Proposed Planning Process for the 2008 Commercial Airport Emission Inventory

Technical Report

August 15, 2010

Prepared by:

Alamo Area Council of Governments

Prepared in Cooperation with the
Texas Commission on Environmental Quality

The preparation of this report was financed through grants from the State of Texas through the Texas Commission on Environmental Quality

Title: Proposed Planning Process for the 2008 Commercial Airport Emission Inventory	**Report Date:** August 15, 2010
Authors: AACOG Natural Resources/ Transportation Department	**Type of Report:** Technical Report
Performing Organization Name & Address: Alamo Area Council of Governments 8700 Tesoro Drive Suite 700 San Antonio, Texas 78217	**Period Covered:** 2008

Sponsoring Agency:
Prepared In Cooperation With The Texas Commission On Environmental Quality
The preparation of this report was financed through grants from the State of Texas through the Texas Commission on Environmental Quality

Abstract: The Clean Air Act is the comprehensive federal law that regulates airborne emissions across the United States. This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Local and state planners employ a number of tools and data sets to evaluate regional air quality and compare ambient concentrations with the NAAQS. Chief among these evaluation tools is an emissions inventory that accurately describes, chemically, spatially and temporally, the emissions that contribute to regional air pollution. The compilation of the 2008 emissions inventory (EI) for the AACOG region requires extensive research and analysis, providing a vast database of regional pollution sources and emission rates. By understanding these varied sources that create ozone precursor pollutants, planners, political leaders, and citizens can work together to protect heath and the environment. The objective of the proposal is to provide a review of and update the commercial airport section of the 2008 National Emissions Inventories published by TCEQ. AACOG staff identified emission sources at the San Antonio International Airport (SAIA) and prepared a plan to carry out “bottom-up” research that will provide improved emissions inventory data. Emission sources at the SAIA include aircraft operations, ground support equipment (GSE), parking garages and roadways (on-road), aircraft evaporative loss, fuel storage, and non-road equipment. These categories accounted for 0.9% of the 2005 anthropogenic NOx emissions and 0.7% of the 2005 anthropogenic VOC emissions in Bexar County.

Related Reports:	**Distribution Statement:**	**Permanent File:**
2005 Emission Inventory for the Alamo Area Council of Governments Region	Alamo Area Council of Governments, Natural Resources/Transportation Department	Alamo Area Council of Governments, Natural Resources/Transportation Department

Table of Contents

List of Tables

List of Figures

Introduction

Background

The Clean Air Act is the comprehensive federal law that regulates airborne emissions across the United States.[1] This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Of the many air pollutants commonly found throughout the country, the EPA has recognized six "criteria" pollutants that can injure health, harm the environment, or cause property damage. The EPA refers to these pollutants as criteria air pollutants because health-based criteria (science-based guidelines) are the bases for setting permissible levels. The primary NAAQS sets the threshold levels, concentration values above which human health is put at risk, for each criteria pollutant.

San Antonio is currently in attainment of the ozone NAAQS. However, "on January 6, 2010, EPA proposed to strengthen the national ambient air quality standards (NAAQS) for ground-level ozone, the main component of smog. The proposed revisions are based on scientific evidence about ozone and its effects on people and the environment. EPA is proposing to strengthen the 8-hour "primary" ozone standard, designed to protect public health, to a level within the range of 0.060-0.070 parts per million (ppm). EPA is also proposing to establish a distinct cumulative, seasonal "secondary" standard, designed to protect sensitive vegetation and ecosystems, including forests, parks, wildlife refuges and wilderness areas. EPA is proposing to set the level of the secondary standard within the range of 7-15 ppm-hours."[2] According to the EPA, "the health effects associated with ozone exposure include respiratory health problems ranging from decreased lung function and aggravated asthma to increased emergency department visits, hospital admissions and premature death. The environmental effects associated with seasonal exposure to ground-level ozone include adverse effects on sensitive vegetation, forests, and ecosystems."[3]

To meet the stricter standards, local and state air quality planners need to have an accurate record of emission sources in the region. The compilation of the 2008 emissions inventory (EI) for the AACOG region requires extensive research and analysis, providing a vast database of regional pollution sources, their emissions, and emission rates. By understanding these varied sources that create ozone precursor pollutants, planners, political leaders, and citizens can work together to protect heath and the environment.

Objectives and Approach

The objective of this proposal is to provide a review and update of the aircraft source portion of the 2008 National Emissions Inventories (NEI) published by TCEQ. The proposal follows the steps listed below.

1. Review the aircraft portion of the NEI provided by the TCEQ and compare emissions to the AACOG's EI.

---

[1] US Congress, 1990. Clean Air Act. Available online: http://www.epa.gov/air/caa/. Accessed 07/19/10.

[2] EPA, January 6, 2010. "Fact Sheet: Proposal to Revise the National Ambient Air Quality Standards for Ozone". p. 1. Available online: http://www.epa.gov/air/ozonepollution/pdfs/fs20100106std.pdf. Accessed 06/28/10.

[3] EPA, September 16, 2009. "Fact Sheet: EPA to Reconsider Ozone Pollution Standards"., p. 1. Available online: http://www.epa.gov/air/ozonepollution/pdfs/O3_Reconsideration_FACT%20SHEET_091609.pdf. Accessed 06/28/10.

2. Identify any significant source categories that are under or over estimated or where additional or more detailed emissions inventory input at a sub-county level can be provided.
3. Identify emission sources and prepare a plan to carry out “bottom-up” research that will provide improved emissions inventory inputs.
4. Generate raw local inputs such as population figures, local activity profiles, and spatial surrogates.

Emphasis is placed on the 2008 NEI because it reflects the latest available inventory data. For this reason, the aircraft emissions inventory in the TCEQ’s Texas Air Emissions Repository (TexAER) and the supporting documentation published by the Eastern Research Group, Inc. (ERG)[4] were reviewed. AACOG identified areas where additional and more detailed emissions inventory data can be developed at a sub-county level of analysis.

The focus of these improvements is not the end-product generation of emissions estimates in units of tons per day, but rather the raw local inputs such as population sizes, local activity profiles, spatial surrogates, temporal profiles, and other data. All proposed survey work in this plan is accompanied by a survey design describing the population, the information to be collected from the population, a description of how AACOG intends to collect a sample, the type of sample to be drawn from the population, the desired margin of error, and the minimum sample size necessary to achieve the desired margin of error.

Inventory of Pollutants

To make the 2008 EI a reliable starting point for anticipated photochemical modeling the following precursors of ozone will be included:

- Nitrogen Oxides (NO_x)
- Volatile Organic Compounds (VOC)
- Carbon Monoxide (CO)

Geographic Area

Emissions will be calculated for the San Antonio International Airport (SAIA), which is the only commercial airport within the AACOG region (figure 1).

Data Sources

Emissions for each source category will be calculated by AACOG using procedures developed by EPA and TCEQ. All current federal and state regulations will be taken into account when calculating emissions. Empirical data on annual aircraft landings and take-offs at SAIA, by specific aircraft type, will be obtained from GCR & Associates, Inc.[5] Internet site. For consistency and accuracy, this data will be compared with data from other sources such as the Federal Aviation Administration’s software, Terminal Area Forecast (TAF)[6] reports, and the SAIA’s annual reports published by the City of San Antonio’s Department of Aviation[7].

---

[4] Eastern Research Group, Inc., July 17, 2009, “Compilation of Activity Data and the Development of Criteria Pollutant Emission Estimates for Aircraft”. TCEQ, Austin, TX. Available online: *ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/NEI/2008/Aircraft/*. Accessed 07/20/10.

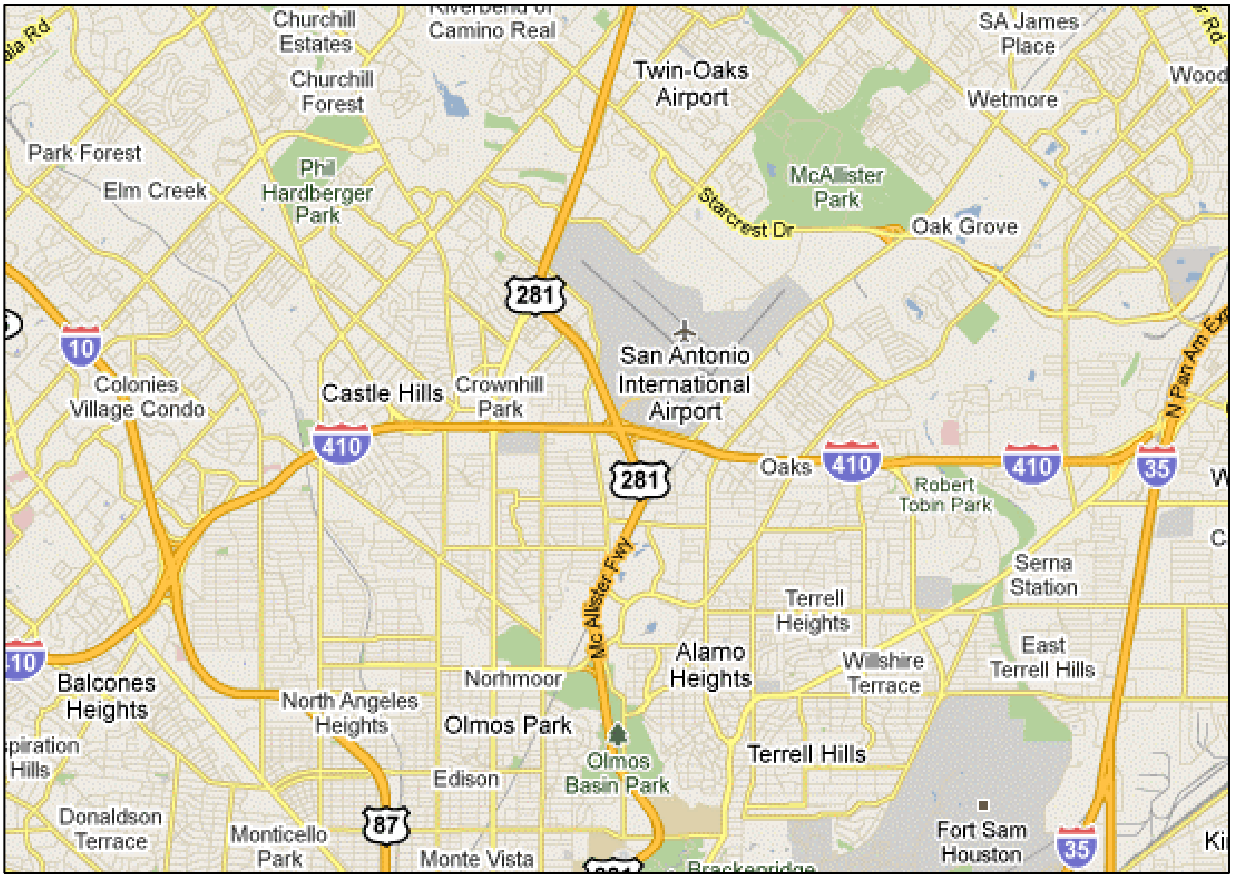
[5] GCR and Associates, Inc. 2005. Airport IQ Data Center. Available online: http://www.airportiq.com/ Accessed 07/20/10.

