopters should also be accompanied by an analysis to determine helicopter-specific emissions factors to use for generic helicopter types, like military helicopters or general aviation helicopters.

5.3 Touch and Go Operations

This inventory included some, but not all, of the TGO operations submitted by the Commonwealth of Virginia for military bases. AEDT has a limited number of profiles available for modeling TGO operations, causing several reported operations to be dropped from the inventory. Future research could be conducted to determine generic TGO emissions factors for military fixed-wing and rotary aircraft to use in the case that they cannot be modeled using AEDT. Using results from this inventory, Table 5-1 shows the average overall emissions factors by SCC from TGO operations in Virginia. When compared to the generic emissions factors (Table 3-7) for military aircraft, which are meant to represent the entire LTO cycle, emissions factors are noticeably higher for nitrogen oxides and sulfur dioxide. Further modeling to include other military airports and all potential military aircraft would help to develop generic emissions factors for TGO operations.

Table 5-1. Average overall emissions factors by SCC as calculated by AEDT for all airports with TGO operations (pounds per operation)

SCC	CO	NOx	PM10-PRI	PM2.5-PRI	SO2	VOC
2275001000	29.22	88.19	0.75	0.75	12.78	4.18
2275050011	396.14	0.72	0.32	0.32	0.45	3.81
2275050012	1.42	10.40	0.07	0.07	1.92	0.00

Future research could also develop TGO emission factors for GAA. Many small airports have a significant amount of TGO operations, because many GAA users are involved in flight training for pilot licensing requirements. TGO operations allow users to practice multiple takeoffs and landings in a short amount of time. An effort to determine TGO fractions at these airports would help to better represent emissions at smaller airports, since the current generic emissions factors are based on the full LTO cycle. A recent study quantified the excess emissions due to a TGO and found that an aircraft go-around (one pass) can increase emissions produced in the LTO cycle by 6%-40%, depending on engine type and time

[15]. Similarly, when a go-around occurs, the fuel used in the LTO cycle increases by 16%-60%, emphasizing the potential impacts of TGO on airport emissions and associated air quality.

5.4 Cruise (In-flight) Emissions and Improved Vertical Allocation

As discussed earlier, airport studies using AEDT model aircraft activities during the landing and takeoff cycle, and that captures emissions within the lowest 3,000 feet of the atmosphere. However, emissions from aircraft during cruise mode or in-flight at higher elevations have also been shown to affect surface air quality, and few studies have quantified the relative contribution of emissions from LTO vs. in-flight on surface air quality [16][17]. Given increasing interest in capturing all anthropogenic and natural sources of emissions that affect surface air quality, and with recent modeling platforms moving to model the entire Northern Hemisphere in a single simulation to capture large-scale dynamics and trans-continental transport that may affect local-scale air pollution impacts, there is a justification to incorporate these emissions as well. Future studies can be configured to use AEDT to capture in-flight emissions while creating the NEI estimates.

Further, the current NEI and as well as the recent previous versions represent aircraft emissions as a single point associated with each airport. Since AEDT provides emissions by mode for each airport and there is a unique airport-specific profile of vertical distribution of emissions within the lowest 3,000 ft, future studies can use this information to develop vertical profiles of aircraft emissions during LTO for better spatial representation of emissions for air quality modeling.

6 References

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Appendix A. Instructions for State Review

2023 Aircraft LTO Data Processing for the National Emission Inventory

Purpose

To assist state, local, and tribal agencies in their submittal of aircraft-related activity data, UNC-IE working as a contractor to EPA compiled the aircraft operations data from several Federal Aviation Administration's (FAA) data sources including the following: 2023 T-100 dataset, 2023 Terminal Area Forecast (TAF) data, 2023 Air Traffic Activity Data Systems (OPSNET) data, and 2023 Airport Master Record (form 5010) data. These data are available for review and revision by agencies to accurately estimate activity data for all aircraft types. These compiled data, including local revisions, will be used to calculate the 2023 National Emission Inventory (NEI) aviation emissions.

Please note that by reviewing and correcting the operations data in this dataset you will NOT need to submit an airport emissions file to EIS. If you send the revisions back to EPA by December 8, 2024, EPA will perform the processing tasks required, such as matching EIS facility, unit, and process IDs for the airports, as well submitting the emissions inventory to the EIS Gateway. This will be the easiest way for agencies to submit local data into EIS; those who choose not to participate in this data gathering process, but still want local emissions data included in EIS, will be required to prepare their data to meet all EIS input requirements and submit it themselves.

The EPA would like to stress the importance of this review. Emissions estimated for airports include hazardous air pollutants (or HAPs) besides criteria pollutants. It is essential that we do the best we can estimating these HAPs as they will be used in the EPA's Air Toxics Screening Assessment (AirToxScreen). AirToxScreen is EPA's screening tool that provides communities with information about health risks from air toxics. AirToxScreen is part of EPA's new approach to air toxics that provides updated data and risk analyses on an annual basis, helping state, local and tribal air agencies, EPA, and the public more easily identify existing and emerging air toxics issues. Additionally, it would be helpful if states that have knowledge of the number of operations at military bases in their state, to review that data. In the past, errors in military operations have shown risk at airbases that turned out to not have the level of activity reported by the operations data.

Background

The T-100 data is derived from commercial aviation operations, reported directly by the airlines and specifically includes very detailed information about large commercial air carriers, air taxis, and business flights. Because the T-100 aircraft data are provided for individual aircraft specifying manufacturer and aircraft model, they can be matched to specific aircraft in the FAA's Aviation Environmental Design Tool (AEDT) which is a SQL based software tool used to estimate emissions. Because of the details provided in T-100, it is also possible to identify which aircraft are typically used for air taxi services based on typical passenger capacity. All non-air taxi data in the T-100 data are assumed to be larger commercial aircraft.

The FAA's TAF and OPSNET datasets do not provide operations data at the aircraft manufacturer and model level of detail that the T-100 data does; instead, operations are provided for general aircraft types (i.e., air carriers, air taxis, general aviation, and military). OPSNET includes actual operations at FAA controlled facilities, while TAF includes the OPSNET data and also modeled operations for other non-FAA controlled facilities. Note that the TAF and OPSNET data are provided as operations (separate operation counts for each landing and takeoff leg), such that the TAF and OPSNET operations need to be divided by 2 to get LTOs for calculating emissions.

For this release of operations data, UNC-IE adjusted the TAF/OPSNET data to avoid issues of double counting when combining T-100 data with TAF/OPSNET data, because both the T-100 data and the TAF/OPSNET data that are reported by the airports include commercial air carriers and air taxis. This adjustment is done by SCC in the T-100 data for each airport and comparing these values to the SCC grouped operations data from TAF and OPSNET at the same airport. Priority is given to maintaining T100 activity data due to it having higher specificity than activity from other datasets as follows:

- For large commercial aircraft (SCC: 2275020000), T100 operations counts are used and OPSNET/TAF operations data for air carriers are ignored.
- For air taxi-sized aircraft, T-100 operations are included by default. If TAF/OPSNET has additional operations, then the difference between TAF/OPSNET and the sum of T100 activity are included as generic aircraft. For example, if T100 reports 1,000 operations for Airport1 and TAF reports 2,000 operations, the database will include 1,000 operations with specific airframe/engine combinations from T100 and 1,000 generic operations from TAF. Conversely, if T100 reports 2,000 operations for Airport2 and TAF reports 1,000 operations, the database will include 2,000 operations with specific airframe/engine combinations from T100 and ignore the TAF operations.

The 5010 forms are used for airport infrastructure planning and include a variety of information about airport operations and characteristics, and some records have operations for similar general aircraft types as the TAF/OPSNET. Such information is particularly important for smaller facilities where data sources are sparse. For records in the FAA 5010 data without aircraft category, there are estimates of different aircraft types, e.g., Single Engine Aircraft, Multi Engine Aircraft, Jet Engine Aircraft, Helicopters, etc., and EPA will assume that all of these aircraft can be grouped as general aviation unless the airport is designated as a military airport. Activity from military airports will be assumed to be military aircraft. These data were compared by SCC to the TAF/OPSNET data and adjusted for double counting using a similar approach to that used to adjust the T-100 and TAF/OPSNET data. The TAF/OPSNET data was considered to be of higher quality than the 5010 data and was given priority in the adjustment as the T-100 was prioritized in the T-100 with TAF/OPSNET adjustment.

