GUIDANCE FOR QUANTIFYING SPECIATED ORGANIC GAS EMISSIONS FROM AIRPORT SOURCES

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Ver. 1

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ACRONYMS AND ABBREVIATIONS

A/C	Air conditioning
ACRP	Airport Cooperation Research Program
AEE	FAA Office of Environment and Energy
APP	FAA Office of Planning and Programming
APU	Auxiliary power unit
ARFF	Airport rescue and firefighting facilities
Avgas	Aviation gasoline, also known as 100 low lead or 100LL
CAA	Clean Air Act
CARB	California Air Resources Board
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CO	Carbon monoxide
EA	Environmental Assessment
EDMS	Emissions and Dispersion Modeling System
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FID	Flame ionization detector
GA	General aviation
GAV	Ground access vehicles
GPU	Ground power unit
GSE	Ground service equipment
HAP	Hazardous air pollutant
HHRA	Human health risk assessment
ICAO	International Civil Aviation Organization
IRIS	Integrated Risk Information System
LTO	Landing and takeoff
MOBILE	U.S. EPA motor vehicle emission rate program
MOVES	U.S. EPA Mobile Vehicle Emission Simulator
MSAT	Mobile Source Air Toxic
MEK	Methyl ethyl ketone
NAAQS	National Ambient Air Quality Standards
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NMOG	Non methane organic gas
NOx	Nitrogen oxides
OG	Organic gas
PM	Particulate matter
SCC	Source classification code
SPECIATE	U.S. EPA data system of speciation profiles
SO_2	Sulfur dioxide, an EPA criteria pollutant
THC	Total hydrocarbons
TIM	Time in mode
TOC	Total organic compounds
TOG	Total organic gas
VMT	Vehicle miles traveled
VOC	Volatile organic compound, a precursor to ozone

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1 INTRODUCTION

Inventories of airport-related speciated organic gases (OGs) which include the OGs identified by the United States Environmental Protection Agency (U.S. EPA) to be hazardous air pollutants (HAPs) and the OGs listed in the EPA's Integrated Risk Information System (IRIS)[1] are not required by current EPA regulations. [2] However, per Federal Aviation Administration (FAA) Order 1050.1E Change 1, *Environmental Impacts: Policies and Procedures*,[3] FAA policy is that "If air toxics analysis is performed, [the Emissions and Dispersion Modeling System] EDMS should be used or supplemented with other air toxic methodology and models in consultation with the appropriate FAA program office and [FAA's Office of Environment and Energy] AEE." This guidance provides the means to comply with FAA's policy by presenting a methodology to prepare airport-related emissions inventories of speciated OG/HAP emissions. In cases where it is necessary to prepare such an airport-related inventory, the inventory must be prepared following the approach described in this document to ensure consistency. Inventories must also be prepared utilizing EDMS.

This document provides an approach to, and technical guidance for, preparing speciated OG/HAP emission inventories in support of environmental documents prepared by, or on behalf of, the FAA under the National Environmental Policy Act (NEPA)--it does not address requirements of the California Environmental Quality Act (CEQA). Besides an emissions inventory, NEPA reports (i.e., Federal Environmental Assessments (EAs) and Environmental Impact Statements (EISs)) must not include any other type of OG/HAP assessment including, but not limited to, dispersion, toxicity weighting, exposure, or health risk quantifications. When assessments involving dispersion, toxicity weighting, exposure, or health risk quantifications are required by CEQA, proper analysis methodology should be employed. These types of assessments require a complete understanding of both the reaction of OGs/HAPs in the atmosphere and downstream plume evolution. Because the science of these atmospheric reactions with respect to airport-related OGs/HAPs is still evolving, the related level of understanding is currently limited.

The approach to preparing a speciated OG emission inventory is based on what is currently known about airport-related emissions. Both the FAA and EPA recognize that even though the amount of aircraft engine emission test data is growing, the amount is still limited and there are research gaps that need to be addressed. Through measurement campaigns and studies, the FAA, in partnership with other Federal agencies and the scientific community, is currently collecting additional emissions data and performing analysis with respect to the ultimate fate of these emissions in the atmosphere.

[1] http://www.epa.gov/iris/

[2] In this guidance, air toxics and toxic air contaminants are referred to as hazardous air pollutants (HAPs). When organic gases are speciated, two groups of gases result, those that are HAPs and those that are not. The collective "group" of gases discussed in this guidance are referred to as "speciated organic gases" and methodologies are presented to estimate airport-related emissions of both. For a detailed discussion of the relationship of HAPs and OG, along with other "groups" of OG, please see Section 1.5.1 of this guidance.

[3] Appendix A, Section 2.4

1.1 Background

In 2003, the FAA's AEE undertook an assessment to determine what was already known about speciated OGs at airports, in general, and aircraft-related OGs, in particular [FAA, 2003]. This initial body of work (referred to as the *FAA Resource Document for HAPs*) focused on those OGs specifically identified by the EPA to be HAPs and was prepared in response to the rising interest by various federal, state and local governmental agencies and the general public in connection with the emerging topic of these pollutants. The need for a more unified approach and technical guidelines for evaluating speciated OG/HAP emissions for airport-related sources (the approach and guidelines presented in this document) was one of the FAA's recommendations from this initial work.

Summary of Findings, Observations and Outcomes from the FAA's Initial Work

1. According to the U.S. General Accounting Office, most U.S. commercial airports represent a small percentage (approximately 0.5 percent) of the total overall air pollution emissions generated in an urban area [GAO, 2003].

2. Air monitoring studies in the vicinities of several large airports have thus far not detected HAP levels considered above those that normally occur in urban areas. Additionally, the samples from these studies have not segregated any OG associated with airport sources from the OG released from motor vehicles or any other mobile or stationary source.

3. The emission levels of OGs from new aircraft engines are predicted to decline over current and historic levels as turbine and internal combustion engines become progressively more fuel efficient and less polluting.

1.2 Relevant Regulations

Under the Clean Air Act (CAA) and its amendments, the EPA is charged with developing standards and guidelines for the control of air pollutant emissions, including HAPs. Of particular relevance to airports, Section 231 of the CAA directs the EPA to "issue proposed emission standards applicable to the emission of any air pollutant from any class or classes of aircraft or aircraft engines which in its judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare". Presently, the emission standards developed by EPA as a result of the Section 231 directive apply only to aircraft engine smoke and engine exhaust products such as carbon monoxide (CO), nitrogen oxides (NOx) and unburned OGs--the aircraft engine standards do not apply directly to emissions of OGs or any OG designated by the EPA to be a HAP.