[6] Federal Aviation Administration, 2009. “Terminal Area Forecast Reports”. Washington, DC. Available online: http://aspm.faa.gov/main/taf.asp. Accessed 07/20/10.

[7] City of San Antonio, Dec. 2008. “Airport Statistic 2008”. Department of Aviation. Available online: http://www.sanantonio.gov/Aviation/statistics.asp. Accessed 07/20/10.

Comprehensive research, using the aircrafts' user's manuals and the default values of Emission & Dispersion Modeling System (EDMS) model,[8] will be conducted to collect engine specification and emission factors.

Figure 1: Location of San Antonio International Airport[9]



A list of Ground Support Equipment (GSE) will be compiled by sending a survey instrument to all tenants at SAIA and information on output power (HP), emission factors, and load factors will be collected from the equipment user's manuals and default values used in the EDMS model. The EDMS model will be used to calculate emissions for parking garages; however its default emission factors for vehicles will be replaced with those of Motor Vehicle Emission Simulator model (MOVES)[10].

The EDMS model does not estimate aircraft evaporative emissions, which result from refueling, diurnal (temperature-driven) losses, and pre-flight safety procedures. Procedures approved by

---

[8] The Federal Aviation Administration, Nov. 2009. "Emissions & Dispersion Modeling System, Version 5.1.2". Available online: http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/. Accessed 07/20/10.

[9] "San Antonio International Airport". Available online: http://www.san-antonio-airport.com/. Accessed 08/05/10.

[10] U.S. EPA, December 2009. Office of Transportation and Air Quality Washington, DC. Motor Vehicle Emission Simulator. Available online: http://www.epa.gov/otaq/models/moves/index.htm. Accessed 07/21/10.

EPA and published by the Federal Aviation Administration[11] will be used to calculate emissions from these sources. EPA's NONROAD2008a Model[12] will be applied to process non-road equipment at SAIA.

Refined Emission Categories

At SAIA, emissions occur from daily operations and a diverse range of sources. AACOG staff proposes updates and expansion of the following emission sources for inclusion in the 2008 emission inventory:

- ☐ Aircraft Operations (commercial, general aviation, and military operations)
- ☐ Ground Support Equipment (GSE)
- ☐ Parking Garages and Roadways (On-road)
- ☐ Aircraft Evaporative Loss
- ☐ Fuel Storage
- ☐ Non-road Equipment

Emission contributions from each of the proposed categories, compared to the total anthropogenic emission inventory for Bexar County, are provided in table 1. Local data collected for commercial, general aviation, and military operations, as well as the categories of GSE, parking garages, annual fuel consumption at the airport, and non-road equipment will be used to calculate emissions through a "bottom-up" calculation methodology.

Efforts will be made to obtain a robust GSE inventory because electrification of this equipment is a commonly considered control strategy. Aircraft can be relatively large emission sources, but are unlikely candidates for emission reductions. However, aircraft emissions shall not be ignored because San Antonio is a large metropolitan area and significant military aircraft activity exists in the region.

Table 1: Contribution of Emissions for each Proposed Refined Category at SAIA for the 2005 Bexar County Anthropogenic Emissions, tons/day

Emission Inventory Category	NO_x		VOC	
	Tons	Percentage	Tons	Percentage
Aircraft Operations	1.22	0.66%	0.42	0.37%
Ground Support Equipment	0.35	0.19%	0.26	0.23%
Parking Garages	0.07	0.04%	0.07	0.07%
Aircraft Evaporative Loss	0.00	0.00%	0.03	0.03%
Fuel Storage	0.00	0.00%	0.02	0.02%
Non-road Equipment	0.02	0.01%	0.01	0.01%
Total Bexar County Anthropogenic Emissions (mobile, point, area, non-road)	185.34	100%	112.60	100%

---

[11] Federal Aviation Administration, June 2, 2005. "Air Quality Procedures for Civilian Airports and Air Force Bases, Appendix D: Aircraft Emission Methodology". Office of Environment and Energy. Washington, DC. Available online: http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/App_D.PDF. Accessed 08/05/10.

[12] U.S. Environmental Protection Agency, Dec. 2008. "NONROAD2008a Model". Office of Transportation and Air Quality. Available online: http://www.epa.gov/otaq/nonrdmdl.htm. Accessed 06/13/10.

Texas and AACOG Commercial Aircraft Emission Inventories

AACOG reviewed TCEQ’s 2005 and 2008 emission inventories for aircraft and categories that are under or over estimated or where additional or more detailed emissions inventory inputs at a sub-county level can be provided. Table 2 provides comparisons between the two emission inventories for all airports located in Bexar County in the 2008 TexAER and the AACOG's 2005 emission inventory. Military aircraft in the AACOG region often use civil airports as well as the airports located at military bases throughout Bexar County. General aviation (GA) aircraft use SAIA, Stinson airport, and five small private airports within Bexar County.

As shown in the table, there is a significant difference for several emission source categories associated with airport operations, especially for the military aircraft category. VOC emissions for the AACOG emission inventory were 105% greater than the emissions in TexAER and the NOx emissions were 47% greater than the results from TexAER. Although AACOG’s emission inventory was larger, commercial aircraft emissions were less than the emission published in TexAER database.

Table 2: Comparison of Airport Emission Sources for Bexar County in TexAER 2008 and 2005 AACOG Emission Inventories

Emissions Source	2005 AACOG Tons/Day			2008 TexAER Tons/Day			Difference		
	VOC	NO_x	CO	VOC	NO_x	CO	VOC	NO_x	CO
Airport GSE/APU	0.282	0.495	7.222	0.060	0.191	1.770	0.221	0.304	5.453
Military Aircraft	0.520	1.676	4.971	0.010	0.001	0.209	0.510	1.675	4.761
Commercial/AT*Aircraft	0.188	1.057	0.956	0.653	2.857	3.480	-0.465	-1.800	-2.524
General Aviation Aircraft	0.283	0.119	2.998	0.496	0.026	4.814	-0.213	0.093	-1.816
Garages And Roadways	0.640	0.511	5.111	-	-	-	-	-	-
Aircraft Evaporative Loss	0.082	0.000	0.000	-	-	-	-	-	-
Fuel Storage	0.044	0.000	0.000	-	-	-	-	-	-
Jet Engine Testing	0.079	0.250	0.602	-	-	-	-	-	-
Boilers	0.000	0.004	0.002	-	-	-	-	-	-
Non-Road Equipment	0.380	0.399	3.111	-	-	-	-	-	-
TOTAL	2.497	4.510	24.973	1.219	3.075	10.273	1.277	1.435	14.700

*****AT = Air Taxi operations.

Aircraft Operations

Emissions associated with aircraft landing and take-off (LTO) cycles at SAIA are calculated using the EDMS model, version 5.1.2.[13] The EDMS model uses EPA approved emission factors and estimation methodology. Information on aircraft type, engine specification, and number of annual LTO are entered into the EDMS model to estimate the amount of pollutants attributed to the landing and take-off cycle for each aircraft. Emissions will be calculated for the following aircraft categories:

- ☐ Commercial Aircraft
- ☐ General Aviation Aircraft
  - ☐ Jet
  - ☐ Piston
  - ☐ Turbo
- ☐ Military Aircraft

Detailed information on the various types of aircraft categories, their engine types, and total number of operations is provided in Appendix A. The following steps are proposed for the processing of aircraft data:

1. Collect local 2008 activity data for each aircraft operation at SAIA.
2. Calculate aircraft ozone precursor emissions using local data in the EDMS model.
3. Temporally allocate emissions by hour.
4. Spatially allocate emissions to the 4km grid system used in the photochemical model.

This "bottom-up" approach will enhance the accuracy of emission estimations and spatial allocation. Local data used in the EDMS model and produce by the spatial allocation, along with the final results, will be provided to TCEQ.

Step 1: Collect Activity Data for Aircraft Operations

Landing and take-off operational data was obtained from GCR[14] for all non-military aircraft that used SAIA in 2008. The data includes information for commercial and GA aircraft, including Jet,[15] Turbo-Prop,[16] and Piston[17] aircraft. The Federal Aviation Administration (FAA) provides the total number of military operations for 2008. However, FAA data does not clarify the exact military aircraft types for each operation. Personnel at SAIA's control tower will provide military aircraft types that use the airport.

---

[13] The Federal Aviation Administration, Nov. 2009. "Emissions & Dispersion Modeling System". Available online: http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/. Accessed 07/21/10.

[14] GCR and Associates, Inc. 2005. Airport IQ Data Center. Available online: http://www.airportiq.com/ Accessed 07/20/10.

[15] "The principle of all jet engines is essentially the same. The engine draws air in at the front and compresses it. The air then combines with fuel and the engine burns the resulting mixture. The combustion greatly increases the pressure of the gases which are then exhausted out of the rear of the engine.", KnowledgeRush. Available online: http://www.knowledgerush.com/kr/encyclopedia/Jet_engine. Accessed 08/03/10.

[16] "A turboprop …(uses) the power of the jet engine to drive a propeller", Free-Definition. Available online: http://www.free-definition.com/Turboprop.html. Accessed 08/03/10.