The following hierarchy was used to adjust operations data.

1. T100
2. OPSNET (adjust for double counting from T100 if available)
3. TAF (adjust for double counting from T100 if available)
4. 5010 (adjust for double counting from T100 if available)

T100_Ops	**OPSNET/TAF_Ops**	**5010_Ops**	**Source**
>0	Between 0 and [T100_Ops]	Between 0 and [T100_Ops]	T100
0	0	>0	5010
0	>0	N/A	OPSNET/TAF
>0	>[T100_Ops]	N/A	T100 and OPSNET/TAF-T100 (air taxis only)
>0	>0 and <[T100_Ops]	>[T100_Ops]	T100
>0	0	>[T100_Ops]	T100 and 5010-T100 (air taxis only)

Data used highlighted in blue.

Reviewing/Revising Data

For the 2023 inventory, UNC-IE (as EPA's contractor) built a small cloud-based web server to facilitate the sharing of CSV files of operations data by state or tribe. **Note that UNC-IE will share total operations, not LTOs as was done for 2020, to maintain consistency with the formats provided in available data sources.** The CSV files have similar fields to what was shared in 2020. However, UNC-IE included aircraft type and engine types in addition to Aircraft Engine Type Code (AETC) to make it easier for states to recognize the activity. A draft version of the updated AETC table is linked on the download page. The server features a single login credential that all states and tribes can use to access the system to allow states and tribes to more easily delegate the review task to other members of their team. The server will ask users to provide simple contact information including name, email, and organization to allow UNC-IE and EPA to monitor survey responses and attribute edits to the proper user. This contact information will be stored in a text file on the server. The website will allow users to download operations data and then make any necessary changes offline. Then the user can return to the website and upload the revised version of the CSV. The server will do some simple checks to ensure all necessary fields are included to preserve data integrity, and the user will be notified by a pop-up box that the data was received successfully. Users can add new airports in the case where operations data were not provided initially by simply appending that data to the end of the CSV.

The web server will also contain a Data Dictionary that will give examples for each of the columns in the spreadsheet.

The operations data will include the Airport identification information, aircraft information, and operations data. The facility data will include airport identification information, FIPS, county, and state in addition to SCC, and taxi in/out estimates.

Instructions

To review existing airport operations data and submit revisions, please follow the instructions below.

1. From the Download Data page, download the 2023 airport operations data file for the state or territory you are working with.
2. From the Download Data page, download the draft version of the AETC table for reference. The Download Data page also has SCC codes for your reference.
3. Open the downloaded CSV files in your spreadsheet program (e.g., Microsoft Excel).
4. Review the existing operations data in the downloaded file. Refer to the Data Dictionary for column descriptions and the draft AETC table for reference.
5. To change existing data, first decide if the activity is represented by the correct equipment. If not, edit the AEDT_EquipID and AETC fields accordingly.
6. Then, decide if the activity attributed to the equipment is correct. Edit Total_Ops (operations), Taxi_In (seconds), Taxi_Out (seconds), and Comments columns of the spreadsheet if changes are desired. Note that the Taxi_In and Taxi_Out values are defaults provided by AEDT.
7. Finally, review whether your organization uses the same SCC code for this activity. If your airport usually assigns the activity from that airframe to a different SCC code, you may edit the values in the SCC and ProcessDescription columns for that airframe. You can change the SCC code even if you do not need to change the equipment or operations values.
8. After you're finished revising the data, visit the Upload Revisions page.
9. Fill out your contact information, information about your data revisions, and upload your CSV file.
10. The web site will check the file for basic formatting and display an error if it finds a mismatch. Correct any errors and reupload your CSV file.
11. When your data has been accepted, you'll see a confirmation page with the title Data Revisions Uploaded, and a listing of your submitted information.

Notes for Revisions

- **Please submit revisions by December 8, 2024**

- Column headers need to remain intact
- Please start your editing process using the data downloaded from this website
- Unedited records should be left *as is* in your uploaded file
- Revisions must be uploaded in a CSV (comma-separated values) file, not XLS or XLSX
- If you have additional data questions, please contact Brian Naess at naess@unc.edu

Login Credentials

You will need to log in when accessing the site:
[URL is no longer active]

Please log in with the following credentials:

[Log in credentials no longer valid]

Revision Process

Please submit revisions by December 8, 2024. The EPA will review the state-submitted data to ensure that it is appropriate and reasonable. Once the operations data have been finalized, then the aircraft specific operations data will be run using AEDT 3g to estimate criteria and HAP emissions for aircraft engine exhaust, auxiliary power units, and ground support equipment. The remaining aircraft type data will use generic emission factors to calculate emissions.

If you need assistance, contact Janice Godfrey at Godfrey.Janice@epa.gov.

Note EPA strongly encourages agencies to review and, if necessary, submit their operations data to the EPA via this review process. In doing so, then states need not submit EIS staging tables for the 2023 NEI.

Table A-1. Data Dictionary for fields used in the collection of state and tribal operations data.

Column	Description	Example
FIPS	5-digit Federal Information Processing Standards county code	4013
State	Two-letter state or territory abbreviation	AZ
County	Full county name	Maricopa
Site_Name	Name of the airport	Phoenix Sky Harbor Intl
EIS_Facility_ID	ID code used in EIS for this airport	10583311

Column	Description	Example
T100_code	Official Airline Guide code for airport as used in T100 data	PHX
FAA5010_code	3-4 character alphanumeric identifier assigned to facility and used in Airport Master Record (5010) data	PHX
AEDT_apt_id	Numeric code used in AEDT for the airport	27233
SCC	10-digit Source Classification Code	2275020000
ProcessDescription	SCC description	Commercial Aircraft, Total: All Types
AirframeModel	Description of the airframe either from T100 data or from AEDT	Airbus A319-100 Series
EngineCode	AEDT Engine Model	CFM56-5B9/2P
AEDT_EquipID	Numeric code used in AEDT [FLEET].[dbo].[FLT_EQUIPMENT] table that matches airframe with engine	949
AETC	Numeric code used in EPAs Aircraft Engine Type Code table to represent the airframe/engine combination	200949
Total_Ops	Sum of landings and takeoffs	19996
Taxi_In	Taxi time in seconds	406
Taxi_Out	Taxi time in seconds	894
EPASource	Primary source used for the operations value	T100
Comments	Users can use this space to comment on edits/additions or provide additional information not captured in existing columns	

Appendix B. State Operations Data

Refer to state_operations_inputs_with_comments-v10.xlsx

Appendix C. Generic Aircraft Type Emission Factors

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275001000	Military Aircraft, All Types	106990	1,3-Butadiene	9.213E-05
2275001000	Military Aircraft, All Types	540841	2,2,4-Trimethylpentane	0.000E+00
2275001000	Military Aircraft, All Types	91576	2-Methyl Naphthalene	1.125E-05
2275001000	Military Aircraft, All Types	83329	Acenaphthene	0.000E+00
2275001000	Military Aircraft, All Types	208968	Acenaphthylene	0.000E+00
2275001000	Military Aircraft, All Types	75070	Acetaldehyde	2.333E-04
2275001000	Military Aircraft, All Types	107028	Acrolein	1.337E-04
2275001000	Military Aircraft, All Types	120127	Anthracene	0.000E+00
2275001000	Military Aircraft, All Types	71432	Benzene	9.180E-05
2275001000	Military Aircraft, All Types	56553	Benzo(a)anthracene	0.000E+00
2275001000	Military Aircraft, All Types	50328	Benzo(a)pyrene	0.000E+00
2275001000	Military Aircraft, All Types	205992	Benzo(b)fluoranthene	0.000E+00
2275001000	Military Aircraft, All Types	191242	Benzo(ghi)perylene	0.000E+00
2275001000	Military Aircraft, All Types	207089	Benzo(k)fluoranthene	0.000E+00
2275001000	Military Aircraft, All Types	218019	Chrysene	0.000E+00
2275001000	Military Aircraft, All Types	CO	CO	1.298E-02
2275001000	Military Aircraft, All Types	CO2	CO2	1.321E+00
2275001000	Military Aircraft, All Types	53703	Dibenzo(ah)anthracene	0.000E+00
2275001000	Military Aircraft, All Types	100414	Ethylbenzene	9.503E-06
2275001000	Military Aircraft, All Types	206440	Fluoranthene	0.000E+00
2275001000	Military Aircraft, All Types	86737	Fluorene	0.000E+00
2275001000	Military Aircraft, All Types	50000	Formaldehyde	6.723E-04