This guidance focuses on the airport-related OGs designated by the EPA to be HAPs and/or listed in the EPA's IRIS. It is important to note that the EPA has not established National Ambient Air Quality Standards (NAAQS) for any OG. With respect to OGs, the EPA's focus is primarily on a subset species referred to as volatile organic compounds (VOCs)[4] because VOCs are highly reactive with NOx in the presence of sunlight and form ozone--a pollutant for which the EPA has NAAQS and for which numerous areas within the U.S. are designated non-attainment. Therefore, while the HAPs emitted from aircraft engines, and most other airport sources, are not specifically regulated by the CAA or other (e.g., International Civil Aviation Organization (ICAO)) emission standards, the pollutants are controlled indirectly through the control of the other primary pollutants (e.g., through the control of ozone which, in certain regulated areas, results in a reduction in emissions of VOCs).

Currently, the EPA controls the emission levels of 187 OGs that the agency has designated as HAPs. The sources for which the amounts of these OGs are regulated are major individual and grouped stationary sources, as well as lesser emitting area sources.[5] While some airports may have stationary sources that are subject to EPA's HAP-related controls, airport-related emission sources--sources that primarily consist of aircraft, non-road vehicles such as ground support equipment (GSE), and on-road vehicles such as cars, trucks, vans, and buses--are not subject to these major individual/grouped stationary source or area source regulations.

Airport studies should only report the OGs designated by the EPA to be HAPs and those included in the EPA's IRIS database. Therefore, the primary focus of this documents discussion is this subset of OGs (although comprehensive OG information is presented and discussed).

OGs That Should be Reported in Airport Studies

Airport studies should only report the airport-related OGs designated by the EPA to be HAPs and the OGs included in the EPA's IRIS database.

It should be emphasized that preparation of an emissions inventory of airport-related speciated OG/HAP emissions is neither required nor recommended for all NEPA documents because, under NEPA, air quality assessment are not always required in support of an EA or EIS. Rather, these guidelines apply only when preparing an emissions inventory is called for (i.e., on a "case-by-case" basis).

1.3 Purpose of this Guidance

As stated in the Introduction, the purpose of this document is to provide a uniform approach to, and technical guidance for, preparing an inventory of airport-related speciated OG emissions which include HAPs. This information is intended to serve as a template for the FAA, airport sponsors, and others in preparing an emission inventory of airport-related speciated OGs while taking into consideration the inherent limitations associated with the assessment of these pollutants. The primary aim of an emissions inventory, if conducted, is to fulfill disclosure

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[4] The "group" of OGs referred to as VOCs excludes certain organic compounds because they have negligible photochemical reactivity (see Section 1.5.1 of this guidance for additional information).

[5] The EPA published an initial list of 188 HAPs. However, on December 19, 2005, methyl ethyl ketone (MEK) (2-butanone) was removed from the list because there was "adequate data on the health and environmental effects [of MEK] to determine that emissions, ambient concentrations, bioaccumulation, or deposition of the substance may not reasonably be anticipated to cause adverse effects to human health or adverse environmental effects."

requirements for airport improvement projects (or actions) evaluated under the NEPA [NEPA, 1970].

Guideline Purpose

The purpose of this guideline is to provide a uniform approach to, and technical guidance for, preparing an inventory of airport-related speciated OGs (including known HAPs) in support of environmental documents prepared by, or on behalf of, the FAA under NEPA.

1.3.1 Developmental Approach to this Guidance

The principles below were considered when developing this guidance. These principles take into account the current limitations and potentially significant uncertainties associated with these specialized pollutants.

Framework Principles for This Guidance

- Consistency with other methods of evaluating airport-related air pollutants. - Because both criteria pollutants and the speciated OGs associated with airports originate from the same sources (e.g., aircraft, ground support equipment (GSE), and motor vehicles), it is important that the evaluation of these two categories of air emissions is aligned and interconnected to the fullest extent possible. This approach facilitates the use of consistent (or comparable) input data and other important assumptions that are viewed as central to obtaining consistent and reliable results.
- Support the current state-of-the-science. - The FAA is establishing a nationally consistent approach to preparing inventories of airport-related speciated OG, including known HAPs. However, it must be recognized that the topic of airport-related speciated OG is new and dynamic and these guidelines will be updated as scientific and other advancements are made in connection with these pollutants.
- Reflective of the limitations of available databases, procedures and other means of estimating airport-related emissions. - The estimation of airport-related speciated OG involves a wide and varied array of information, data and other supporting materials. These data include aircraft-specific OG speciation profiles; airport-specific operational data; and applicable computer models or other computational techniques. Unfortunately, not all of these assessment parameters and requirements are easily obtainable, readily adaptable or tested for reliability for this highly specialized application.
- Responsive to the immediate need for consistent and practical guidelines. – Despite the existing gaps in information and tools, the potential air quality impacts associated with these emissions are of utmost interest, and this interest will continue into the future as the nation's airport infrastructure and airspace are expanded and improved.

Based upon these provisions and considerations, it is evident that guidelines for preparing an emissions inventory for airport-related speciated OGs/HAPs will help to address certain short-term needs of both the aviation and regulatory communities, while other facets of the evaluation processes are continually advanced. These needs include the ability to quantify the effects (if any) that airport improvement projects or actions may have on the types, sources and amounts of speciated OG/HAPs.

1.4 Additional FAA Guidelines and Other Resources

Other documents, guidelines and resources developed or sponsored by the FAA that provide further support for the assessment of airport air quality issues and that may be applicable to evaluations of airport-related speciated OGs are listed below. Notably, the *Recommended Best Practice For Quantifying Speciated Organic Gas Emissions From Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines* was recently published by the FAA as a companion to this document. This document details joint efforts between the FAA and the EPA to update OG/HAP speciation profile data from these types of aircraft. An abstract of the aircraft-engine related document and abstracts of the other documents, guidelines, and resources are provided below.