[17] A piston-engine with propeller as propulsion

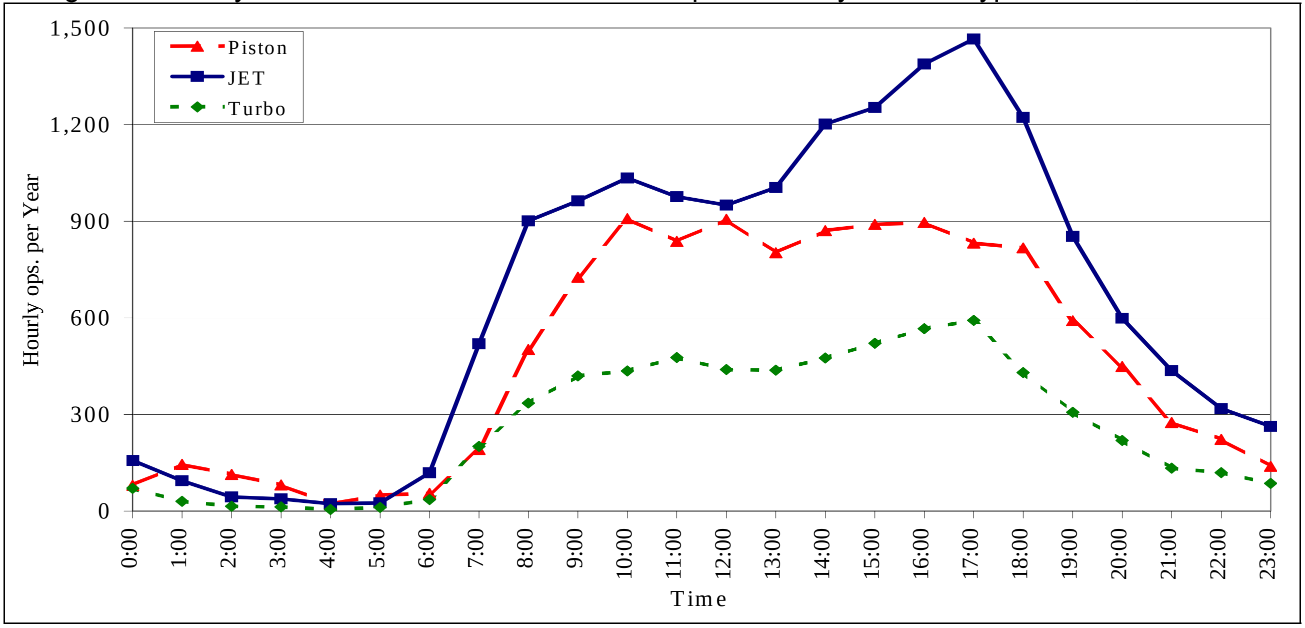
Step 2: Calculate Emissions Using EDMS Model

The annual number of operations and exact engine types for each aircraft will be entered into the EDMS model. The EDMS model will be applied to calculate emissions for each aircraft type: commercial, GA jet, GA turbo, GA piston, and military flights.

Step 3: Temporally Allocate Emissions from Aircraft Operations

Processing emissions in a photochemical model includes such steps as chemical speciation, temporal allocation, and spatial allocation of emissions data. These steps necessitate the allocation of aircraft emissions to the grid-cell based modeling system and conversion of daily emissions data to hourly data as required by the CAMx model.[18] For this task, the commercial airlines' arrival and departure schedules and GCR's landing and take-off data for each aircraft will be studied to determine the temporal distribution for all aircraft operations. The following figure provides temporal allocation of arrivals and departures for 2005 GA flights. Temporal allocation will be updated for the 2008 EI.

Figure 2: Hourly Distribution of General Aviation Operations by Aircraft Type at SAIA, 2005



Step 4: Spatially Allocate Emissions from Aircraft Operations

To allocate emissions spatially, information on runway patterns for each aircraft type was obtained from the San Antonio Department of Aviation (Table 3). The information provides the percentage of annual flights that take place at the end of each runway. This will make it possible to assign EDMS-generated aircraft emissions to each runway's end based on the percentages of runway utilization. The emissions will be based on arrival and departure of each flight. Figure 3 depicts schematics of runways that will be used to allocate aircraft emissions to each runway.

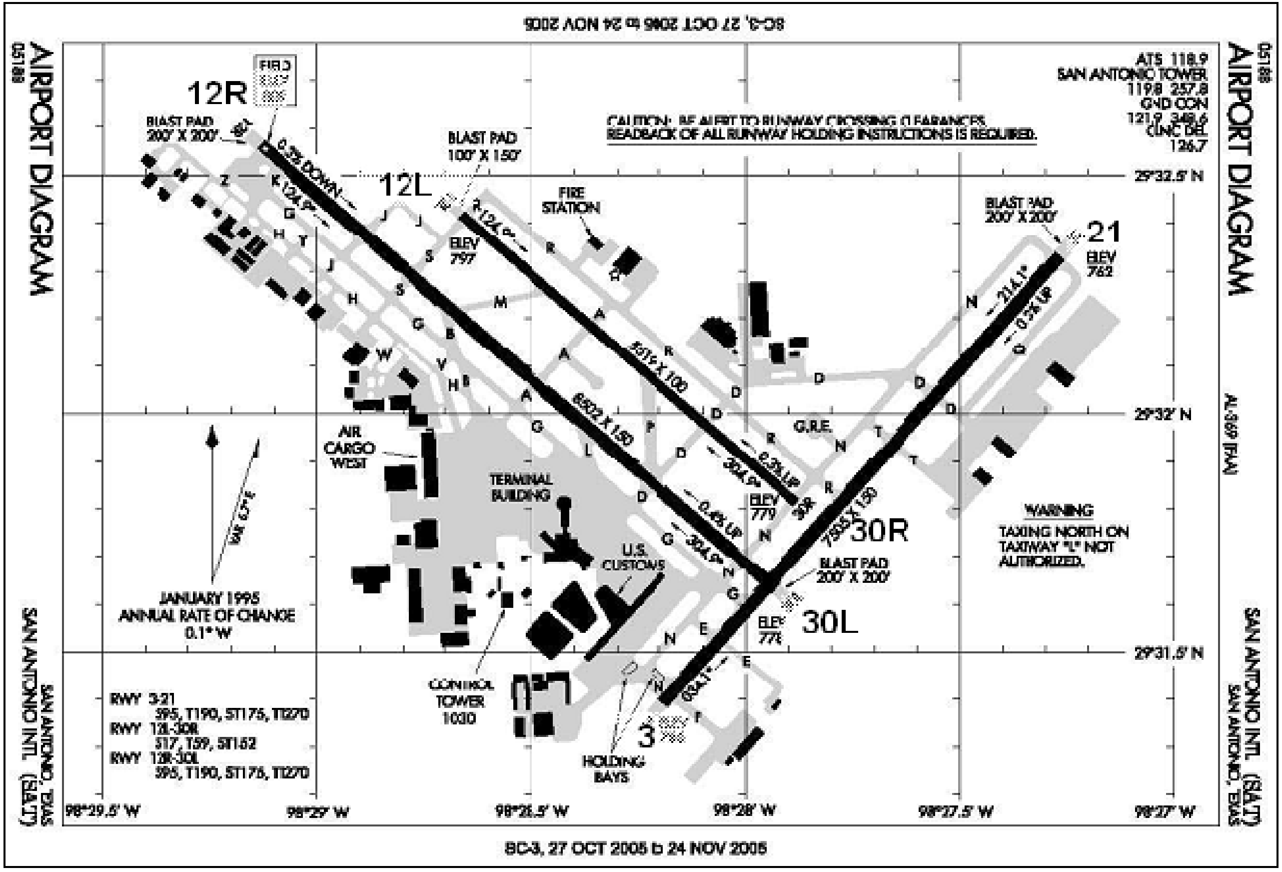
---

[18] ENVIRON International Corporation, March, 2010. "CAMx: Comprehensive Air Quality Model With Extensions, Version 5.20". Novato, California, Available online: http://www.camx.com/. Accessed 08/06/10.

Table 3: Percentage of Aircraft Operations by Allocated Runway and Direction at SAIA

Runway	Departure				Arrival			
	Commercial	Jet	Turbo	Piston	Commercial	Jet	Turbo	Piston
RW 12R	45%	61%	58%	51%	74%	70%	72%	58%
RW 12L	0%	3%	1%	4%	0%	2%	5%	13%
RW 21	2%	2%	2%	4%	3%	2%	2%	4%
RW 30R	0%	0%	2%	3%	0%	0%	1%	4%
RW 30L	14%	18%	14%	11%	13%	15%	11%	10%
RW 3	38%	16%	23%	27%	10%	11%	9%	11%
Total	99%	100%	100%	100%	100%	100%	100%	100%

Figure 3: Runway Schematics at SAIA



To calculate hourly emissions by runway and aircraft type, the following formula will be used:

Equation (1)

EM_{AB} = PAO x EM_A x HR_B

Where,

EM_{AB} = Aircraft emissions by aircraft type A and by hour B (VOC, NOx, or CO)

PAO = Percentage of aircraft operations allocated by runway and aircraft category (Commercial, jet GA, turbo GA, piston GA, and military) (from SAIA)

EM_A = Emission by mode for aircraft type A (from EDMS model)

HR_B = Percentage of total operations during hour B (from GCR's data and SAIA schedules)

In the next step, aircraft emissions for the flight modes of take-off (0 – 305 meters), climb out (305 – 914 meters), and approach (914 – 0 meters) are allocated to the CAMx photochemical grid system. Emissions from aircraft above 3,000 feet in elevation will not be calculated. At those elevations, aircraft are usually above the mixing height for San Antonio[19] and emissions would have an insignificant impact on ground-level ozone monitors in San Antonio.

To allocate emissions to the CAMx grid cells, height, latitude, and longitude are calculated for 8 nodes at incremental ground distances from the ends of each runway. Figure 3, which provides a diagram of the layout and dimensions of runways at SAIA, is used to calculate the latitude and longitude of each node. Figure 4 shows these nodes superimposed on an aerial photo of the airport, illustrating the horizontal location and distance of these nodes relative to both ends of each runway. In addition, grid cells are displayed in a light green color.

The landing angle of aircraft is set at 3° and departure angle at 9°. These angles are the same as those used in previous versions of the Dallas State Implementation Plan for the Dallas/Fort Worth International Airport. This information, in addition to the formula below, is used in TransCAD geographic information system (GIS) software[20] to locate eight nodes within the CAMx horizontal and vertical grid cells to replicate the 3-dimensonal paths of aircraft. The aircraft emissions by mode and runway are then equally distributed and allocated to these nodes.

Equation (2)

$$H = D \times \mathrm{TAN}\,(\mathrm{Angle} \times \mu / 180^\circ)$$

Where,

H = height of the node
D = ground distance from the runway end point (from Table 4)
μ = mathematical constant pi (≈3.14159)
Angle = Angle of slope (3° or 9°)

Table 4 contains the heights, latitudes, and longitudes of nodes for runway 3/21. Four nodes are used to allocate take off and climb out emissions. For allocation of landing emissions, six nodes are used. These are spaced in 1,000-meter increments from the end of the runway. The heights of the landing nodes start at 264 meters (which is the height of the plane at 5,000 meters ground distance from the airport) due to the uncertainty of aircraft direction before this distance.