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275001000	Military Aircraft, All Types	193395	Indeno(1,2,3-cd)pyrene	0.000E+00
2275001000	Military Aircraft, All Types	98828	Isopropylbenzene	1.638E-07
2275001000	Military Aircraft, All Types	67561	Methanol	9.858E-05
2275001000	Military Aircraft, All Types	108383	M-Xylene And P-Xylene	1.540E-05
2275001000	Military Aircraft, All Types	91203	Naphthalene	2.955E-05
2275001000	Military Aircraft, All Types	110543	N-Hexane	0.000E+00
2275001000	Military Aircraft, All Types	NOX	NOx	1.117E-02
2275001000	Military Aircraft, All Types	95476	O-Xylene	9.066E-06
2275001000	Military Aircraft, All Types	85018	Phenanthrene	0.000E+00
2275001000	Military Aircraft, All Types	108952	Phenol	3.965E-05
2275001000	Military Aircraft, All Types	PM10-PRI	PM10	6.965E-04
2275001000	Military Aircraft, All Types	PM25-PRI	PM2.5	6.798E-04
2275001000	Military Aircraft, All Types	123386	Propionaldehyde	3.970E-05
2275001000	Military Aircraft, All Types	SO2	SOx	1.055E-03
2275001000	Military Aircraft, All Types	100425	Styrene	1.688E-05
2275001000	Military Aircraft, All Types	108883	Toluene	3.506E-05
2275001000	Military Aircraft, All Types	VOC	VOC	5.433E-03
2275020000	Commercial Aircraft, All Types	106990	1,3-Butadiene	5.245E-05
2275020000	Commercial Aircraft, All Types	540841	2,2,4-Trimethylpentane	1.466E-06
2275020000	Commercial Aircraft, All Types	91576	2-Methyl Naphthalene	6.404E-06
2275020000	Commercial Aircraft, All Types	83329	Acenaphthene	0.000E+00
2275020000	Commercial Aircraft, All Types	208968	Acenaphthylene	0.000E+00
2275020000	Commercial Aircraft, All Types	75070	Acetaldehyde	1.328E-04

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275020000	Commercial Aircraft, All Types	107028	Acrolein	7.613E-05
2275020000	Commercial Aircraft, All Types	120127	Anthracene	0.000E+00
2275020000	Commercial Aircraft, All Types	71432	Benzene	5.226E-05
2275020000	Commercial Aircraft, All Types	56553	Benzo(a)anthracene	1.297E-09
2275020000	Commercial Aircraft, All Types	50328	Benzo(a)pyrene	9.621E-10
2275020000	Commercial Aircraft, All Types	205992	Benzo(b)fluoranthene	1.892E-09
2275020000	Commercial Aircraft, All Types	191242	Benzo(ghi)perylene	1.726E-11
2275020000	Commercial Aircraft, All Types	207089	Benzo(k)fluoranthene	1.892E-09
2275020000	Commercial Aircraft, All Types	218019	Chrysene	1.313E-09
2275020000	Commercial Aircraft, All Types	CO	CO	1.119E-02
2275020000	Commercial Aircraft, All Types	CO2	CO2	2.418E+00
2275020000	Commercial Aircraft, All Types	53703	Dibenzo(ah)anthracene	2.551E-09
2275020000	Commercial Aircraft, All Types	100414	Ethylbenzene	5.409E-06
2275020000	Commercial Aircraft, All Types	206440	Fluoranthene	2.492E-09
2275020000	Commercial Aircraft, All Types	86737	Fluorene	0.000E+00
2275020000	Commercial Aircraft, All Types	50000	Formaldehyde	3.827E-04
2275020000	Commercial Aircraft, All Types	193395	Indeno(1,2,3-cd)pyrene	2.050E-09
2275020000	Commercial Aircraft, All Types	98828	Isopropylbenzene	9.326E-08
2275020000	Commercial Aircraft, All Types	67561	Methanol	5.611E-05
2275020000	Commercial Aircraft, All Types	108383	M-Xylene And P-Xylene	8.767E-06
2275020000	Commercial Aircraft, All Types	91203	Naphthalene	1.682E-05
2275020000	Commercial Aircraft, All Types	110543	N-Hexane	0.000E+00
2275020000	Commercial Aircraft, All Types	NOX	NOx	9.288E-03

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275020000	Commercial Aircraft, All Types	95476	O-Xylene	5.161E-06
2275020000	Commercial Aircraft, All Types	85018	Phenanthrene	1.112E-08
2275020000	Commercial Aircraft, All Types	108952	Phenol	2.257E-05
2275020000	Commercial Aircraft, All Types	PM10-PRI	PM10	5.385E-04
2275020000	Commercial Aircraft, All Types	PM25-PRI	PM2.5	5.256E-04
2275020000	Commercial Aircraft, All Types	123386	Propionaldehyde	2.260E-05
2275020000	Commercial Aircraft, All Types	SO2	SOx	8.910E-04
2275020000	Commercial Aircraft, All Types	100425	Styrene	9.606E-06
2275020000	Commercial Aircraft, All Types	108883	Toluene	1.996E-05
2275020000	Commercial Aircraft, All Types	VOC	VOC	3.082E-03
2275050011	General Aviation, Piston	106990	1,3-Butadiene	9.285E-07
2275050011	General Aviation, Piston	540841	2,2,4-Trimethylpentane	3.394E-08
2275050011	General Aviation, Piston	91576	2-Methyl Naphthalene	0.000E+00
2275050011	General Aviation, Piston	83329	Acenaphthene	8.640E-08
2275050011	General Aviation, Piston	208968	Acenaphthylene	4.876E-07
2275050011	General Aviation, Piston	75070	Acetaldehyde	5.874E-07
2275050011	General Aviation, Piston	107028	Acrolein	5.684E-08
2275050011	General Aviation, Piston	120127	Anthracene	1.006E-07
2275050011	General Aviation, Piston	71432	Benzene	3.837E-06
2275050011	General Aviation, Piston	56553	Benzo(a)anthracene	1.184E-08
2275050011	General Aviation, Piston	50328	Benzo(a)pyrene	1.184E-08
2275050011	General Aviation, Piston	205992	Benzo(b)fluoranthene	1.420E-08
2275050011	General Aviation, Piston	191242	Benzo(ghi)perylene	3.077E-08

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275050011	General Aviation, Piston	207089	Benzo(k)fluoranthene	1.420E-08
2275050011	General Aviation, Piston	218019	Chrysene	1.184E-08
2275050011	General Aviation, Piston	CO	CO	6.007E-03
2275050011	General Aviation, Piston	CO2	CO2	9.595E-02
2275050011	General Aviation, Piston	53703	Dibenzo(ah)anthracene	0.000E+00
2275050011	General Aviation, Piston	100414	Ethylbenzene	1.393E-06
2275050011	General Aviation, Piston	206440	Fluoranthene	1.077E-07
2275050011	General Aviation, Piston	86737	Fluorene	1.787E-07
2275050011	General Aviation, Piston	50000	Formaldehyde	2.549E-06
2275050011	General Aviation, Piston	193395	Indeno(1,2,3-cd)pyrene	9.468E-09
2275050011	General Aviation, Piston	98828	Isopropylbenzene	0.000E+00
2275050011	General Aviation, Piston	7439921	Lead	7.686E-06
2275050011	General Aviation, Piston	67561	Methanol	0.000E+00
2275050011	General Aviation, Piston	91203	Naphthalene (gas phase)	4.327E-07
2275050011	General Aviation, Piston	91203	Naphthalene (solid phase)	1.073E-05
2275050011	General Aviation, Piston	110543	N-Hexane	6.632E-07
2275050011	General Aviation, Piston	NOX	NOx	3.250E-05
2275050011	General Aviation, Piston	85018	Phenanthrene	3.006E-07
2275050011	General Aviation, Piston	108952	Phenol	0.000E+00
2275050011	General Aviation, Piston	PM10-PRI	PM10	1.184E-04
2275050011	General Aviation, Piston	PM25-PRI	PM2.5	8.166E-05
2275050011	General Aviation, Piston	123386	Propionaldehyde	5.684E-08
2275050011	General Aviation, Piston	SO2	SOx	5.000E-06