FAA Guidelines and Other Resources

- *FAA Environmental Desk Reference for Airport Actions* [FAA, 2007]. This document is a compendium of regulations and requirements that guides a user in evaluating environmental impacts of airport actions under NEPA and other special-purpose regulations.
- *FAA Resource Document for HAPs.* Provides a compilation of what was known about airport- and aircraft-related HAPs in publicly available materials in the year 2003. Presented both as a narrative summary and assembled in an annotated bibliography, these materials cover a broad range of information related to this subject. Topics include HAP emission types and sources, agency regulations, air monitoring data and other supporting information.
- *NEPA Implementing Instructions for Airport Actions (FAA Order 5050.4B)* and *Environmental Impacts: Policies and Procedures (FAA Order 1050.1E, Change 1)* [FAA, 2006a, FAA 2006b]. These two documents provide guidelines for the preparation of EAs, EISs and other similar reviews for airport projects or actions required under NEPA. Under the topic of air quality, these guidelines address the criteria air pollutants and the federal CAA General Conformity Rule. The topic of HAPs is briefly addressed in Order 1050.1E (and 5050.4B).
- *Air Quality Procedures for Civilian Airports and Air Force Bases* and its *Addendum* [FAA, 1997 and 2004]. Referred to as the "*Air Quality Handbook*", this document provides guidance on conducting air quality impact assessments for airport projects and actions required under NEPA and the federal CAA. Contains comprehensive/detailed methodologies on preparing emission inventories and conducting dispersion modeling of airport-related criteria pollutants. The technical guidance and procedures provided are applicable to the assessment of OGs and particulate matter (PM): the two primary classes of HAPs.
- *Emissions and Dispersion Modeling System (EDMS-Version 5.1),* [FAA, 2008]. This software was specifically designed for the assessment of airport-related air quality impacts. Developed by the FAA and updated on a regular basis, EDMS is designated by the FAA as the "required" model for the assessment of aviation-related sources of the EPA criteria air pollutants and their precursors. The *EDMS User's and Technical Manuals* provide comprehensive information on the proper application of this model.
- *Aircraft and Airport-Related Hazardous Air Pollutants: Research Needs and Analysis*, [Transportation Research Board, 2008]. Provides guidance on the most important projects to the airport community for ACRP consideration in the area of HAPs. This report examines the state of the latest research on aviation-related HAP emissions and identified knowledge gaps that existing research has not yet bridged.
- *Recommended Best Practice For Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, [FAA and EPA, Peer Review Draft, February 28, 2009]. This Recommended Best Practice was produced through an inter-agency partnership and provides an approach to, and technical support for, the quantification of organic gases from this source.

1.5 Important Considerations and Limitations

To address current data gaps, information and evaluation methods will require ongoing and additional research involving the aviation, scientific, and regulatory communities. This may take considerable time and may dictate changes to this guidance document. In the meantime, the topic of speciated OGs/HAPs associated with airports is subject to public disclosure. Therefore, these guidelines are prepared with the recognition that not all of the necessary components are fully developed or in place but with the expectation that scientific advancements will be continually made and incorporated into this "living" guidance document.

Considerations and Limitations Associated With the Evaluation of Airport-Related Speciated OG/HAPs

- <u>There are no Federal regulatory guidelines that specifically address any individual OG from airport sources</u> - By definition, neither airports, in general (nor aircraft) are subject to the regulations of Section 112 (*Hazardous Air Pollutants*) of the CAA insofar as it relates to the development of HAPs inventories of an individual OG/HAP.[a] Moreover, there are no regulatory guidelines on either the federal or state levels that identify when, or under what conditions, the evaluation of speciated OG (an in particular HAPs) from these sources is required nor do they define the type and extent of the analysis.
- <u>Emission inventory results are estimates and are not directly comparable to regulatory standards or other acceptable criteria</u>. – For disclosure and/or alternative comparative purposes, an emission inventory provides a useful estimate of the quantity of a specific OG. However, by itself, the results of an emission inventory are not comparable to any enforceable measures of acceptability. It should be noted that the methodology presented in this document will provide the best estimate of airport-related OG/HAP emissions currently available but the use of the inventories for regulatory purposes is not recommended due to the current lack of quality data available in this area.

[a] It should be noted however, that some sections of Section 112 could potentially implicate airports by other means (i.e., Maximum Achievable Control Technology (MACT) standards can be applicable to airport stationary sources, but only relative to required control technologies. Additionally, it should be noted that state/local air pollution control agencies can exercise discretion in determining acceptability and enforcement.

In complying with NEPA, the FAA's environmental documentation provides full discussion and disclosure of significant environmental impacts. NEPA requires this to inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. Section 1502.22 of the Council on Environmental Quality (CEQ) Regulations state: "…when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement [EIS] and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking" [CEQ, 1986]. The purpose of this section is to document the "information that is lacking" (uncertainties and limitations) with respect to the methodologies discussed in this guidance document. The following specific factors are discussed--OG (and HAP) speciation profiles and health risk assessments.