The vertical heights by the three different aircraft operation modes and June 2006 photochemical model vertical grid layers are shown in figure 5. Aircraft emissions are allocated to the first 8 vertical layers of the photochemical model grid system. Once the emissions are geo-coded to correct location and height, the data will be converted to the Emission Preprocessing System 3 (EPS3) format used by the photochemical model.

---

[19] The Federal Aviation Administration, Nov. 2009. "Emissions & Dispersion Modeling System". Available online: http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/. Accessed 07/20/10.
[20] Caliper Corporation, Jan. 2, 2008. "TRANSCAD: Transportation GIS Software". Version 5.0. Newton MA.

Figure 4: Aerial View of Calculated Nodes

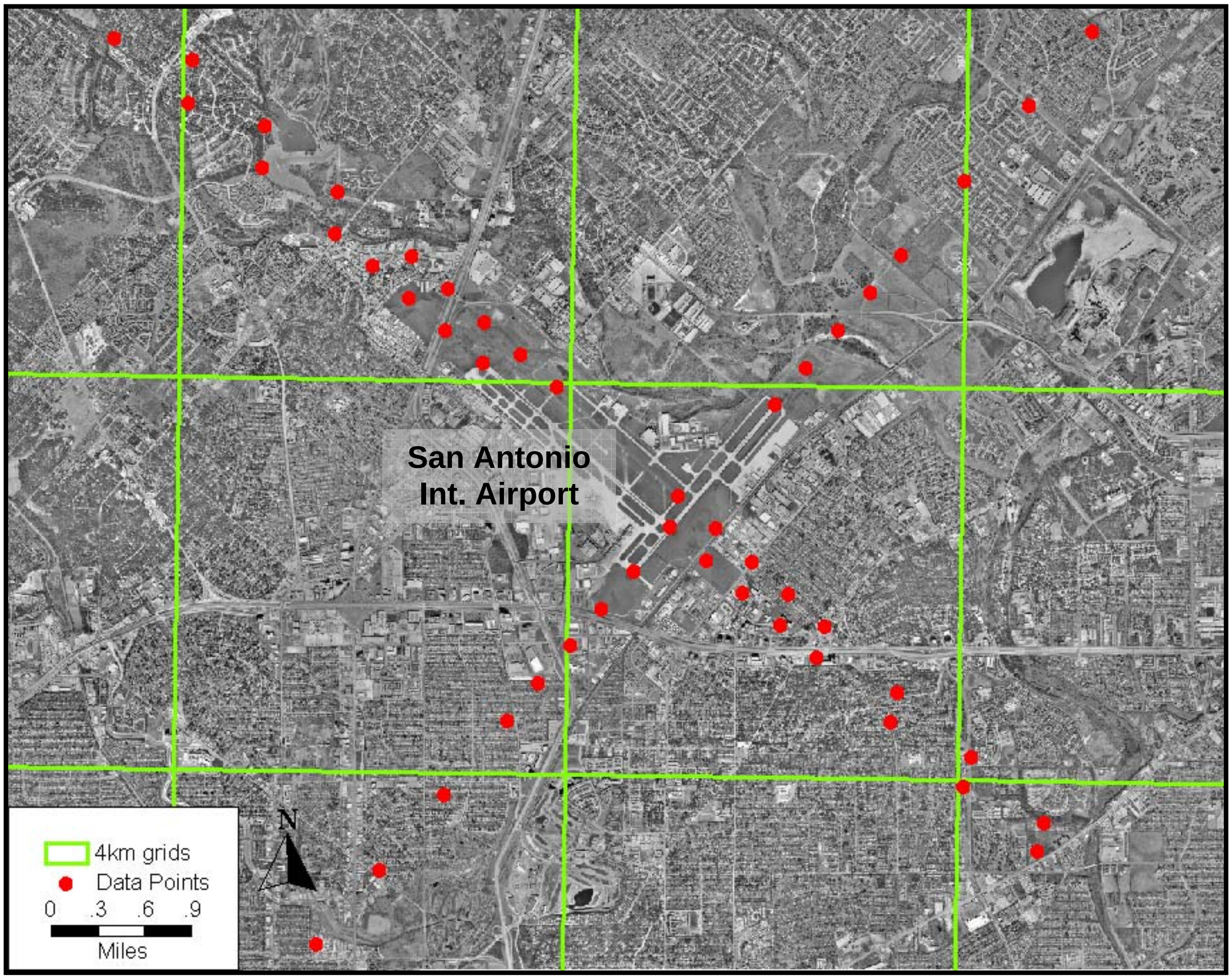
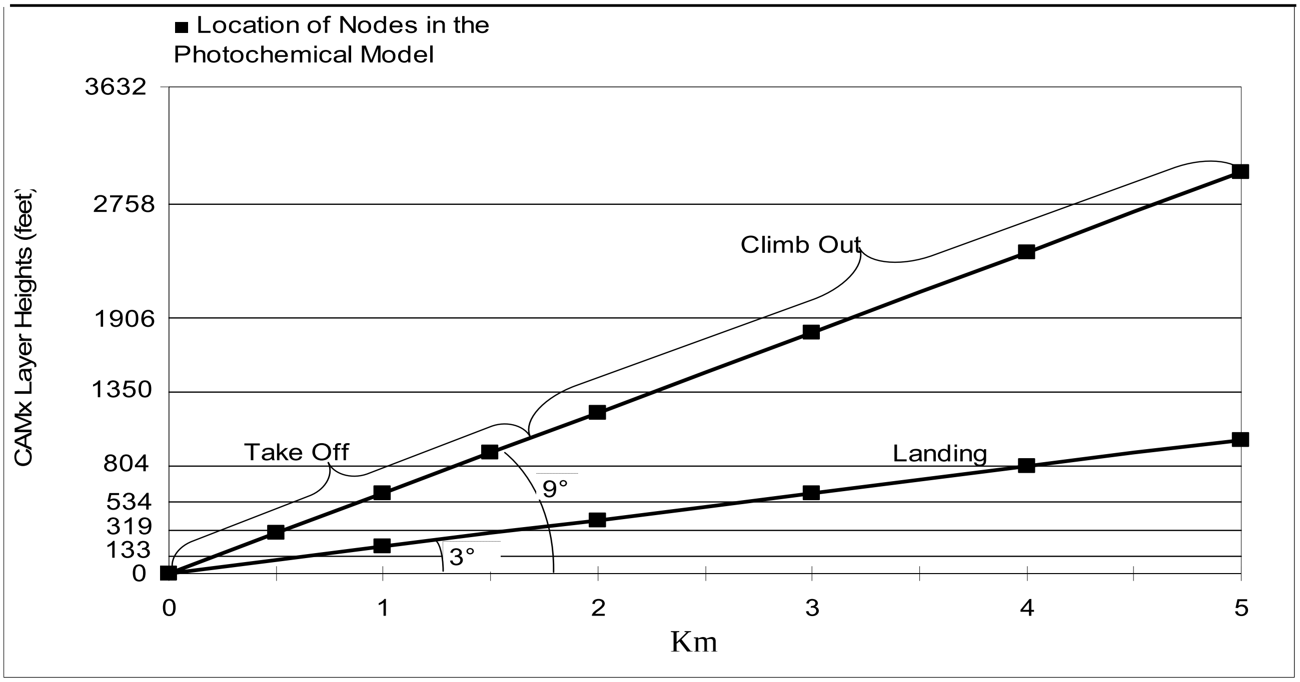


Table 4: Dimensional Features of Calculated Pathway Nodes for Landing and Take-off

Runway Nodes (Direction)	Distance from End of Runway (m)	Latitude (Y coordinate)	Longitude (X Coordinate)	Node Height (m) for 9º - Take off	Node Height (m) for 9º - Climb out	Node Height (m) for 3º - Landing
Runway 3 Nodes (Northeast)	0	-1157.69	150.96	0	N/A	0
	500	-1157.31	151.27	79	N/A	N/A
	1,000	-1156.94	151.58	158	N/A	53
	1,500	-1156.56	151.89	238	N/A	N/A
	2,000	-1156.18	152.20	N/A	317	106
	3,000	-1155.43	152.83	N/A	475	158
	4,000	-1154.68	153.45	N/A	634	211
	5,000	-1153.92	154.08	N/A	792	264
Runway 21 Nodes (Southwest)	0	-1159.41	149.53	0	N/A	0
	500	-1159.79	149.22	79	N/A	N/A
	1,000	-1160.17	148.90	158	N/A	53
	1,500	-1160.54	148.59	238	N/A	N/A
	2,000	-1160.92	148.28	N/A	317	106
	3,000	-1161.67	147.66	N/A	475	158
	4,000	-1162.43	147.03	N/A	634	211
	5,000	-1163.18	146.41	N/A	792	264

N/A: these nodes are not used for allocation of emissions

Figure 5: Calculated Heights of Nodes for LTO Operations at End of Runways*



*Note: Angles in diagram are for illustration purposes only and are not to scale.

Ground Support Equipment

Ground support equipment (GSE) is used to support and service aircraft on the ground between flights. The equipment provides support for ground power operations, aircraft transport, and loading operations (for both cargo and passengers). Data will be collected for the following equipment:

- ☐ Aircraft Pushback Tractor
- ☐ Air Conditioner Unit
- ☐ Air Start Unit
- ☐ Baggage Tug
- ☐ Belt Loader
- ☐ Cargo Loader
- ☐ Catering Truck
- ☐ Deicing Equipment
- ☐ Fuel Truck
- ☐ Lavatory Truck
- ☐ Water Truck
- ☐ Fork Lift
- ☐ Lift
- ☐ Ground Power Unit
- ☐ Other Truck

The following steps will be used to calculate GSE emissions:

1. Conduct a survey of GSE to determine equipment population, usage rates, and equipment characteristics.
2. Calculate ozone precursor emissions.
3. Spatially allocate emissions from GSE to the 4km photochemical model grids.

Raw local input data such as equipment population sizes, local activity profiles, and spatial surrogates will be provided to TCEQ.

Step 1: Conduct a Survey of Local GSE Equipment
For this emission inventory, a list of GSE equipment will be compiled from a survey sent to all tenants at SAIA. Other necessary information such as output (HP), emission factors, and load factors for the equipment will be compiled from equipment user's manuals and/or default values used in the EDMS model. After the surveys are completed, the tenants at SAIA and the City's Department of Aviation will be contacted and consulted to assure the accuracy and completeness of the sample data. Although the EDMS model provides a default GSE allocation to each aircraft, this allocation will not be used to calculate emissions.