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275050011	General Aviation, Piston	100425	Styrene	3.221E-07
2275050011	General Aviation, Piston	108883	Toluene	9.853E-06
2275050011	General Aviation, Piston	VOC	VOC	7.524E-05
2275050011	General Aviation, Piston	1330207	Xylene	5.552E-06
2275050012	General Aviation, Turbine	106990	1,3-Butadiene	5.866E-06
2275050012	General Aviation, Turbine	540841	2,2,4-Trimethylpentane	1.313E-07
2275050012	General Aviation, Turbine	91576	2-Methyl Naphthalene	7.163E-07
2275050012	General Aviation, Turbine	83329	Acenaphthene	0.000E+00
2275050012	General Aviation, Turbine	208968	Acenaphthylene	0.000E+00
2275050012	General Aviation, Turbine	75070	Acetaldehyde	1.486E-05
2275050012	General Aviation, Turbine	107028	Acrolein	8.516E-06
2275050012	General Aviation, Turbine	120127	Anthracene	5.221E-11
2275050012	General Aviation, Turbine	71432	Benzene	5.846E-06
2275050012	General Aviation, Turbine	56553	Benzo(a)anthracene	7.903E-12
2275050012	General Aviation, Turbine	50328	Benzo(a)pyrene	4.327E-12
2275050012	General Aviation, Turbine	205992	Benzo(b)fluoranthene	0.000E+00
2275050012	General Aviation, Turbine	191242	Benzo(ghi)perylene	7.178E-13
2275050012	General Aviation, Turbine	207089	Benzo(k)fluoranthene	0.000E+00
2275050012	General Aviation, Turbine	218019	Chrysene	7.359E-12
2275050012	General Aviation, Turbine	CO	CO	4.789E-03
2275050012	General Aviation, Turbine	CO2	CO2	4.966E-01
2275050012	General Aviation, Turbine	53703	Dibenzo(ah)anthracene	0.000E+00
2275050012	General Aviation, Turbine	100414	Ethylbenzene	6.051E-07

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275050012	General Aviation, Turbine	206440	Fluoranthene	1.092E-10
2275050012	General Aviation, Turbine	86737	Fluorene	0.000E+00
2275050012	General Aviation, Turbine	50000	Formaldehyde	4.281E-05
2275050012	General Aviation, Turbine	193395	Indeno(1,2,3-cd)pyrene	0.000E+00
2275050012	General Aviation, Turbine	98828	Isopropylbenzene	1.043E-08
2275050012	General Aviation, Turbine	67561	Methanol	6.277E-06
2275050012	General Aviation, Turbine	108383	M-Xylene And P-Xylene	9.806E-07
2275050012	General Aviation, Turbine	91203	Naphthalene	1.881E-06
2275050012	General Aviation, Turbine	110543	N-Hexane	0.000E+00
2275050012	General Aviation, Turbine	NOX	NOx	1.619E-04
2275050012	General Aviation, Turbine	95476	O-Xylene	5.773E-07
2275050012	General Aviation, Turbine	85018	Phenanthrene	4.858E-10
2275050012	General Aviation, Turbine	108952	Phenol	2.525E-06
2275050012	General Aviation, Turbine	PM10-PRI	PM10	1.184E-04
2275050012	General Aviation, Turbine	PM25-PRI	PM2.5	1.155E-04
2275050012	General Aviation, Turbine	123386	Propionaldehyde	2.528E-06
2275050012	General Aviation, Turbine	SO2	SOx	3.679E-05
2275050012	General Aviation, Turbine	100425	Styrene	1.075E-06
2275050012	General Aviation, Turbine	108883	Toluene	2.233E-06
2275050012	General Aviation, Turbine	VOC	VOC	3.447E-04
2275060011	Air Taxi, Piston	106990	1,3-Butadiene	9.285E-07
2275060011	Air Taxi, Piston	540841	2,2,4-Trimethylpentane	3.394E-08
2275060011	Air Taxi, Piston	91576	2-Methyl Naphthalene	0.000E+00
2275060011	Air Taxi, Piston	83329	Acenaphthene	2.202E-07
2275060011	Air Taxi, Piston	208968	Acenaphthylene	1.243E-06
2275060011	Air Taxi, Piston	75070	Acetaldehyde	5.874E-07

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275060011	Air Taxi, Piston	107028	Acrolein	5.684E-08
2275060011	Air Taxi, Piston	120127	Anthracene	2.564E-07
2275060011	Air Taxi, Piston	71432	Benzene	3.837E-06
2275060011	Air Taxi, Piston	56553	Benzo(a)anthracene	3.017E-08
2275060011	Air Taxi, Piston	50328	Benzo(a)pyrene	3.017E-08
2275060011	Air Taxi, Piston	205992	Benzo(b)fluoranthene	3.620E-08
2275060011	Air Taxi, Piston	191242	Benzo(ghi)perylene	7.843E-08
2275060011	Air Taxi, Piston	207089	Benzo(k)fluoranthene	3.620E-08
2275060011	Air Taxi, Piston	218019	Chrysene	3.017E-08
2275060011	Air Taxi, Piston	CO	CO	1.407E-02
2275060011	Air Taxi, Piston	CO2	CO2	2.684E-01
2275060011	Air Taxi, Piston	53703	Dibenzo(ah)anthracene	0.000E+00
2275060011	Air Taxi, Piston	100414	Ethylbenzene	1.393E-06
2275060011	Air Taxi, Piston	206440	Fluoranthene	2.745E-07
2275060011	Air Taxi, Piston	86737	Fluorene	4.555E-07
2275060011	Air Taxi, Piston	50000	Formaldehyde	2.549E-06
2275060011	Air Taxi, Piston	193395	Indeno(1,2,3-cd)pyrene	2.413E-08
2275060011	Air Taxi, Piston	98828	Isopropylbenzene	0.000E+00
2275060011	Air Taxi, Piston	7439921	Lead	7.686E-06
2275060011	Air Taxi, Piston	67561	Methanol	0.000E+00
2275060011	Air Taxi, Piston	91203	Naphthalene (gas phase)	4.327E-07
2275060011	Air Taxi, Piston	91203	Naphthalene (solid phase)	2.736E-05
2275060011	Air Taxi, Piston	110543	N-Hexane	6.632E-07
2275060011	Air Taxi, Piston	NOX	NOx	7.900E-05
2275060011	Air Taxi, Piston	85018	Phenanthrene	7.662E-07
2275060011	Air Taxi, Piston	108952	Phenol	0.000E+00
2275060011	Air Taxi, Piston	PM10-PRI	PM10	3.017E-04
2275060011	Air Taxi, Piston	PM25-PRI	PM2.5	2.081E-04
2275060011	Air Taxi, Piston	123386	Propionaldehyde	5.684E-08
2275060011	Air Taxi, Piston	SO2	SOx	7.500E-06
2275060011	Air Taxi, Piston	100425	Styrene	3.221E-07
2275060011	Air Taxi, Piston	108883	Toluene	9.853E-06
2275060011	Air Taxi, Piston	VOC	VOC	8.484E-05
2275060011	Air Taxi, Piston	1330207	Xylene	5.552E-06
2275060012	Air Taxi, Turbine	106990	1,3-Butadiene	8.558E-06
2275060012	Air Taxi, Turbine	540841	2,2,4-Trimethylpentane	1.915E-07
2275060012	Air Taxi, Turbine	91576	2-Methyl Naphthalene	1.045E-06
2275060012	Air Taxi, Turbine	83329	Acenaphthene	0.000E+00
2275060012	Air Taxi, Turbine	208968	Acenaphthylene	0.000E+00
2275060012	Air Taxi, Turbine	75070	Acetaldehyde	2.167E-05
2275060012	Air Taxi, Turbine	107028	Acrolein	1.242E-05