1.5.1 OG Speciation Profiles

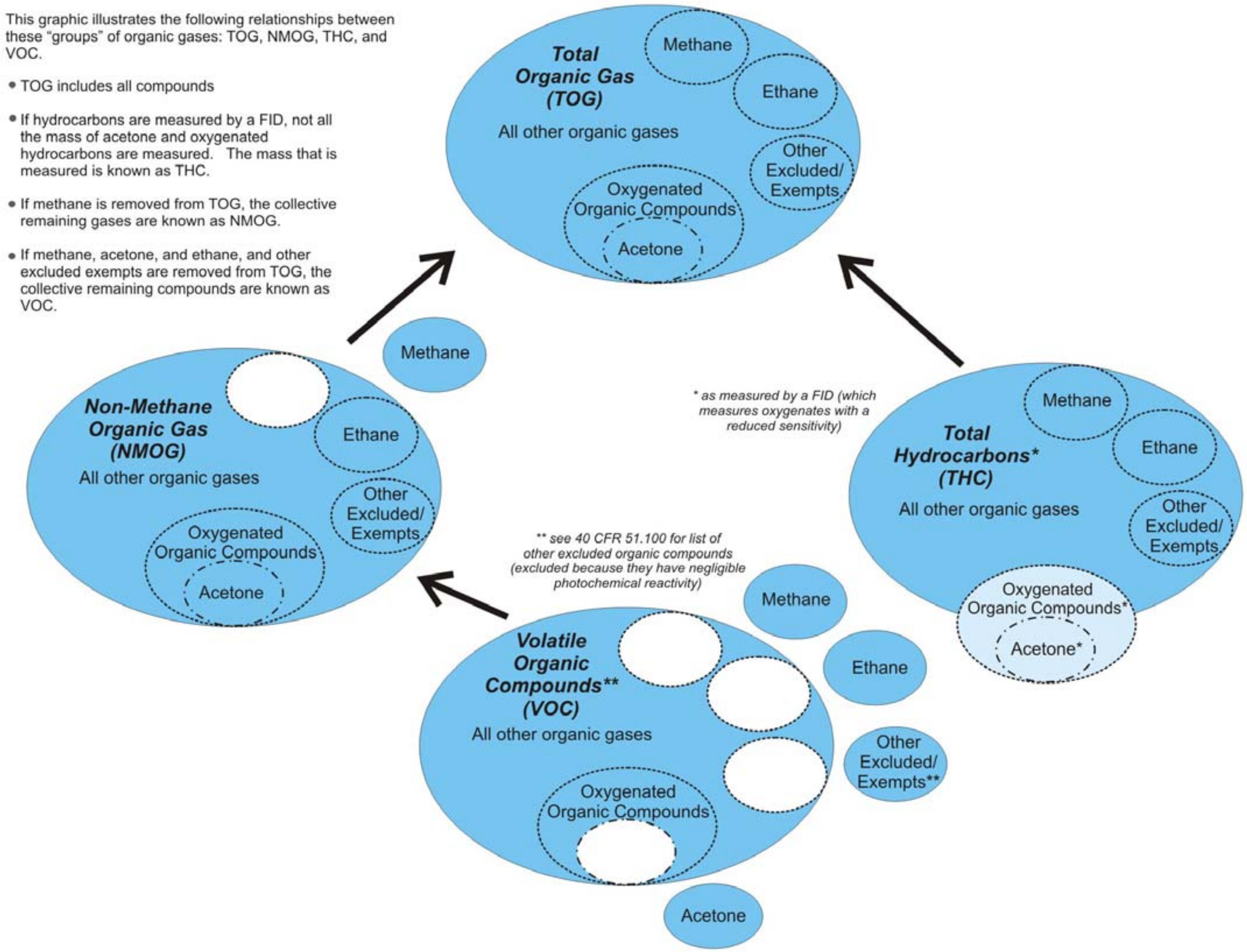
Speciation profiles, in the form of mass fractions, can be used to estimate quantities of individual OGs. A mass fraction is the fraction portion of one substance (xA) relative to the total mixture mass (mtotal). Groups of OG emissions are defined a variety of ways depending on the reason for the assessment/analysis (e.g., preparation of an emissions inventory or photochemical analysis), the modeling need, and/or the regulatory context. Typical groups of OG emissions are total OG (TOG)[6], non-methane OG (NMOG), total hydrocarbon (THC), and volatile organic compounds (VOC). The individual, and groups, of OGs included in each "group" of these gases are described in the following and illustrated on **Figure 1**:

- TOG – TOG is defined by the California Air Resources Board (CARB) as compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate. TOG includes all organic gas compounds emitted to the atmosphere, including the low reactivity compounds (e.g., methane, ethane, various chlorinated fluorocarbons, acetone, perchloroethylene, volatile methyl siloxanes, and oxygenated OG).
- NMOG - As implied, NMOGs include all organic compounds except methane which is the most common OG and a greenhouse gas that is sometimes excluded from the assessment/analysis of organic compounds.
- THC – Organic compounds in exhaust, as measured by a flame ionization detector (FID) per ICAO's Annex 16.[7] Notably, a FID does not accurately measure all of the mass of oxygenated OG, which influences the abundances of specific chemical compounds relative to the total in the measured exhaust. This is important because these abundances dictate the amounts of each speciated compound in the exhaust plume
- VOC – VOC is defined by EPA as any compound of carbon that participates in atmospheric photochemical reactions. For aircraft, this is further defined as exhaust TOG corrected to exclude the mass of methane, ethane, and acetone and to fully account for the mass of formaldehyde and acetaldehyde [U.S. EPA 2007].[8] Notably, additional compounds are excluded/exempt from this group of OG when sources other than aircraft engines are being considered. VOC also excludes carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

The HAP speciation profiles adopted by regulatory agencies, and used in this guidance, are intended for use in developing gross estimates of speciated HAP (and OG) emissions on a state- or region-wide basis. These profiles are **not** intended for evaluations of site-specific impacts at the project level. As such, although the speciation profiles discussed in this document are based on the best data, information, and techniques currently available, the factors are subject to a high degree of imprecision and uncertainty.

[6] Also referred to as total organic compounds (TOC) when discussed in an air quality context.
[7] ICAO's Annex 16 addresses protection of the environment from the effect of aircraft noise and aircraft engine emissions.
[8] Per the EPA definition of VOC at http://www.epa.gov/ttn/naaqs/ozone/ozonetech/def_voc.htm

Figure 1
Groups of OGs



1.5.1.1 Conversion Factors

As stated above, depending on the technique used to prepare an estimate, an estimate of mass OG emissions could be representative of TOG, NMOG, THC, or VOC. If an estimate of OG emissions is prepared and the mass OG emissions are not classified as TOG, analysts must first apply a conversion factor to the mass OG emissions prior to using the TOG-specific speciation profiles discussed in this document. Again, *the speciation profiles discussed in this document are TOG specific profiles* of known individual OG species. Therefore, prior to applying a profile to an estimate of mass OG, it will be necessary to convert the mass OG to TOG. The NMOG, THC, and VOC to TOG conversion factors are provided in **Table 1** (THC conversion factors are provided in the Table 1 footnotes).

1.5.2 OG Toxicity and Health Risk Assessments

This guidance does not address the dispersion modeling of, nor the preparation of human health risk assessments (HHRA) for, individual airport-related HAPs as scientific knowledge of these analyses with respect to airports is still very limited. Notably, the FAA is conducting and fostering research to advance knowledge of human health impacts associated with airport sources.