In order to make a general conclusion about the targeted population, the number of returned surveys required for an accurate representation of the population is an important factor. The survey and the follow-ups with representatives of airliners/tenants and the City's authorities at SAIA should provide a 100% count of all GSE equipment in operation at SAIA. However, estimation of the minimum number of returned survey questionnaires required for this study is determined as described below. Since initially determining a suitable sample size is not always clear-cut, several major factors must be considered. Due to time and budget constraints, a 95% level of confidence, which is the risk of error, the researcher is willing to accept, is chosen. Similarly, the confidence interval, which determines the level of sampling accuracy, was set at +/- 5%. Since the population is finite, the following equation was used to select the sample size.[21]

---

[21] Rea, L. M. and Parker, R. A., 1992. "Designing and Conducting Survey Research". Jossey-Bass Publishers: San Francisco.

Equation (1)

$$RN = [CLV^2 \times 0.25 \times POP] / [CLV^2 \times 0.25 + (POP - 1) CIN^2]$$

Where,

RN = Number of survey responses needed to accurately represent the population
CLV = 95% confidence level (1.96)
POP = Population size (30 airport tenants)
CIN = ± 5% confidence interval (0.05)

For a 5% confidence interval:

$$\begin{aligned} RN &= [(1.96)^2 \times (0.25) \times 30] / [(1.96)^2 \times (0.25) + (30 - 1) \times (0.05)^2] \\ &= 27.89 \text{ responses} \end{aligned}$$

Thus, 28 survey responses are needed in order to meet the 95% level of confidence, and the ±5% confidence interval for equipment population. The cover letter and the questionnaire that have been prepared for this survey are provided in the following pages. This survey is expected to capture 100 percent of the survey population; therefore there is no margin of error.

Step 2: Estimate Emissions of Ozone Precursors

Information on equipment features, such as HP, load factor, average operation time per aircraft in minutes, and emission factors, will be collected using the surveys, EDMS model, and the equipment user's manuals. Since information on the model year and model name are collected through surveys, research will be conducted to collect additional equipment information needed for estimating emissions.

The annual number of aircraft operations that use each GSE will be determined to identify the frequency of use of surveyed GSE. Total numbers of aircraft that need specific GSE service at arrival or departure are determined by studying the features, size, and function of each aircraft that landed at SAIA in the year 2008. For example, if an aircraft, due to its size and function, does not need a catering truck, emissions from the truck will not be included. Overall, this procedure requires grouping of surveyed equipment by their types and functions and finding correct aircraft matches among the list of commercial aircraft that landed at SAIA.

AACOG
Alamo Area Council
Of Governments

Nov. 14, 2008

Operations Manager,

Re: 2008 San Antonio Emissions Inventory

The Alamo Area Council of Governments (AACOG) requests your assistance in developing the 2008 emission inventory for San Antonio International Airport. AACOG is conducting this inventory in order to assess local air quality and quantify pollutants within the San Antonio metropolitan area and contiguous counties. This inventory is especially significant because the San Antonio region currently risks being declared in non-attainment of federal air quality standards.

With this survey, we are requesting information on ground support equipment (GSE) used in your operations during the 2008 calendar year. The purpose of this survey is to provide better information and services to the region, as well as help minimize additional regulation on the community.

Your input is vital to this process and will serve to affect a true emission inventory, which will eventually be delivered to the U.S. Environmental Protection Agency. Please provide your responses by the date indicated. The information you provide will be considered strictly confidential and unavailable to public information requests. Please submit your response by, December 19, 2008.

Thank you for your time and participation. If you have any questions or comments please feel free to contact Parviz Nazem at (210) 362-5317.

Sincerely yours,

Gloria Arriaga
Executive Director

Enclosures (1)

Airport Ground Support Equipment (GSE) Survey

Tenant Name:

GSE Type	Fuel Type (diesel, gasoline, LNG, electric)	Number of Units (how many)	Model Name	Model Year (if known)	Horse Power (if known)	Average Minutes per Airplane (if known)
Aircraft Pushback Tractor						
Air Conditioner Unit						
Air Start Unit						
Baggage Tug						
Belt Loader						
Cargo Loader						
Catering Truck						
Deicing Equipment						
Fuel Truck						
Lavatory Truck						
Water Truck						
Fork Lift						
Lift						
Ground Power Unit						
Other Trucks:						

The following equation will be used to calculate GSE emissions.

Equation (2)

$$AE_A = EP_A \times MIN_A \times HP_A \times LF_A \times EF_A \times LAND_A$$

Where,

AE_A = Emissions for each type of equipment A
EP_A = Equipment population of type A (based on survey)
MIN_A = Minutes/Aircraft of use for equipment A (based on survey and EDMS model)
HP_A = Horsepower for equipment type A (based on survey, user's manual, and EDMS model)
LF_A = Typical load factor for equipment type A (based on EDMS and NONROADa model)
EF_A = Average emissions of pollutant per unit of use for equipment type A, g/hp-hr (EDMS model)
$LAND_A$ = Annual number of applicable aircraft landings and take-offs for equipment A (from GCR's aircraft operations data and EDMS model)

The EDMS model will be used to calculate any GSE emissions used by GA aircraft at SAIA.

Step 3: Spatially Allocate Emissions

Emissions will be spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model. Emissions will be geo-coded to the geographic location of SAIA.

Parking Garages

Vehicles owned by employees, businesses, vacationers and business travelers frequently use parking lots and parking structures at SAIA. Parking lots at SAIA, including employee, long term, hourly, and economy lots and garages, will be analyzed using the EDMS model. EDMS emissions estimates are based on the number of vehicles using each facility, as well as the average speed, idle time and distance traveled. Information on usage frequencies, idling times, and trip lengths of vehicles are entered into the EDMS model. Emission factors used by the EDMS model to calculate vehicle emissions will be replaced with emission factors from the MOVES[22] model. Data collected will include activity rates at the following locations:

- ☐ Daily Parking Utilization Rates
  - o Employee Parking
  - o Long Term Parking
  - o Hourly Parking
  - o Economy Parking
  - o Cell Phone Parking lot
- ☐ Roadway Average Daily Traffic
  - o Airport Blvd.
  - o South Terminal Dr.
  - o Airport Loop

The following steps are proposed to calculate emissions from vehicles using SAIA roadways and parking garages:

1. Collect local 2008 traffic volume and utilization data.
2. Calculate ozone precursor emissions using EDMS and MOVES models.
3. Spatially allocate emissions to the 4km grid system used in the photochemical model.

Raw local input data such as population sizes, local activity profiles, and spatial surrogates will be provided to TCEQ.

Step 1: Collect Local Input Data

Parking utilization data for SAIA parking facilities will be obtained from the Department of Aviation, and the average length of trips inside and outside of the lots will be calculated using roadway and parking lot schematics. Roadway speed limits (35 miles per hour) will be used for roadways. Driving speeds and idle times will be estimated for parking lots based on site visits. The average annual traffic (AAT) volumes on the Airport access roads, which are a function of passenger enplanement activities, will be determined from TxDOT's saturation maps.

Step 2: Estimate Ozone Precursor Emissions

The EDMS model will be used to calculate emissions from vehicles using the roadways and parking garages. Information on parking lot usage frequency, roadway speeds, idling time inside of parking facilities, and trip lengths on the access roads will be entered into the EDMS model. Emissions factors used for on-road vehicles in the EDMS model will be based on the MOVES[23] model.

---

[22] U.S. Environmental Protection Agency, December 2009. "Motor Vehicle Emission Simulator". Office of Transportation and Air Quality Washington, DC. Available online: http://www.epa.gov/otaq/models/moves/index.htm. Accessed 07/21/10.

[23] *Ibid*.

Step 3: Spatially Allocate Emissions

Emissions will be spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model. Emissions will be geo-coded to the geographic location of SAIA.

Evaporative Emissions

Evaporative emissions are associated with refueling, diurnal, and pre-flight safety procedures used for piston aircraft based at SAIA. As described in Appendix D of "Air Quality Procedures for Civilian Airports & Air Force Bases" [24], evaporative related emissions from Jet fuel are insignificant due to the low vapor pressure of the fuel and the use of quick-connect refueling nozzles. Since the EDMS model does not estimate evaporative emissions, the following steps are proposed for calculating evaporative emissions at SAIA:

1. Collect 2008 aviation fuel consumption data and determine the number of piston aircraft based at SAIA.
2. Calculate evaporative VOC emissions for based piston aircraft using EPA approved methodology.
3. Spatially allocate emissions to the 4km grid system used in the photochemical model.

Step 1: Collect Local Input Data

Fixed Based Operators (FBOs) at SAIA report their total annual sales of aviation fuel to the City of San Antonio[25]. Unfortunately, these reports aggregate together the sales of AvGas and Jet fuel. The total number of piston engine aircraft based at SAIA is available from the GCR[26] data for SAIA.

Step 2: Estimate Ozone Precursor Emissions

Refueling

Piston engine aircraft fuel usage will be estimated from 2008 SAIA total aviation fuel consumption data obtained from the City of San Antonio. Total fuel usage is an aggregation of AvGas and Jet fuel consumption rates, which will be split to estimate the amount of AvGas. According to the National Business Aviation Association (NBAA) fact book, piston engine aircraft consume 22.2% of the total aviation gas consumed.[27] In addition, the EPA-approved emission factor for refueling and spillage loss of 4.61 grams of hydrocarbon (HC) per gallon of AvGas fuel consumed will be used.[28] The following equation will be used to calculate VOC emissions from refueling activities:

Equation (1)

$$AE = FC_{08} \times PP \times EF \times CON$$

Where,

AE = Refueling and spillage emissions, tons VOC

---

[24] Federal Aviation Administration, June 2, 2005. "Air Quality Procedures for Civilian Airports and Air Force Bases, Appendix D: Aircraft Emission Methodology". Office of Environment and Energy. Washington, DC. p. D-5. Available online: http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/App_D.PDF. Accessed 08/05/10.

[25] COSA. "2009 San Antonio International Airport Fuel Report". San Antonio, TX.

[26] GCR and Associates, Inc. 2005. Airport IQ Data Center. Available online: http://www.airportiq.com/ Accessed 07/20/10.

[27] National Business Aviation Association. "NBAA Business Aviation Fact Book 2003". p. 34. Washington, DC 20036-2527. Available online: http://www.jetsalesofstuart.com/downloads/nbaa_factbook.pdf. Accessed 07/21/10.