SCC	Aircraft TypeCat	CAS No	Pollutant	Emission factors (tons/LTO)
2275060012	Air Taxi, Turbine	120127	Anthracene	1.331E-10
2275060012	Air Taxi, Turbine	71432	Benzene	8.528E-06
2275060012	Air Taxi, Turbine	56553	Benzo(a)anthracene	2.014E-11
2275060012	Air Taxi, Turbine	50328	Benzo(a)pyrene	1.103E-11
2275060012	Air Taxi, Turbine	205992	Benzo(b)fluoranthene	0.000E+00
2275060012	Air Taxi, Turbine	191242	Benzo(ghi)perylene	1.829E-12
2275060012	Air Taxi, Turbine	207089	Benzo(k)fluoranthene	0.000E+00
2275060012	Air Taxi, Turbine	218019	Chrysene	1.876E-11
2275060012	Air Taxi, Turbine	CO	CO	1.806E-03
2275060012	Air Taxi, Turbine	CO2	CO2	6.858E-01
2275060012	Air Taxi, Turbine	53703	Dibenzo(ah)anthracene	0.000E+00
2275060012	Air Taxi, Turbine	100414	Ethylbenzene	8.827E-07
2275060012	Air Taxi, Turbine	206440	Fluoranthene	2.784E-10
2275060012	Air Taxi, Turbine	86737	Fluorene	0.000E+00
2275060012	Air Taxi, Turbine	50000	Formaldehyde	6.245E-05
2275060012	Air Taxi, Turbine	193395	Indeno(1,2,3-cd)pyrene	0.000E+00
2275060012	Air Taxi, Turbine	98828	Isopropylbenzene	1.522E-08
2275060012	Air Taxi, Turbine	67561	Methanol	9.157E-06
2275060012	Air Taxi, Turbine	108383	M-Xylene And P-Xylene	1.431E-06
2275060012	Air Taxi, Turbine	91203	Naphthalene	2.745E-06
2275060012	Air Taxi, Turbine	110543	N-Hexane	0.000E+00
2275060012	Air Taxi, Turbine	NOX	NOx	3.877E-04
2275060012	Air Taxi, Turbine	95476	O-Xylene	8.421E-07
2275060012	Air Taxi, Turbine	85018	Phenanthrene	1.238E-09
2275060012	Air Taxi, Turbine	108952	Phenol	3.683E-06
2275060012	Air Taxi, Turbine	PM10-PRI	PM10	3.017E-04
2275060012	Air Taxi, Turbine	PM25-PRI	PM2.5	2.944E-04
2275060012	Air Taxi, Turbine	123386	Propionaldehyde	3.688E-06
2275060012	Air Taxi, Turbine	SO2	SOx	8.124E-05
2275060012	Air Taxi, Turbine	100425	Styrene	1.568E-06
2275060012	Air Taxi, Turbine	108883	Toluene	3.257E-06
2275060012	Air Taxi, Turbine	VOC	VOC	5.029E-04

Appendix D. Total Annual Emissions by SCC

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2265008005	Ground Support Equipment, Gasoline	Carbon Monoxide	CO	17,306
2270008005	Ground Support Equipment, Diesel	Carbon Monoxide	CO	39
2275001000	Military Aircraft, Total	Carbon Monoxide	CO	48,340
2275020000	Commercial Aircraft, Total: All Types	Carbon Monoxide	CO	91,491
2275050011	General Aviation, Piston	Carbon Monoxide	CO	194,285
2275050012	General Aviation, Turbine	Carbon Monoxide	CO	58,732
2275060011	Air Taxi, Piston	Carbon Monoxide	CO	6,398
2275060012	Air Taxi, Turbine	Carbon Monoxide	CO	7,651
2275070000	Auxiliary Power Units	Carbon Monoxide	CO	3,390
2275050011	General Aviation, Piston	Lead	7439921	242
2275050012	General Aviation, Turbine	Lead	7439921	0
2275060011	Air Taxi, Piston	Lead	7439921	4
2275060012	Air Taxi, Turbine	Lead	7439921	0
2265008005	Ground Support Equipment, Gasoline	Nitrogen Oxides	NOX	542
2270008005	Ground Support Equipment, Diesel	Nitrogen Oxides	NOX	152
2275001000	Military Aircraft, Total	Nitrogen Oxides	NOX	41,411
2275020000	Commercial Aircraft, Total: All Types	Nitrogen Oxides	NOX	90,643
2275050011	General Aviation, Piston	Nitrogen Oxides	NOX	1,021
2275050012	General Aviation, Turbine	Nitrogen Oxides	NOX	2,080
2275060011	Air Taxi, Piston	Nitrogen Oxides	NOX	36
2275060012	Air Taxi, Turbine	Nitrogen Oxides	NOX	1,643
2275070000	Auxiliary Power Units	Nitrogen Oxides	NOX	2,893
2265008005	Ground Support Equipment, Gasoline	PM10 Primary (Filt + Cond)	PM10-PRI	31
2270008005	Ground Support Equipment, Diesel	PM10 Primary (Filt + Cond)	PM10-PRI	6
2275001000	Military Aircraft, Total	PM10 Primary (Filt + Cond)	PM10-PRI	2,524
2275020000	Commercial Aircraft, Total: All Types	PM10 Primary (Filt + Cond)	PM10-PRI	710
2275050011	General Aviation, Piston	PM10 Primary (Filt + Cond)	PM10-PRI	3,711
2275050012	General Aviation, Turbine	PM10 Primary (Filt + Cond)	PM10-PRI	1,443
2275060011	Air Taxi, Piston	PM10 Primary (Filt + Cond)	PM10-PRI	137

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275060012	Air Taxi, Turbine	PM10 Primary (Filt + Cond)	PM10-PRI	1,223
2275070000	Auxiliary Power Units	PM10 Primary (Filt + Cond)	PM10-PRI	394
2265008005	Ground Support Equipment, Gasoline	PM2.5 Primary (Filt + Cond)	PM25-PRI	28
2270008005	Ground Support Equipment, Diesel	PM2.5 Primary (Filt + Cond)	PM25-PRI	6
2275001000	Military Aircraft, Total	PM2.5 Primary (Filt + Cond)	PM25-PRI	2,464
2275020000	Commercial Aircraft, Total: All Types	PM2.5 Primary (Filt + Cond)	PM25-PRI	710
2275050011	General Aviation, Piston	PM2.5 Primary (Filt + Cond)	PM25-PRI	2,560
2275050012	General Aviation, Turbine	PM2.5 Primary (Filt + Cond)	PM25-PRI	1,408
2275060011	Air Taxi, Piston	PM2.5 Primary (Filt + Cond)	PM25-PRI	95
2275060012	Air Taxi, Turbine	PM2.5 Primary (Filt + Cond)	PM25-PRI	1,194
2275070000	Auxiliary Power Units	PM2.5 Primary (Filt + Cond)	PM25-PRI	394
2265008005	Ground Support Equipment, Gasoline	Sulfur Dioxide	SO2	4
2270008005	Ground Support Equipment, Diesel	Sulfur Dioxide	SO2	2
2275001000	Military Aircraft, Total	Sulfur Dioxide	SO2	3,976
2275020000	Commercial Aircraft, Total: All Types	Sulfur Dioxide	SO2	9,643
2275050011	General Aviation, Piston	Sulfur Dioxide	SO2	163
2275050012	General Aviation, Turbine	Sulfur Dioxide	SO2	473
2275060011	Air Taxi, Piston	Sulfur Dioxide	SO2	3
2275060012	Air Taxi, Turbine	Sulfur Dioxide	SO2	345
2275070000	Auxiliary Power Units	Sulfur Dioxide	SO2	410
2265008005	Ground Support Equipment, Gasoline	Volatile Organic Compounds	VOC	470
2270008005	Ground Support Equipment, Diesel	Volatile Organic Compounds	VOC	9
2275001000	Military Aircraft, Total	Volatile Organic Compounds	VOC	20,096
2275020000	Commercial Aircraft, Total: All Types	Volatile Organic Compounds	VOC	12,564
2275050011	General Aviation, Piston	Volatile Organic Compounds	VOC	2,544
2275050012	General Aviation, Turbine	Volatile Organic Compounds	VOC	4,259