The human health and environmental effects of airport-related OGs/HAPs combined with OGs/HAPs from other sources are not well documented. Further, it is difficult to accurately predict the incidence of human disease or the types of effects that such a chemical exposure has on humans. For example, the unit risk values and the reference concentrations that provide toxicity weighting values for HAPs and the OGs in IRIS are based on toxicological data that are typically obtained and, indeed most often only available, from animal studies. Any adverse effects at high doses for short exposure durations in animals are extrapolated to estimate the effects on humans at low doses for long exposure durations. The affected organs, the types of adverse effects, and the severity of the effects may all differ between study animals and humans (inter-species differences), or between humans and humans (intraspecies differences). These differences are often associated with variations in the particular toxic kinetics, or movement, of a chemical through the exposed organism, such as the absorption, distribution, metabolism, and excretion of the chemical.

There is also considerable uncertainty in the quantitative analysis of airport-related OG emissions, toxicity determinations, and the relative evaluation of human health risks associated with exposure to HAPs. The models that are used to prepare such assessments are subject to error due to the variability of air patterns, atmospheric flow, and the myriad factors that can alter the final concentration of a contaminant in the air. These factors contribute to several dispersion modeling limitations, including:

1) dispersion models are more reliable for predicting long-term concentrations than for estimating short-term concentrations at specific locations; and

2) dispersion models are reasonably reliable in predicting the magnitude of the highest concentrations likely to occur, but without respect to a specific time or location.

Table 1
Conversion Factors

EDMS Source		SPECIATE Profile Number	SPECIATE Profile Name	Profile Quality Rating[c]	Conversion Factors: VOC-to-TOG[a]	TOG-to-VOC[a]	NMOG-to-TOG[a]	TOG-to-NMOG[a]
Aircraft	Piston	1099	Aircraft Landing/Takeoff (LTO) - General Aviation	3 - C	1.17	0.93	1.12	0.89
	Turbofan, Turbojet, and Turboprop and Auxiliary Power Units (APUs)[b, d]	5565[e]	[unknown at this writing]	5 - A	1.01	0.99	1.00	1.00
GSE	Diesel	1201	Light-Duty Diesel Vehicles	3 - C	1.00	1.00	1.18	0.85
	Gasoline, Liquid Petroleum Gas, Natural Gas	1186	Heavy Duty Gasoline Trucks	3 - C	1.03	0.97	1.03	0.98
Boilers/ Space Heaters	Coal Fired Boilers	1178	Coal-Fired Boiler - Electric Generation	1 - E	1.02	0.98	1.00	1.00
		1185	Coal-Fired Boiler - Industrial	2 - D	1.22	0.82	1.00	1.00
	Liquid Petroleum Gas, Natural Gas	0003	External Combustion Boiler - Natural Gas	4 - B	2.27	0.44	2.78	0.36
	Residual Fuel Oil	0001	External Combustion Boiler - Residual Oil	4 - B	1.64	0.61	5.26	0.19
Distillate Fuel Oil Boilers/Space Heaters		0002	External Combustion Boiler - Distillate Oil	4 - B	1.00	1.00	1.95	0.51
Emergency Generators	Distillate Oil (Diesel)	0009	Reciprocating Distillate Oil Engine	2 - D	1.17	0.86	1.13	0.88
	Gasoline Fuel	1101	Light Duty Gasoline Vehicles - 46 Car Study	4 - B	1.13	0.89	1.13	0.89
	Kerosene/Naptha (Jet Fuel)	0007	Natural Gas Turbine	3 - C	3.33	0.30	N/A	N/A
	Natural Gas	1001	Internal Combustion Engine - Natural Gas	3 - C	10.74	0.09	4.45	0.22
Incinerators -- Single and Multiple Chamber; Fire Training -- JP-4, JP-5, JP-8 Propane and Tekflame		0122	Bar Screen Waste Incinerator	2 - D	5.92	0.17	5.10	0.20
Fuel Storage	Gasoline	1190	Gasoline Marketed - Summer Blend - 1984	4 - B	1.00	1.00	1.01	0.99
	Jet Kerosene, Distillate Oil, Residual Oil	0297	Fixed Roof Tank - Crude Oil Refinery	3 - C	1.13	0.89	1.10	0.91
	Jet Naphtha (JP-4)	0100	Fixed Roof Tank - Commercial Jet Fuel (Jet A)	3 - C	1.00	1.00	1.00	1.00
Surface Coating/ Painting	Adhesive	1088	Surface Coating Operations - Adhesive Application	3 - C	1.17	0.86	1.76	0.57
	Enamel	1018	Surface Coating Operations - Coating Application - Enamel	4 - B	1.06	0.94	2.15	0.47
	Lacquer	1017	Surface Coating Operations - Coating Application - Lacquer	4 - B	1.00	1.00	1.18	0.85
	Primer	1019	Surface Coating Operations - Coating Application - Primer	4 - B	1.00	1.00	1.23	0.81
	Solvent Base	1003	Surface Coating Operations - Coating Application -Solvent-Base Paint	4 - B	1.01	0.99	1.35	0.74
	Thinner	1016	Surface Coating Operations - Thinning Solvents - Composite	4 - B	1.01	0.99	1.30	0.77
	Varnish/Shellac	0127	Surface Coating - Varnish/Shellac	2 - D	1.63	0.61	1.00	1.00
	Water Base	1013	Surface Coating Operations - Coating Application - Water-Base Paint	4 - B	1.06	0.94	8.92	0.11
Deicing, all processes -- Ethylene and Propylene Glycol		2419	Aerosols, Special Purpose	4 - B	1.12	0.89	3.64	0.27
Solvent Degreasers		1195	Degreasing - Composite	4 - B	1.65	0.61	1.04	0.96

[a] Compounds are referenced as follows: VOC as VOC, TOG as TOG, NMOG as NMOG.
[b] Source: FAA/EPA Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines, February 2009 (Final Review Draft)
[c] With the exception of turbofan, turbojet, and turboprop aircraft engines, all profile quality ratings obtained from EPA's SPECIATE database. A rating of "A" or" 5" equates to "highest quality rating". A rating of "E" or "1" equates to a "lowest quality rating".
[d] To convert THC to TOG or THC to NMOG, the conversion factor is 1.16. To convert THC to VOC, the conversion factor is 1.15.
[e] EPA has assigned Profile No. 5565 to the speciation profile for aircraft equipped with turbofan, turbojet, and turboprop engines and APU's. The profile will be included in EPA's SPECIATE Version 5.0 (to be released by the EPA in 2009).