[28] J. Borowiec, T. Qu, and C. Bell, March 2000. "1996, 1999, and 2007 Airport Emission Inventory". Texas Transportation Institute, College Station, TX.

FC_{08} = Total aviation fuel consumption for 2008 (from SAIA)
PP = Percentage of aviation fuel consumption by piston aircraft (22.2%)
EF = Emission factor (4.61 HC g/gal)
CON = HC to VOC conversion ratio (1.000)[29]

Pre-flight Safety

For calculating evaporative emissions from safety checks, the number of aircraft stationed at airports, the percentage of aircraft with piston engines, and the number of “local” aircraft operations are needed. The 2008 total “local” operations at SAIA for all aircraft types were 2,234 flights annually, attributed to 226 based aircraft[30], of which 147 aircraft are considered piston-engine aircraft (65%). The following equation will be used for pre-flight safety check emissions.

Equation (3)
AE = (OPS / 2) x PERP x EF x CON / 2,000 lbs/ton

Where,
AE = Annual pre-flight safety checks emissions, tons VOC/yr
OPS = Number of operations for all aircraft types (2,234 operations, 2 ops per LTO cycle from GCR data)
PERP = Percentage of piston aircraft (65% GCR data)
EF = Emission factor (0.20 lbs per LTO cycle)
CON = HC to VOC conversion ratio (1.000)

Diurnal Losses

Diurnal evaporation is associated with fuel venting due to diurnal temperature changes. Based piston engine aircraft, while parked, are subject to ambient temperature variation which causes the AvGAS fuel to evaporate from vents installed on piston engine aircraft. The following equation, introduced in Appendix D of the EPA publication entitled, “Air Quality Procedures for Civilian Airports & Air Force Bases,”[31] is used for quantifying HC evaporative emissions resulting from based piston aircraft diurnal losses:

Equation (2)
AE = NUM x EF x CON

Where,
AE = Diurnal emissions, tons VOC
NUM = Number of piston aircraft (from GCR data)

---

[29] U.S. Environmental Protection Agency, December 2005. “Conversion Factors for Hydrocarbon Emission Components”. Office of Transportation and Air Quality Washington, DC. p. 3. Available online: http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05015.pdf. Accessed 08/05/10.

[30] GCR and Associates, Inc. 2005. Airport IQ Data Center. Available online: http://www.airportiq.com/ Accessed 07/20/10.

[31] Federal Aviation Administration, June 2, 2005. “Air Quality Procedures for Civilian Airports and Air Force Bases, Appendix D: Aircraft Emission Methodology”. Office of Environment and Energy. Washington, DC. p. D-5. Available online: http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/App_D.PDF. Accessed 08/05/10.

EF = Emission factor (0.15 lbs/day/based aircraft)
CON = HC to VOC conversion ratio (1.000)

Step 3: Spatially Allocate Emissions

Evaporative emissions will be spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model. Emissions will be geo-coded to the location of SAIA.

Fuel Storage

Fuel storage emissions include evaporative VOC emissions due to the transfer of fuel from and to storage tanks or bulk terminals by tanker trucks. The methodology proposed to estimate emissions from fuel storage relies on local data. The following steps will be used to calculate emissions from fuel storage:

1. Collect data on fuel consumption.
2. Calculate ozone precursor emissions.
3. Spatially allocate emissions to the 4km photochemical model grids.

Raw local input data such as emissions and spatial surrogates will be provided to TCEQ.

Step 1: Collect Data on Fuel Consumption

To calculate emissions, information on the total fuel consumption for general aviation flights will be collected from SAIA. Piston-powered aircraft consume virtually all of the AvGas consumed each year, approximately 22.2 percent of the total general aviation fuel consumption per year.[32]

Step 2: Estimate Emissions of Ozone Precursors

According to the methodology described by the EPA[33], the non-fugitive VOC emission factor for storage tank filling is 1081 mg/L. The formula proposed calculates VOC emissions from fuel storage:

Equation (1)

$$AE = FUEL \times PERF \times EF$$

Where,

AE = Pre-flight safety check emissions, tons VOC
FUEL = Annual amount of aviation fuel consumed (from SAIA)
PERF = Percentage of fuel consumed by piston aircraft (22.2%)
EF = Emission factor (1081 mg/L)

Step 3: Spatially Allocate Emissions

Fuel storage emissions will be spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model. Emissions will be geo-coded to the location of SAIA.

---

[32] National Business Aviation Association. “NBAA Business Aviation Fact Book 2003”. p. 34. Washington, DC 20036-2527. Available online: http://www.jetsalesofstuart.com/downloads/nbaa_factbook.pdf. Accessed 08/04/10.

[33] EPA, July 2006. “Documentation for the Final 2002 Non-point Sector (Feb 06 Version) National Emission Inventory for Criteria and Hazardous Air Pollutants”. EPA Contract No. 68-D-02-063. Prepared by: E.H. Pechan & Associates, Inc. Durham, NC, p. A-9. Available online: ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/nonpoint/2002nei_final_nonpoint_documentation0206version.pdf. Accessed 08/04/10.

Non-road Equipment

Commercial, industrial, and lawn and garden non-road equipment used at commercial airports are a source of NOx and VOC emissions. The following non-road equipment types are commonly used at commercial airports:

- Generators
- Compressors
- Paint Machines
- Light Plants
- Welding Machines
- Water Pumps
- Pressure Washers
- Concrete Saws
- Carts
- Fork Lifts
- Aerial Lifts
- Sweepers
- Off-Highway Trucks
- Rotary Tillers
- Chainsaws
- Trimmer/Edger/Brush Cutters
- Leaf Blowers
- Lawn Mowers
- Rear Engine Riding Mowers
- Lawn & Garden Tractors
- Turf Equipment

The methodology proposed to estimate emissions from non-road equipment relies on local data from surveys and data used in the NONROAD2008a model. The following steps will be used to calculate emissions from non-road equipment:

1. Conduct a survey of equipment used by tenants and the city of San Antonio (COSA) at SAIA to determine equipment use rates and characteristics.
2. Calculate ozone precursor emissions.
3. Spatially allocate emissions to the 4km photochemical model grids.

Raw local input data such as population size, local activity profiles, and spatial surrogates will be provided to TCEQ.

Step 1: Conduct a Survey of Non-Road Equipment at SAIA

The City of San Antonio was contacted to obtain a list of non-road equipment used at the SAIA. This list includes information on the tenants at SAIA and data on the following characteristics:

- Equipment type and quantity
- Activity rates – total annual hours of use
- Temporal profiles – hours of use on weekdays and weekends
- Horse-power (HP)
- Fuel type

Since the survey included all the equipment used by COSA and tenants at SAIA, the survey results are statistically significant.

AACOG
Alamo Area Council
Of Governments

Nov. 14, 2008

Operations Manager,

Re: <u>2008 San Antonio Emissions Inventory</u>

The Alamo Area Council of Governments (AACOG) requests your assistance in developing the 2008 emission inventory for San Antonio International Airport. AACOG is conducting this inventory in order to assess local air quality and quantify pollutants within the San Antonio metropolitan area and contiguous counties. This inventory is especially significant because the San Antonio region currently risks being declared in non-attainment of federal air quality standards.

With this survey, we are requesting information on equipment used in your operations during the 2008 calendar year. The purpose of this survey is to provide better information and services to the region, as well as help minimize additional regulation on the community.

Your input is vital to this process and will serve to develop a true emission inventory. Please provide your responses by the date indicated. The information you provide will be considered strictly confidential and unavailable to public information requests. Please submit your response by, December 19, 2008.

Thank you for your time and participation. If you have any questions or comments please feel free to contact Parviz Nazem at (210) 362-5317.

Sincerely yours,

Gloria Arriaga
Executive Director

Enclosures (1)

Equipment Survey

Equipment Type	**Fuel Type** (diesel, 2-cycle, 4-cycle, electric)	**Number of Units** (how many)	**Horsepower**	**Average number of Hours Each Unit Operates** (Weekdays)	**Average number of Hours Each Unit Operates** (Weekends)
Generators					
Compressors					
Paint Machines					
Light Plants					
Welding Machines					
Water Pumps					
Pressure Washers					
Concrete Saws					
Fork Lifts					
Aerial Lifts					
Sweepers					
Off-Highway Trucks					
Rotary Tillers					
Chainsaws					
Trimmer/Edger/ Brush Cutters					
Leaf Blowers					
Lawn Mowers					
Rear Engine Riding Mowers					
Lawn & Garden Tractors					
Turf Equipment					
Leaf Blowers					
Other Equipment					

Step 2: Estimate Emissions of Ozone Precursors

EPA's NONROAD2008a Model[34] emission factors and load factors will be used to calculate emissions associated with operations of non-road equipment at SAIA. The following equation will be used to calculate emissions from non-road equipment at SAIA:

Equation (1)

$$AE_A = EP_A \times HRS_A \times HP_A \times LF_A \times EF_A$$

Where:

AE_A = emissions for equipment type A (tons/yr)
EP_A = equipment population for equipment type A (from survey)
HRS_A = annual hours for equipment type A (from survey)
HP_A = average rated horsepower for equipment type A (from survey)
LF_A = typical load factor for equipment type A (from NONROAD2008a model)
EF_A = average emissions of pollutant per unit of use for equipment type A (from NONROAD2008a model)

Step 3: Spatially Allocate Emissions

Emissions will be spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model. Emissions will be geo-coded to the location SAIA.

---

[34] U.S. Environmental Protection Agency, Dec. 2008. "NONROAD 2008 Model". Available online: Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency, July 2009. "NONROAD2008a Model". Available online: http://www.epa.gov/otaq/nonrdmdl.htm. Accessed 06/13/10.