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275060011	Air Taxi, Piston	Volatile Organic Compounds	VOC	39
2275060012	Air Taxi, Turbine	Volatile Organic Compounds	VOC	2,110
2275070000	Auxiliary Power Units	Volatile Organic Compounds	VOC	401
2275070000	Auxiliary Power Units	1-Methylnaphthalene	90120	1.00
2275001000	Military Aircraft, Total	1,3-Butadiene	106990	340.78
2275020000	Commercial Aircraft, Total: All Types	1,3-Butadiene	106990	213.07
2275050011	General Aviation, Piston	1,3-Butadiene	106990	32.55
2275050012	General Aviation, Turbine	1,3-Butadiene	106990	72.48
2275060011	Air Taxi, Piston	1,3-Butadiene	106990	0.42
2275060012	Air Taxi, Turbine	1,3-Butadiene	106990	35.91
2275070000	Auxiliary Power Units	1,3-Butadiene	106990	6.80
2275001000	Military Aircraft, Total	2-Methylnaphthalene	91576	41.61
2275020000	Commercial Aircraft, Total: All Types	2-Methylnaphthalene	91576	26.02
2275050011	General Aviation, Piston	2-Methylnaphthalene	91576	0.00
2275050012	General Aviation, Turbine	2-Methylnaphthalene	91576	8.85
2275060011	Air Taxi, Piston	2-Methylnaphthalene	91576	0.00
2275060012	Air Taxi, Turbine	2-Methylnaphthalene	91576	4.38
2275070000	Auxiliary Power Units	2-Methylnaphthalene	91576	0.83
2265008005	Ground Support Equipment, Gasoline	2,2,4-Trimethylpentane	540841	7.88
2275001000	Military Aircraft, Total	2,2,4-Trimethylpentane	540841	0.00
2275020000	Commercial Aircraft, Total: All Types	2,2,4-Trimethylpentane	540841	0.04
2275050011	General Aviation, Piston	2,2,4-Trimethylpentane	540841	1.06
2275050012	General Aviation, Turbine	2,2,4-Trimethylpentane	540841	1.60
2275060011	Air Taxi, Piston	2,2,4-Trimethylpentane	540841	0.02
2275060012	Air Taxi, Turbine	2,2,4-Trimethylpentane	540841	0.78
2270008005	Ground Support Equipment, Diesel	2,2,4-Trimethylpentane	540841	0.00
2275001000	Military Aircraft, Total	Acenaphthene	83329	0.00
2275020000	Commercial Aircraft, Total: All Types	Acenaphthene	83329	0.00
2275050011	General Aviation, Piston	Acenaphthene	83329	2.71
2275050012	General Aviation, Turbine	Acenaphthene	83329	0.00
2275060011	Air Taxi, Piston	Acenaphthene	83329	0.10
2275060012	Air Taxi, Turbine	Acenaphthene	83329	0.00
2275001000	Military Aircraft, Total	Acenaphthylene	208968	0.00
2275020000	Commercial Aircraft, Total: All Types	Acenaphthylene	208968	0.00

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275050011	General Aviation, Piston	Acenaphthylene	208968	15.27
2275050012	General Aviation, Turbine	Acenaphthylene	208968	0.00
2275060011	Air Taxi, Piston	Acenaphthylene	208968	0.57
2275060012	Air Taxi, Turbine	Acenaphthylene	208968	0.00
2270008005	Ground Support Equipment, Diesel	Acetaldehyde	75070	0.26
2275001000	Military Aircraft, Total	Acetaldehyde	75070	862.96
2275020000	Commercial Aircraft, Total: All Types	Acetaldehyde	75070	539.56
2275050011	General Aviation, Piston	Acetaldehyde	75070	27.97
2275050012	General Aviation, Turbine	Acetaldehyde	75070	183.60
2275060011	Air Taxi, Piston	Acetaldehyde	75070	0.27
2275060012	Air Taxi, Turbine	Acetaldehyde	75070	90.93
2275070000	Auxiliary Power Units	Acetaldehyde	75070	17.21
2275001000	Military Aircraft, Total	Acrolein	107028	494.54
2275020000	Commercial Aircraft, Total: All Types	Acrolein	107028	309.31
2275050011	General Aviation, Piston	Acrolein	107028	6.35
2275050012	General Aviation, Turbine	Acrolein	107028	105.22
2275060011	Air Taxi, Piston	Acrolein	107028	0.03
2275060012	Air Taxi, Turbine	Acrolein	107028	52.11
2275070000	Auxiliary Power Units	Acrolein	107028	9.87
2275001000	Military Aircraft, Total	Anthracene	120127	0.00
2275020000	Commercial Aircraft, Total: All Types	Anthracene	120127	0.00
2275050011	General Aviation, Piston	Anthracene	120127	3.15
2275050012	General Aviation, Turbine	Anthracene	120127	0.00
2275060011	Air Taxi, Piston	Anthracene	120127	0.12
2275060012	Air Taxi, Turbine	Anthracene	120127	0.00
2275001000	Military Aircraft, Total	Benz[a]Anthracene	56553	0.00
2275020000	Commercial Aircraft, Total: All Types	Benz[a]Anthracene	56553	0.00
2275050011	General Aviation, Piston	Benz[a]Anthracene	56553	0.37
2275050012	General Aviation, Turbine	Benz[a]Anthracene	56553	0.00
2275060011	Air Taxi, Piston	Benz[a]Anthracene	56553	0.01
2275060012	Air Taxi, Turbine	Benz[a]Anthracene	56553	0.00
2265008005	Ground Support Equipment, Gasoline	Benzene	71432	9.19
2275001000	Military Aircraft, Total	Benzene	71432	339.56
2275020000	Commercial Aircraft, Total: All Types	Benzene	71432	212.31
2275050011	General Aviation, Piston	Benzene	71432	124.10
2275050012	General Aviation, Turbine	Benzene	71432	72.23

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275060011	Air Taxi, Piston	Benzene	71432	1.74
2275060012	Air Taxi, Turbine	Benzene	71432	35.78
2275070000	Auxiliary Power Units	Benzene	71432	6.77
2275001000	Military Aircraft, Total	Benzo[a]Pyrene	50328	0.00
2275020000	Commercial Aircraft, Total: All Types	Benzo[a]Pyrene	50328	0.00
2275050011	General Aviation, Piston	Benzo[a]Pyrene	50328	0.37
2275050012	General Aviation, Turbine	Benzo[a]Pyrene	50328	0.00
2275060011	Air Taxi, Piston	Benzo[a]Pyrene	50328	0.01
2275060012	Air Taxi, Turbine	Benzo[a]Pyrene	50328	0.00
2275001000	Military Aircraft, Total	Benzo[b]Fluoranthene	205992	0.00
2275020000	Commercial Aircraft, Total: All Types	Benzo[b]Fluoranthene	205992	0.00
2275050011	General Aviation, Piston	Benzo[b]Fluoranthene	205992	0.45
2275050012	General Aviation, Turbine	Benzo[b]Fluoranthene	205992	0.00
2275060011	Air Taxi, Piston	Benzo[b]Fluoranthene	205992	0.02
2275060012	Air Taxi, Turbine	Benzo[b]Fluoranthene	205992	0.00
2275001000	Military Aircraft, Total	Benzo[g,h,i,]Perylene	191242	0.00
2275020000	Commercial Aircraft, Total: All Types	Benzo[g,h,i,]Perylene	191242	0.00
2275050011	General Aviation, Piston	Benzo[g,h,i,]Perylene	191242	0.96
2275050012	General Aviation, Turbine	Benzo[g,h,i,]Perylene	191242	0.00
2275060011	Air Taxi, Piston	Benzo[g,h,i,]Perylene	191242	0.04
2275060012	Air Taxi, Turbine	Benzo[g,h,i,]Perylene	191242	0.00
2275001000	Military Aircraft, Total	Benzo[k]Fluoranthene	207089	0.00
2275020000	Commercial Aircraft, Total: All Types	Benzo[k]Fluoranthene	207089	0.00
2275050011	General Aviation, Piston	Benzo[k]Fluoranthene	207089	0.45
2275050012	General Aviation, Turbine	Benzo[k]Fluoranthene	207089	0.00
2275060011	Air Taxi, Piston	Benzo[k]Fluoranthene	207089	0.02
2275060012	Air Taxi, Turbine	Benzo[k]Fluoranthene	207089	0.00
2265008005	Ground Support Equipment, Gasoline	Carbon Dioxide	CO2	300,650
2270008005	Ground Support Equipment, Diesel	Carbon Dioxide	CO2	75,870
2275001000	Military Aircraft, Total	Carbon Dioxide	CO2	5,169,239
2275020000	Commercial Aircraft, Total: All Types	Carbon Dioxide	CO2	22,929,019
2275050011	General Aviation, Piston	Carbon Dioxide	CO2	3,019,910
2275050012	General Aviation, Turbine	Carbon Dioxide	CO2	6,106,909
2275060011	Air Taxi, Piston	Carbon Dioxide	CO2	122,056
2275060012	Air Taxi, Turbine	Carbon Dioxide	CO2	2,815,247
2275001000	Military Aircraft, Total	Chrysene	218019	0.00