Model estimates of concentrations that occur at a specific time and site are poorly correlated with actual observed concentrations and are much less reliable. Therefore, it is difficult to correlate monitoring results to modeled air concentrations, and it is correspondingly difficult to make predictions about potential human exposures at specific locations. Also, Gaussian plume models use hourly meteorological data which, while allowing for variation in data with changes in altitude, are assumed to be uniform at those altitudes. Consequently, the accuracy of the modeling results degrades as distance from the source increases.

Another source of error in human health risk assessments is the typically employed assumption that an individual is constantly exposed to a particular chemical over a 70-year lifetime. This assumption does not account for changes in a person's age, size, health, geographical residence, or location (indoors versus outdoors, home versus work, etc.) over time.

Health Risk Assessments

Due to the limitations discussed in this section, the FAA believes that at this time it is not appropriate to analyze the health related effects of HAPs associated with proposed airport development projects.

While the methodology discussed in this guidance document may show that emissions of HAPs would increase with a project's build alternative when compared to a no-action alternative, it is not possible to meaningfully identify whether these emission levels would adversely impact human health. Further, given all the limitations and uncertainties, the FAA believes that health risk assessments would not assist NEPA decision makers or public understanding of whether exposure to some level of emissions resulting from a project (or action) would be harmful.

2 APPROACH and PROCESS

Under NEPA, all federal agencies, including the FAA, are required to identify and describe potential impacts to the human and natural environments that would result from their action(s); including those related to air quality. The analyses and environmental review that identifies/describes these potential impacts are typically documented in EAs and EISs. One of the main goals of this guidance is to make explicit the uniform methodology to be used for identifying/reporting potential impacts to the types and levels of airport-related OGs--with emphasis on preparing/reporting emission inventories of airport-related HAPs and those OG species identified in EPA's IRIS.

As part of FAA's policy, any airport HAPs emission inventories must be prepared using the most current version of the EDMS. Notably, the output of EDMS currently provides fully speciated OG values (394 compounds), but only the compounds considered/identified by EDMS to be HAPs or being included in the IRIS database should be reported in NEPA documentation.[9]

HAPs Emission Inventories

Although EDMS provides fully speciated OG values, only those compounds identified in EDMS as being a HAP and those identified as being included in the IRIS database should be reported in NEPA documentation.

NEPA reports (i.e., EAs and EISs) must not include any other type of HAP assessment including, but not limited to, dispersion, toxicity weighting, exposure, or health risk quantifications (except when required by CEQA and even in that case, proper analysis methodology should be employed). These types of assessments require a more complete understanding of both HAPs reactions in the atmosphere and downstream plume evolution. Because the science of these factors with respect to airport-related HAPs is still evolving, the understanding of the factors is currently limited.

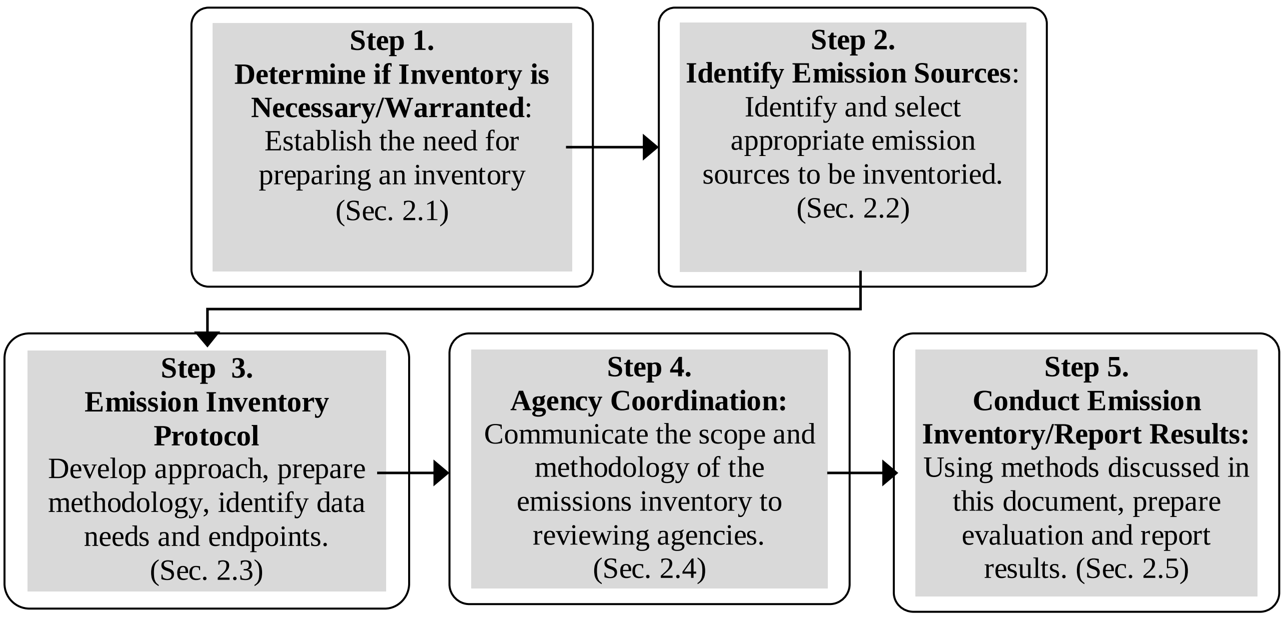
When preparing an emissions inventory, it is important to identify all of the sources of OGs/HAPs at an airport that would be affected by a proposed project/action and, to include these sources in the HAPs emissions inventory. The inventory should not include sources that are not related to an airport's proposed project/action (e.g., non-airport related motor vehicle traffic on a road adjacent to an airport that is not used for airport access and/or egress and is not part of a proposed action/project).

It is also important not to compare an OG inventory prepared for one airport to the inventory of another airport because doing so would not provide any meaningful conclusions (i.e., reporting that one airport emits more or less OGs than another airport is not an indication that one airport is "better" or "worse" than another airport). It is also important to consider that the evaluation of speciated OGs emitted from airport-related sources is an evolving field of study. Therefore, future data sets may result in necessary modifications to this guidance.