Appendix A

SAIA Aircraft Operations, 2008

Table A-1. 2008 Commercial Aircraft Type and Arrival Activity at SAIA

ID	Aircraft Name	Engine Type	Number of Operation
1	ATR 42-300	PW120	4
2	Airbus A300F4-200 Series	CF6-50A Low emissions fuel nozzle	4
3	Airbus A300F4-600 Series	PW4158 Reduced smoke	676
4	Airbus A310-200 Series	CF6-80A3	16
5	Airbus A318-100 Series	CFM56-5B1/2P DAC-II	524
6	Airbus A319-100 Series	CFM56-5B7/P	5,508
7	Airbus A320-100 Series	CFM56-5B8/P SAC	1,060
8	Bell 206 Jet Ranger	250B17B	206
9	Boeing 717-200 Series	BR700-715A1-30 Improved fuel injector	272
10	Boeing 727-100 Series	JT8D-15 Reduced emissions	6
11	Boeing 727-200 Series	JT8D-15 Reduced emissions	1,494
12	Boeing 737-200 Series	JT8D-15A	36
13	Boeing 737-300 Series	CFM56-3	18,516
14	Boeing 737-300 Series	CFM56-3-B1	6
15	Boeing 737-400 Series	CFM56-3	100
16	Boeing 737-500 Series	CFM56-3C-1	6,888
17	Boeing 737-600 Series	CFM56-3C-1	2
18	Boeing 737-700 Series	CFM56-7B22	16,934
19	Boeing 737-800 Series	CFM56-7B26	2,094
20	Boeing 737-900 Series	CFM56-7B24	770
21	Boeing 747-200 Series	CF6-50E2 Low emissions fuel nozzle	2
22	Boeing 757-200 Series	PW2037	2,400
23	Boeing 757-200 Series	PW2037	8
24	Boeing 757-300 Series	RB211-535E4B Phase 5	320
25	Boeing 767-200 ER	CF6-80A	6
26	Boeing 767-300 ER	PW4060 Reduced emissions	14
27	Boeing DC-10-30ER	CF6-50C2B Low emissions fuel nozzle	1,056
28	Boeing DC-8 Series 50	JT3D-3B	2
29	Boeing DC-8 Series 70	CFM56-2-C5	478
30	Boeing DC-9-10 Series	JT8D-7 series Reduced emissions	24
31	Boeing DC-9-30 Series	JT8D-15 Reduced emissions	864
32	Boeing DC-9-40 Series	JT8D-11	144
33	Boeing DC-9-50 Series	JT8D-17 Reduced emissions	104
34	Boeing MD-10-30	CF6-6D	312
35	Boeing MD-11	CF6-80C2D1F 1862M39	44
36	Boeing MD-81	JT8D-217C Environmental Kit (E Kit)	34
37	Boeing MD-82	JT8D-217C Environmental Kit (E Kit)	11,064
38	Boeing MD-83	JT8D-219 Environmental Kit (E Kit)	2,860
39	Boeing MD-87	JT8D-217A Environmental Kit (E Kit)	16
40	Boeing MD-88	JT8D-219 Environmental Kit (E Kit)	3,142
41	Bombardier CRJ-700	CF34-3B	14,718
42	Bombardier CRJ-900	CF34-8C5 LEC	1,674
43	Bombardier Challenger 300	AE3007A1 Type 2	166
44	Bombardier Challenger 600	CF34-3B	134
45	Bombardier Global Express	BR700-710A2-20	4
46	Bombardier Learjet 24	CJ610-6	14
47	Bombardier Learjet 25	CJ610-6	120
48	Bombardier Learjet 31	TFE731-2-2B	12

ID	Aircraft Name	Engine Type	Number of Operation
49	Bombardier Learjet 35	TFE731-2-2B	376
50	Bombardier Learjet 40	TFE731-2-2B	44
51	Bombardier Learjet 45	TFE731-2-2B	170
52	Bombardier Learjet 55	TFE731-3	92
53	Bombardier Learjet 60	TFE731-2/2A	184
54	Cessna 172 Skyhawk	IO-320-D1AD	8
55	Cessna 182	IO-360-B	26
56	Cessna 206	IO-360-B	8
57	Cessna 208 Caravan	PT6A-114A	2,570
58	Cessna 210 Centurion	TIO-540-J2B2	66
59	Cessna 310	TIO-540-J2B2	2
60	Cessna 340	TIO-540-J2B2	6
61	Cessna 402	TIO-540-J2B2	1,170
62	Cessna 414	TIO-540-J2B2	152
63	Cessna 425 Conquest I	PT6A-60	30
64	Cessna 441 Conquest II	TPE331-10GT	2
65	Cessna 500 Citation I	JT15D-1 series	10
66	Cessna 501 Citation ISP	JT15D-1 series	10
67	Cessna 525 CitationJet	JT15D-1 series	256
68	Cessna 525 CitationJet	JT15D-1 series	42
69	Cessna 550 Citation II	JT15D-4 series	268
70	Cessna 560 Citation Excel	JT15D-5, -5A, -5B	800
71	Cessna 560 Citation Excel	JT15D-5, -5A, -5B	544
72	Cessna 560 Citation XLS	JT15D-5, -5A, -5B	18
73	Cessna 680 Citation Sovereign	PW308C Annular	236
74	Cessna 750 Citation X	AE3007C Type 2	462
75	Cessna S550 Citation S/II	PW530	2
76	Cirrus SR22	TIO-540-J2B2	14
77	Convair CV-440	R-1820	22
78	Dassault Falcon 10	TFE731-2-2B	24
79	Dassault Falcon 20-C	CF700-2D	130
80	Dassault Falcon 2000	PW308C Annular	192
81	Dassault Falcon 50	TFE731-3	28
82	Dassault Falcon 900	TFE731-3	8
83	DeHavilland DHC-6-100 Twin Otter	PT6A-20	2
84	Dornier 328 Jet	PW306B Annular	24
85	Dornier 328-100 Series	PW119B	8
86	EADS Socata TBM-700	PT6A-64	496
87	Embraer EMB110 Bandeirante	PT6A-27	2
88	Embraer EMB120 Brasilia	PW118	20
89	Embraer ERJ135	AE3007A1/3 Type 3 (reduced emissions	296
90	Embraer ERJ145	AE3007A1E Type 3	3,410
91	Embraer ERJ145	AE3007A1E Type 3	6,480
92	Embraer ERJ170	CF34-8E5 LEC	596
93	Embraer ERJ190	CF34-10E	2
94	Fairchild Hiller FH-227	RDa.7	2
95	Fairchild SA-226-T Merlin III	TPE331-3U	64
96	Fairchild SA-227-AC Metro III	TPE331-10	524

ID	Aircraft Name	Engine Type	Number of Operation
97	Fairchild SA-26-T Merlin II	PT6A-60	4
98	Grumman G-73 Mallard	TIO-540-J2B2	2
99	Gulfstream G100	TFE731-3	8
100	Gulfstream G150	TFE731-3	6
101	Gulfstream G200	PW306A Annular	172
102	Gulfstream G500	BR700-710A1-10	16
103	Gulfstream II	SPEY MK511-8	10
104	Gulfstream II	SPEY Mk511 Transply IIH	10
105	Gulfstream IV-SP	TAY Mk611-8	36
106	Helio U-10 Super Courier	TIO-540-J2B2	8
107	Israel IAI-1124 Westwind I	TFE731-3	22
108	Mitsubishi MU-2	TPE331-10U	778
109	Mitsubishi MU-300 Diamond	JT15D-5, -5A, -5B	192
110	Mooney M20-K	TSIO-360C	42
111	Mooney M20-K	TSIO-360C	4
112	Piaggio P.180 Avanti	PT6A-66	112
113	Pilatus PC-12	PT6A-67B	10
114	Piper PA-28 Cherokee Series	IO-320-D1AD	8
115	Piper PA-31T Cheyenne	PT6A-28	572
116	Piper PA-32 Cherokee Six	TIO-540-J2B2	2
117	Piper PA-34 Seneca	IO-360-B	12
118	Piper PA46-TP Meridian	PT6A-42	2
119	Raytheon Beech 1900-C	PT6A-65B	486
120	Raytheon Beech 1900-D	PT6A-67D	4
121	Raytheon Beech 55 Baron	TIO-540-J2B2	266
122	Raytheon Beech Baron 58	TIO-540-J2B2	50
123	Raytheon Beech Bonanza 36	TIO-540-J2B2	50
124	Raytheon Beechjet 400	JT15D-5, -5A, -5B	456
125	Raytheon Hawker 800	TFE731-3	474
126	Raytheon King Air 100	PT6A-28	2
127	Raytheon King Air 100	TPE331-6	4
128	Raytheon King Air 90	PT6A-135A	190
129	Raytheon Premier I	JT15D-1 series	4
130	Raytheon Super King Air 200	PT6A-42	148
131	Raytheon Super King Air 300	PT6A-60A	8
132	Raytheon Super King Air 300	PT6A-60A	36
133	Robin R 2160 Alpha Sport	O-320	2
134	Robinson R22	IO-320-D1AD	2
135	Rockwell Commander 690	TPE331-10	6
136	Rockwell Commander 700	TSIO-360C	2
137	Rockwell Sabreliner 40	CF700-2D	8
138	Saab 340-A	CT7-5	2
139	Shorts 330	PT6A-45R	4
140	Shorts 360-300 Series	PT6A-65R	14
141	T-38 Talon	J85-GE-5H (w/AB)	28
TOTAL			119,024

Table A-2. 2008 Jet Engines General Aviation Aircraft Type and Arrival Activity at SAIA

ID	Aircraft Name	Engine Type	Number of Operation
1	Airbus A319-100 Series	CFM56-5B6/P	2
2	Airbus A340-500 Series	Trent 556-61 Phase 5 tiled	1
3	BAE 146-300	ALF 502R-5	619
4	Bell UH-1 Iroquois	T400-CP-400	12
5	Boeing 727-200 Series	JT8D-15 Reduced emissions	11
6	Boeing 737-200 Series	JT8D-15A	33
7	Boeing 757-200 Series	RB211-535E4 Phase 5	8
8	Boeing DC-10-30 Series	CF6-50C2 Low emissions fuel nozzle	6
9	Boeing DC-10-40 Series	JT9D-59A	1
10	Boeing DC-9-10 Series	JT8D-7 series Reduced emissions	3
11	Boeing DC-9-30 Series	JT8D-15 Reduced emissions	9
12	Boeing MD-82	JT8D-217C Environmental Kit (E Kit)	3
13	Boeing MD-83	JT8D-219 Environmental Kit (E Kit)	2
14	Bombardier Challenger 300	AE3007A1 Type 2	527
15	Bombardier Challenger 600	ALF 502L-2	297
16	Bombardier Challenger 604	CF34-3B	109
17	Bombardier Global Express	BR700-710A2-20	50
18	Bombardier Learjet 24	CJ610-6	55
19	Bombardier Learjet 25	CJ610-6	372
20	Bombardier Learjet 31	TFE731-2-2B	410
21	Bombardier Learjet 35	TFE731-2-2B	214
22	Bombardier Learjet 36	TFE731-2-2B	14
23	Bombardier Learjet 45	TFE731-2-2B	302
24	Bombardier Learjet 55	TFE731-3	109
25	Bombardier Learjet 60	TFE731-2/2A	594
26	Cessna 172 Skyhawk	TSIO-360C	17
27	Cessna 182	IO-360-B	35
28	Cessna 210 Centurion	TIO-540-J2B2	15
29	Cessna 500 Citation I	JT15D-1 series	3,675
30	Cessna 525 CitationJet	JT15D-1 series	670
31	Cessna 560 Citation XLS	JT15D-5, -5A, -5B	988
32	Cessna 680 Citation Sovereign	PW308C Annular	387
33	Cessna 750 Citation X	AE3007C Type 2	764
34	Cessna S550 Citation S/II	JT15D-4 series	347
35	Dassault Falcon 10	TAY Mk620-15	88
36	Dassault Falcon 100	TFE731-2-2B	34
37	Dassault Falcon 20-C	CF700-2D	33
38	Dassault Falcon 2000-EX	PW308C Annular	545
39	Dassault Falcon 50	TFE731-3	989
40	Dassault Falcon 900	TFE731-3	816
41	Dornier 328 Jet	PW306B Annular	11
42	EADS Socata TBM-700	PT6A-60	5
43	Embraer ERJ135	AE3007A1E Type 3	35