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275020000	Commercial Aircraft, Total: All Types	Chrysene	218019	0.00
2275050011	General Aviation, Piston	Chrysene	218019	0.37
2275050012	General Aviation, Turbine	Chrysene	218019	0.00
2275060011	Air Taxi, Piston	Chrysene	218019	0.01
2275060012	Air Taxi, Turbine	Chrysene	218019	0.00
2275001000	Military Aircraft, Total	Cumene	98828	0.61
2275020000	Commercial Aircraft, Total: All Types	Cumene	98828	0.38
2275050011	General Aviation, Piston	Cumene	98828	0.00
2275050012	General Aviation, Turbine	Cumene	98828	0.13
2275060011	Air Taxi, Piston	Cumene	98828	0.00
2275060012	Air Taxi, Turbine	Cumene	98828	0.06
2275070000	Auxiliary Power Units	Cumene	98828	0.01
2275001000	Military Aircraft, Total	Dibenzo(a,h)Anthracene	53703	0.00
2275020000	Commercial Aircraft, Total: All Types	Dibenzo(a,h)Anthracene	53703	0.00
2275050011	General Aviation, Piston	Dibenzo(a,h)Anthracene	53703	0.00
2275050012	General Aviation, Turbine	Dibenzo(a,h)Anthracene	53703	0.00
2275060011	Air Taxi, Piston	Dibenzo(a,h)Anthracene	53703	0.00
2275060012	Air Taxi, Turbine	Dibenzo(a,h)Anthracene	53703	0.00
2265008005	Ground Support Equipment, Gasoline	Ethyl Benzene	100414	3.52
2275001000	Military Aircraft, Total	Ethyl Benzene	100414	35.15
2275020000	Commercial Aircraft, Total: All Types	Ethyl Benzene	100414	21.98
2275050011	General Aviation, Piston	Ethyl Benzene	100414	43.94
2275050012	General Aviation, Turbine	Ethyl Benzene	100414	7.48
2275060011	Air Taxi, Piston	Ethyl Benzene	100414	0.63
2275060012	Air Taxi, Turbine	Ethyl Benzene	100414	3.70
2275070000	Auxiliary Power Units	Ethyl Benzene	100414	0.70
2275001000	Military Aircraft, Total	Fluoranthene	206440	0.00
2275020000	Commercial Aircraft, Total: All Types	Fluoranthene	206440	0.00
2275050011	General Aviation, Piston	Fluoranthene	206440	3.37
2275050012	General Aviation, Turbine	Fluoranthene	206440	0.00
2275060011	Air Taxi, Piston	Fluoranthene	206440	0.13
2275060012	Air Taxi, Turbine	Fluoranthene	206440	0.00
2275001000	Military Aircraft, Total	Fluorene	86737	0.00
2275020000	Commercial Aircraft, Total: All Types	Fluorene	86737	0.00
2275050011	General Aviation, Piston	Fluorene	86737	5.59
2275050012	General Aviation, Turbine	Fluorene	86737	0.00

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275060011	Air Taxi, Piston	Fluorene	86737	0.21
2275060012	Air Taxi, Turbine	Fluorene	86737	0.00
2270008005	Ground Support Equipment, Diesel	Formaldehyde	50000	0.78
2275001000	Military Aircraft, Total	Formaldehyde	50000	2,486.82
2275020000	Commercial Aircraft, Total: All Types	Formaldehyde	50000	1,554.76
2275050011	General Aviation, Piston	Formaldehyde	50000	111.14
2275050012	General Aviation, Turbine	Formaldehyde	50000	528.93
2275060011	Air Taxi, Piston	Formaldehyde	50000	1.16
2275060012	Air Taxi, Turbine	Formaldehyde	50000	262.04
2275070000	Auxiliary Power Units	Formaldehyde	50000	49.59
2265008005	Ground Support Equipment, Gasoline	Hexane	110543	8.04
2275001000	Military Aircraft, Total	Hexane	110543	0.00
2275020000	Commercial Aircraft, Total: All Types	Hexane	110543	0.00
2275050011	General Aviation, Piston	Hexane	110543	20.76
2275050012	General Aviation, Turbine	Hexane	110543	0.00
2275060011	Air Taxi, Piston	Hexane	110543	0.30
2275060012	Air Taxi, Turbine	Hexane	110543	0.00
2275001000	Military Aircraft, Total	Indeno[1,2,3-c,d]Pyrene	193395	0.00
2275020000	Commercial Aircraft, Total: All Types	Indeno[1,2,3-c,d]Pyrene	193395	0.00
2275050011	General Aviation, Piston	Indeno[1,2,3-c,d]Pyrene	193395	0.30
2275050012	General Aviation, Turbine	Indeno[1,2,3-c,d]Pyrene	193395	0.00
2275060011	Air Taxi, Piston	Indeno[1,2,3-c,d]Pyrene	193395	0.01
2275060012	Air Taxi, Turbine	Indeno[1,2,3-c,d]Pyrene	193395	0.00
2275001000	Military Aircraft, Total	Methanol	67561	364.61
2275020000	Commercial Aircraft, Total: All Types	Methanol	67561	227.97
2275050011	General Aviation, Piston	Methanol	67561	0.00
2275050012	General Aviation, Turbine	Methanol	67561	77.55
2275060011	Air Taxi, Piston	Methanol	67561	0.00
2275060012	Air Taxi, Turbine	Methanol	67561	38.42
2275070000	Auxiliary Power Units	Methanol	67561	7.27
2275001000	Military Aircraft, Total	Naphthalene	91203	109.30
2275020000	Commercial Aircraft, Total: All Types	Naphthalene	91203	68.33
2275050011	General Aviation, Piston	Naphthalene	91203	350.61
2275050012	General Aviation, Turbine	Naphthalene	91203	23.24
2275060011	Air Taxi, Piston	Naphthalene	91203	12.64
2275060012	Air Taxi, Turbine	Naphthalene	91203	11.52