[9] http://www.epa.gov/iris

The FAA recognizes that the need to prepare an emissions inventory of speciated OGs/HAPS is not widely instituted nor uniformly applied on Federal, state or local levels. Several estimations of airport-related speciated OGs/HAPs have already been prepared under NEPA. From these existing works, alternative approaches and techniques have been developed that now provide varying and dissimilar results**.** To address this discrepancy, the overall approach to this section is to provide a clear and consistent process for determining when an airport-related emissions inventory of speciated OGs/HAPs may be warranted and how it must be accomplished. **Figure 2** illustrates the recommended approach to undertaking an airport-related OG/HAP emissions inventory.

Figure 2
Recommended Approach to Undertaking an Airport-Related OG/HAP Emission Inventory

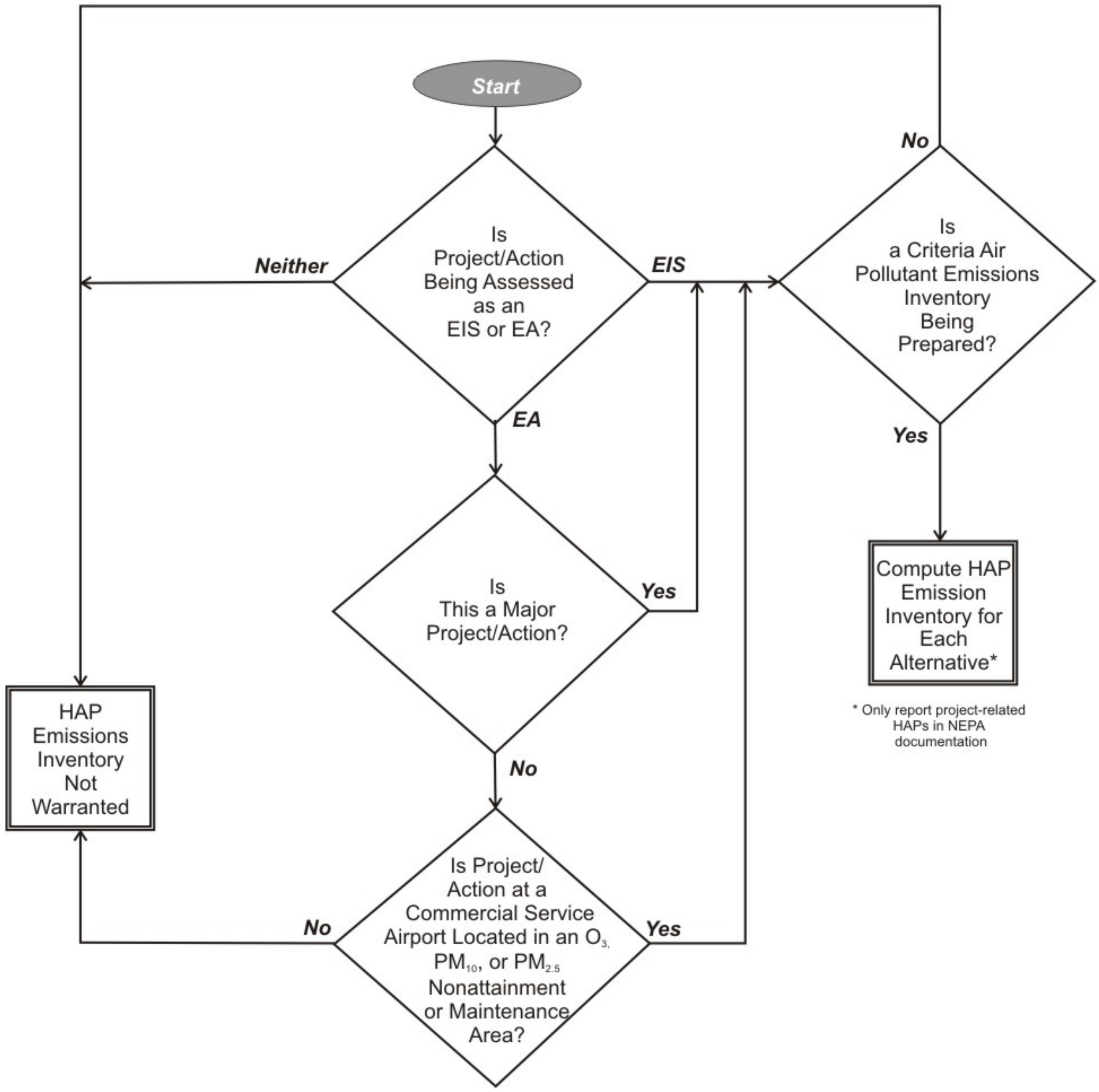


2.1 Determining If an Emissions Inventory is Warranted (Step 1)

The decision to prepare an OG/HAP inventory should be made early in the NEPA process. **Figure 3** provides a flow chart that an analyst can use to determine when airport-related emission inventories of OGs/HAPs must be prepared. As shown, if an EA or EIS is not required to assess a proposed project/action, then preparation of an OG/HAPs inventory is not warranted. In other words only proposed projects/actions evaluated through an EA or EIS should even consider including an OG/HAP inventory. Notably, if a proposed project/action is evaluated through an EIS, an emission inventory must be prepared (for each alternative under consideration) if an inventory of the criteria air pollutants and/or precursors to the criteria air pollutants must be prepared.

When an EIS is being Prepared, When is an OG/HAP Emission Inventory Warranted?
When and EIS is prepared, OG/HAP emission inventories are only warranted when an inventory of the criteria air pollutants and/or precursors to the criteria air pollutants is being prepared.