ID	Aircraft Name	Engine Type	Number of Operation
44	Grumman A-6 Intruder	J52-P-6B	3
45	Gulfstream G150	TFE731-3	14
46	Gulfstream G200	PW306A Annular	4
47	Gulfstream G550	BR700-710-C4-11 Annular	225
48	Gulfstream II	SPEY Mk511 Transply IIH	275
49	Gulfstream IV-SP	TAY 611-8C Transply IIJ	1,085
50	Gulfstream IV-SP	TAY Mk611-8	2
51	Hawker HS-125 Series 1	TFE731-3	490
52	Hawker HS-125 Series 600	TFE731-2-2B	468
53	Hawker HS-125 Series 700	TFE731-3	122
54	Israel IAI-1124 Westwind I	TFE731-3	386
55	Israel IAI-1125 Astra	TFE731-3	51
56	Israel IAI-1125 Astra	TFE731-3	38
57	Israel IAI-1126 Galaxy	PW306A Annular	242
58	Lancair 360	IO-360-B	3
59	Lockheed L-1329 Jetstar II	TFE731-3	5
60	Maule MT-7-235	TIO-540-J2B2	2
61	Mitsubishi MU-300 Diamond	JT15D-4 series	140
62	Mooney M20-K	TSIO-360C	21
63	Piper PA-23 Apache/Aztec	TIO-540-J2B2	1
64	Piper PA-28 Cherokee Series	IO-320-D1AD	2
65	Piper PA-30 Twin Comanche	IO-320-D1AD	18
66	Piper PA-31 Navajo	TIO-540-J2B2	3
67	Piper PA-32 Cherokee Six	TIO-540-J2B2	2
68	Piper PA-42 Cheyenne Series	TPE331-14B	19
69	Piper PA46-TP Meridian	PT6A-42	5
70	Piper PA46-TP Meridian	PT6A-42	1
71	Raytheon Beech Baron 58	TIO-540-J2B2	4
72	Raytheon Beech Bonanza 36	TIO-540-J2B2	4
73	Raytheon Beech Bonanza 36	TIO-540-J2B2	2
74	Raytheon Beechjet 400	JT15D-5, -5A, -5B	266
75	Raytheon Hawker 1000	TFE731-2/2A	4
76	Raytheon Hawker 4000 Horizon	PW308A Annular	19
77	Raytheon Hawker 800	TFE731-3	38
78	Raytheon King Air 100	TPE331-6	154
79	Raytheon King Air 90	PT6A-60	10
80	Raytheon Premier I	JT15D-1 series	8
81	Raytheon Super King Air 200	PT6A-42	6
82	Robinson R22	IO-320-D1AD	2
83	Rockwell Commander 690	TPE331-10UK	188
84	Rockwell Sabreliner 60	CF700-2D	4
TOTAL			17,553

Table A-3. 2008 Turbo-Prop General Aviation Aircraft Type and Arrival Activity at SAIA

ID	Aircraft Name	Engine Type	Number of Operation
1	Aerospatiale N 262	PT6A-45	3
2	BAE Jetstream 1	PT6A-60	5
3	Boeing 737-100 Series	JT8D-15 Reduced emissions	1
4	Cessna 172 Skyhawk	IO-360-B	2
5	Cessna 182	IO-360-B	1
6	Cessna 206	IO-360-B	1
7	Cessna 208 Caravan	PT6A-114A	94
8	Cessna 421 Golden Eagle	TIO-540-J2B2	1
9	Cessna 425 Conquest I	PT6A-60	58
10	Cessna 441 Conquest II	TPE331-10U	64
11	DeHavilland DHC-6-300 Twin Otter	PT6A-27	9
12	Dornier 328-100 Series	PW119B	5
13	EADS Socata TBM-700	PT6A-64	81
14	Embraer EMB120 Brasilia	PW118	4
15	Fairchild Metro IVC	TPE331-12UHR	33
16	Fairchild SA-226-T Merlin III	TPE331-3U	48
17	Fairchild SA-226-T Merlin III	TPE331-3U	106
18	Fairchild SA-227-AC Metro III	TPE331-10	69
19	Fairchild SA-227-AT Expeditor	TPE331-10	41
20	Gulfstream I	RDa.7	88
21	Mitsubishi MU-2	TPE331-1	7
22	Mitsubishi MU-2	TPE331-10	12
23	Mitsubishi MU-2	TPE331-10A	4
24	Mitsubishi MU-2	TPE331-6	49
25	Piaggio P.180 Avanti	PT6A-66	18
26	Pilatus PC-12	PT6A-67B	152
27	Piper PA-31T Cheyenne	PT6A-28	271
28	Piper PA-42 Cheyenne Series	TPE331-10	42
29	Piper PA46-TP Meridian	PT6A-42	88
30	Raytheon Beech 60 Duke	TIO-540-J2B2	1
31	Raytheon Beech Bonanza 36	TIO-540-J2B2	1
32	Raytheon King Air 100	PT6A-28	243
33	Raytheon King Air 90	PT6A-135A	1269
34	Raytheon King Air 90	PT6A-60	863
35	Raytheon Super King Air 200	PT6A-42	1597
36	Raytheon Super King Air 300	PT6A-60A	553
37	Rockwell Commander 690	TPE331-10A	10
38	Rockwell Commander 690	TPE331-10GT	55
TOTAL			5,959

Table A-4. 2008 Piston General Aviation Aircraft Type and Arrival Activity at SAIA

ID	Aircraft Name	Engine Type	Number of Operation
1	Aerostar PA-60	TIO-540-J2B2	36
2	Aviat Husky A1B	IO-360-B	26
3	Bell 206 JetRanger	250B17B	1
4	Cessna 150 Series	O-200	122
5	Cessna 172 Skyhawk	IO-320-D1AD	9
6	Cessna 172 Skyhawk	TSIO-360C	1602
7	Cessna 182	IO-360-B	492
8	Cessna 206	IO-360-B	295
9	Cessna 208 Caravan	PT6A-114A	98
10	Cessna 210 Centurion	TIO-540-J2B2	841
11	Cessna 310	TIO-540-J2B2	317
12	Cessna 340	TIO-540-J2B2	107
13	Cessna 402	TIO-540-J2B2	17
14	Cessna 414	TIO-540-J2B2	219
15	Cessna 421 Golden Eagle	TIO-540-J2B2	375
16	Cirrus SR20	IO-360-B	55
17	Cirrus SR22	TIO-540-J2B2	421
18	Gulfstream G550	BR700-710A1-10	23
19	Lancair 360	IO-360-B	105
20	Maule MT-7-235	250B17B	4
21	Mooney M20-K	TSIO-360C	736
22	Partenavia P.68 Victor	IO-360-B	1
23	Pilatus PC-12	PT6A-67B	257
24	Piper PA-23 Apache/Aztec	TIO-540-J2B2	53
25	Piper PA-24 Comanche	TIO-540-J2B2	31
26	Piper PA-28 Cherokee Series	IO-320-D1AD	233
27	Piper PA-28 Cherokee Series	O-320	104
28	Piper PA-30 Twin Comanche	IO-320-D1AD	17
29	Piper PA-31 Navajo	TIO-540-J2B2	119
30	Piper PA-31T Cheyenne	PT6A-28	5
31	Piper PA-32 Cherokee Six	TIO-540-J2B2	26
32	Piper PA-32 Cherokee Six	TIO-540-J2B2	208
33	Piper PA-34 Seneca	IO-360-B	190
34	Piper PA-34 Seneca	TSIO-360C	21
35	Piper PA-34 Seneca	TSIO-360C	2
36	Piper PA46-TP Meridian	PT6A-42	431
37	Raytheon Beech 18	TPE331-1UA	6
38	Raytheon Beech 60 Duke	TIO-540-J2B2	78
39	Raytheon Beech 99	PT6A-36	15
40	Raytheon Beech Baron 58	TIO-540-J2B2	84
41	Raytheon Beech Baron 58	TIO-540-J2B2	258
42	Raytheon Beech Bonanza 36	TIO-540-J2B2	461
43	Raytheon Beech Bonanza 36	TIO-540-J2B2	63

ID	Aircraft Name	Engine Type	Number of Operation
44	Raytheon Beech Bonanza 36	TIO-540-J2B2	369
45	Rockwell Commander 500	TIO-540-J2B2	8
46	Rockwell Commander 690	TPE331-10	89
47	Rockwell Commander 690	TPE331-10UK	2
48	Sikorsky CH-53 Sea Stallion	T64-GE-100	1
TOTAL			9,033

Table A-5. 2008 Military Aircraft Activity at the San Antonio International Airport

ID	Aircraft Name	Engine Type	Number of Operation
1	Bell UH-1 Iroquois/ T 430	T400	114
2	Boeing 737-200 Series/ T-43	1PW006	634
3	Boeing C-17A/	4PW073	436
4	Boeing DC-9-10 Series	1PW005	436
5	Bombardier Learjet 35A/36A (C-21A)	1AS001	110
6	Lockheed C-130 Hercules	T56A15	60
7	Lockheed C-5 Galaxy	TF391	70
8	Lockheed Martin F-16 Fighting Falcon	F10010	170
9	Raytheon Beechjet 400/ T1	1PW037	888
10	Sikorsky UH-60 Black Hawk	T70070	436
11	T-38 Talon	J855HA	1,158
TOTAL			4,513