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275070000	Auxiliary Power Units	Naphthalene	91203	2.18
2275001000	Military Aircraft, Total	Phenanthrene	85018	0.00
2275020000	Commercial Aircraft, Total: All Types	Phenanthrene	85018	0.00
2275050011	General Aviation, Piston	Phenanthrene	85018	9.41
2275050012	General Aviation, Turbine	Phenanthrene	85018	0.01
2275060011	Air Taxi, Piston	Phenanthrene	85018	0.35
2275060012	Air Taxi, Turbine	Phenanthrene	85018	0.01
2275001000	Military Aircraft, Total	Phenol	108952	146.65
2275020000	Commercial Aircraft, Total: All Types	Phenol	108952	91.69
2275050011	General Aviation, Piston	Phenol	108952	0.49
2275050012	General Aviation, Turbine	Phenol	108952	31.20
2275060011	Air Taxi, Piston	Phenol	108952	0.00
2275060012	Air Taxi, Turbine	Phenol	108952	15.45
2270008005	Ground Support Equipment, Diesel	Propionaldehyde	123386	0.16
2275001000	Military Aircraft, Total	Propionaldehyde	123386	146.85
2275020000	Commercial Aircraft, Total: All Types	Propionaldehyde	123386	91.82
2275050011	General Aviation, Piston	Propionaldehyde	123386	3.77
2275050012	General Aviation, Turbine	Propionaldehyde	123386	31.23
2275060011	Air Taxi, Piston	Propionaldehyde	123386	0.03
2275060012	Air Taxi, Turbine	Propionaldehyde	123386	15.47
2275070000	Auxiliary Power Units	Propionaldehyde	123386	2.93
2275001000	Military Aircraft, Total	Styrene	100425	62.44
2275020000	Commercial Aircraft, Total: All Types	Styrene	100425	39.03
2275050011	General Aviation, Piston	Styrene	100425	10.90
2275050012	General Aviation, Turbine	Styrene	100425	13.28
2275060011	Air Taxi, Piston	Styrene	100425	0.15
2275060012	Air Taxi, Turbine	Styrene	100425	6.58
2275070000	Auxiliary Power Units	Styrene	100425	1.24
2265008005	Ground Support Equipment, Gasoline	Toluene	108883	15.66
2275001000	Military Aircraft, Total	Toluene	108883	129.68
2275020000	Commercial Aircraft, Total: All Types	Toluene	108883	81.09
2275050011	General Aviation, Piston	Toluene	108883	309.56
2275050012	General Aviation, Turbine	Toluene	108883	27.59
2275060011	Air Taxi, Piston	Toluene	108883	4.48
2275060012	Air Taxi, Turbine	Toluene	108883	13.67
2275070000	Auxiliary Power Units	Toluene	108883	2.59

SCC	Process Description	Pollutant	Pollutant CAS	2023 Emissions (Tons)
2275001000	Military Aircraft, Total	Xylenes (Mixed Isomers)	1330207	56.96
2275020000	Commercial Aircraft, Total: All Types	Xylenes (Mixed Isomers)	1330207	35.62
2275050011	General Aviation, Piston	Xylenes (Mixed Isomers)	1330207	174.40
2275050012	General Aviation, Turbine	Xylenes (Mixed Isomers)	1330207	12.12
2275060011	Air Taxi, Piston	Xylenes (Mixed Isomers)	1330207	2.52
2275060012	Air Taxi, Turbine	Xylenes (Mixed Isomers)	1330207	6.00
2275070000	Auxiliary Power Units	Xylenes (Mixed Isomers)	1330207	1.14
2275001000	Military Aircraft, Total	m-Xylene	108383	0.00
2275020000	Commercial Aircraft, Total: All Types	m-Xylene	108383	0.00
2275050012	General Aviation, Turbine	m-Xylene	108383	0.00
2275060012	Air Taxi, Turbine	m-Xylene	108383	0.00
2265008005	Ground Support Equipment, Gasoline	m-Xylene	108383	9.77
2270008005	Ground Support Equipment, Diesel	m-Xylene	108383	0.00
2265008005	Ground Support Equipment, Gasoline	o-Xylene	95476	4.78
2275001000	Military Aircraft, Total	o-Xylene	95476	33.53
2275020000	Commercial Aircraft, Total: All Types	o-Xylene	95476	20.97
2275050011	General Aviation, Piston	o-Xylene	95476	0.40
2275050012	General Aviation, Turbine	o-Xylene	95476	7.13
2275060012	Air Taxi, Turbine	o-Xylene	95476	3.53
2275070000	Auxiliary Power Units	o-Xylene	95476	0.67
2275001000	Military Aircraft, Total	p-Xylene	106423	0.00
2275020000	Commercial Aircraft, Total: All Types	p-Xylene	106423	0.00
2275050011	General Aviation, Piston	p-Xylene	106423	0.00
2275050012	General Aviation, Turbine	p-Xylene	106423	0.00
2275060012	Air Taxi, Turbine	p-Xylene	106423	0.00

Appendix E. Substitute Equipment for AEDT Modeling

Original Airframe	Original Engine	Original Equip_ID	New Airframe	New Engine	New Equip ID
Boeing 707-300 Series	TF33-P-100	52	Boeing 707-300 Series	TF33-P-100	3783
Boeing 727-100 Series	JT8D-15	97	Boeing 727-100 Series	JT8D-15	6486
Lockheed P-3 Orion	TF34-GE-400	1203	Lockheed C-130 Hercules	T56-A-7	3799
Lockheed P-3 Orion	T56-A-14	1217	Lockheed C-130 Hercules	T56-A-7	3799
Lockheed C-130 Hercules	T56-A-15	1218	Lockheed C-130 Hercules	T56-A-15	3798
Lockheed P-3 Orion	T56-A-15	1220	Lockheed C-130 Hercules	T56-A-7	3799
AV-8B Harrier	F402-RR-408	1796	Unknown, Aggregated	Unknown, Aggregated	999905
Maule MT-7-235	IO-320-D1AD	3177	Piper PA-28 Cherokee Series	IO-320-D1AD	3178
Grumman F-14A Tomcat	J79-GE-10	3180	F-104 Starfighter	J79-GE-10B (w/AB)	4232
AV-8B Harrier	F402-RR-406A	3182	Unknown, Aggregated	Unknown, Aggregated	999905
Grumman A-6 Intruder	Spey 555	3186	A-7E Corsair	TF41-A-2	3181
Lockheed C-130 Hercules	R-1820	3188	Lockheed C-130 Hercules	T56-A-7	3799
Lockheed C-130 Hercules ANP:C121	R-1820	3190	Lockheed C-130 Hercules	T56-A-7	3799
Lockheed C-130 Hercules	J85-GE-5H (w/AB)	3191	Lockheed C-130 Hercules	T56-A-7	3799
McDonnell Douglas F-4 Phantom II	J79-GE-8D	3207	Rockwell Super Sabre F100	J57-P-22	4229
Boeing 707-300 Series	TF33-P-100	3211	Boeing 707-300 Series	TF33-P-100	3209
Grumman F-14B/D Super Tomcat	F110-GE-400	3220	Grumman F-14A Tomcat	TF30-P-412A	1815
Boeing F/A-18 Hornet	F404-GE-400	3222	Boeing F/A-18 Hornet	F404-GE-400	4236
Hawker Hunter	J79-GE-10B	3228	LMAASA (FMA) IA-63 Pampa	TFE731-2-2B	1847
Pilatus Turbo Trainer PC-9	PT6A-68	3230	NULL	NULL	345
BAE Nimrod MRA4	BR700-715B1-30	3235	BAC 1-11 200	SPEY MK511-8	1150
Lockheed P-3 Orion	T56-A-14	3237	Lockheed C-130 Hercules	T56-A-7	3799
McDonnell Douglas F-4 Phantom II	J79-GE-8D (w/AB)	3238	LMAASA (FMA) IA-63 Pampa	TFE731-2-2B	1847
Cessna T-37 Tweet	J69-25A	3239	Cessna 552 T-47A	JT15D-5, -5A, -5B	3241
Rockwell Twin Commander 700	TIO-540-J2B2	3256	Pilatus PC-6 Porter	PT6A-42	1464
Lockheed C-130 Hercules	CF6-50C2R	3262	Lockheed C-130 Hercules	T56-A-7	3799
Hawker HS748-1	DART 514	3977	Saab 2000	AE3007A	1446
AV-8A Harrier	F402-RR-408	4222	Unknown, Aggregated	Unknown, Aggregated	999905
Lockheed P-3 Orion	T56 series I	4646	Lockheed C-130 Hercules	T56-A-7	3799

Original Airframe	Original Engine	Original Equip_ID	New Airframe	New Engine	New Equip ID
Lockheed P-3 Orion	T56-A-14	4647	Lockheed C-130 Hercules	T56-A-7	3799
Boeing 727-200 Series	JT8D-7 series	5200	Boeing 727-200 Series	JT8D-7 series	3786
Lockheed Martin F-35 Lightning II	F117-PW-100	6678	Lockheed Martin F-16 Fighting Falcon	F100-PW-200	1812