Figure 3
Determining if an Emissions Inventory is Warranted



The following conditions must be evaluated to determine if an estimate of airport-related OGs/HAPs is warranted for EA projects:

1.) Is the proposed project/action major (e.g., new airport or heliport, new runway or major runway extension, new terminal or major terminal expansion, major construction activity) or is the project at a commercial service airport that is located in a designated nonattainment or maintenance area for ozone, particulate matter 10 microns or less in diameter, or particulate matter 2.5 microns or less in diameter[10]?

and

2.) Is an inventory of the criteria pollutants and/or precursors to the criteria air pollutants being prepared?[11]

If an analyst answers "yes" to both of the conditions above, an OG/HAP emission inventory (an inventory for each of the same alternatives as the criteria pollutant inventory) must be computed and reported in the EA. Notably, where the magnitude of a project/action cannot be determined (i.e., it is questionable whether the project/action is major), an OG/HAPs inventory should be prepared and reported in an EA only when a HAP inventory/evaluation is specifically requested by a regulatory agency.

2.2 Preparing an Emissions Inventory

If it is determined that an emissions inventory of airport-related OG/HAPs is warranted, there are four more steps in the approach to preparing/reporting the results of the inventory. Notably, in connection with EISs and EA's, three of the four steps--identifying the sources to be inventoried, preparing a protocol that defines the evaluation process, and agency coordination--are typically performed for the assessment of the criteria air pollutants. These steps, and the fourth step --preparing the emission inventory and reporting the results--are discussed below.

2.2.1 Airport-Related Sources to be Inventoried (Step 2)

With the exception of construction equipment and construction-related activities, this guidance provides data to support the preparation of a speciated OG/HAP emission inventory for the vast majority of airport-related sources.[12] The following discusses each source.

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[10] An area's attainment status is relevant only in terms of O_3 and particulate matter because the O_3 precursor VOC and particulate matter are contributors to concentrations of OGs/HAPs. Attainment statuses for other criteria pollutants such as CO are not as relevant because levels of these pollutants do not significantly alter the level of HAPs being emitted due to airport actions or operations.,

[11] See Section 2.3.4 of the FAA's Air Quality Procedures for Civilian Airports and Air Force Bases, April 1997.

[12] Although it is recognized that construction activities emit OG, it is not currently possible to accurately speciate the emissions for construction equipment due to lack of data.

2.2.1.1 Sources of OG/HAP Emissions

According to the FAA *Air Quality Handbook*, the primary airport-related sources of air pollutant emissions are: aircraft engines; auxiliary power units (APUs); ground support equipment (GSE); and ground access vehicles (GAV)--including passenger, employee and cargo-related motor vehicles [FAA, 1997]. Stationary sources and fuel storage/transfer facilities are generally less significant sources, by comparison, and construction equipment/activity emissions are considered to be short-term and temporary.

Table 2 summarizes the sources of airport-related OG/HAP emissions, their general characteristics and the types of projects/actions that could affect HAP emission levels.

Aircraft

Aircraft generally represent the largest source of total emissions of the criteria air pollutants (or their precursors) at commercial service or public use airports. For air quality assessment purposes, aircraft are generally classified by aircraft type: commercial (including cargo and charter), commuter (air taxi), GA and military. However, the actual or forecast aircraft fleet mix that makes up these categories is unique to each airport.

Aircraft activity levels are measured as operations (landings and takeoffs) or as LTO cycles (one landing plus one takeoff equals one LTO cycle). Furthermore, a LTO cycle is subdivided into four “operational modes” based on engine power settings: takeoff, climbout, approach and taxi/idle (including taxi-in, taxi-out and queue/delay). A method of estimating OG emissions resulting from aircraft engine “startup” will be developed and provided by the FAA at a later date.

Times-in-mode (TIM) are the periods that an aircraft spends in each of the four operational modes. TIMs are based on aircraft type, an airport’s operational characteristics (e.g., taxi distances and queue delays) and, for approach, takeoff, and climbout, TIMs are based on the atmospheric mixing height.

At airports, aircraft engines are considered to be one of the dominant sources of ground-based OG. It is important to note that the majority of aircraft-related OG is emitted during the low-power engine mode of an LTO cycle (i.e., taxi/idle).

AEE has published a document that could be considered a companion to this document--*Recommended Best Practice For Quantifying Speciated Organic Gas Emissions From Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines.* The document details the joint efforts between the FAA and the EPA to update OG speciation profile data for this source.

Table 2
Sources of Airport-Related OG/HAP Emissions

Source Category	General Characteristics	Projects/Actions Which May Affect HAP Emissions
Aircraft	Classified by aircraft type: commercial, commuter, military and GA.	Projects/actions which increase the number of operations, result in a change in aircraft fleet mix and/or increases taxi/idle times.
	Primary source of OG in low power mode (i.e., taxi/idle).	
	Engine emission standards established by ICAO and promulgated by the EPA.	
Auxiliary Power Units	OG/HAP emissions from APU use are minimized with use of 400 Hz gate power and pre-conditioned air.	Projects/actions which increase the number of aircraft operations and/or category of operations (e.g., commercial, cargo).
Ground Support Equipment	Classified by two broad categories: on-road or non-road; aircraft function (e.g., service truck, baggage tug, pushback tractor, etc.); and fuel type (e.g., gasoline or diesel). Includes ground power units (GPUs).	Projects/actions which increase the number of aircraft operations and/or category of operations (e.g., commercial, cargo).
	Emissions regulated by EPA.	
	Zero-emission and low-emitting GSE are replacing conventionally-fueled equipment.	
Ground Access Vehicles	Includes private and commercial motor vehicles used by airport patrons, employees and cargo carriers.	Projects/actions which increase the number of aircraft operations and/or result in an increase in vehicle-miles-traveled
	Classified by type, weight and fuel use: light duty gas vehicles, heavy-duty diesel trucks, etc.	
	Emissions regulated by EPA.	
Stationary Sources	Include power plants, boilers, generators, fuel storage facilities, fire training facilities and other aviation maintenance and support facilities.	Projects/actions that increase terminal/concourse/cargo facilities. New/changes to/additional fire training facilities.
	Stack emissions are effectively managed with process design and control equipment. Fuel storage facility emissions of OG from storage/handling of jet and diesel fuel are considered minimal due to low vapor pressure (emissions from storage/handling of gasoline and/or Avgas are higher). Newer fire training facilities use low-emitting propane.	
	Emissions from smoke stacks and vapor vents are individually permitted by state and local agencies.	
Construction Activities[a]	Generally classified as on-road and/or non-road equipment and fuel type (gasoline or diesel).	Any project/action that requires demolition and/or construction.
	Emissions regulated by EPA.	

[a] Although it is recognized that construction activities emit OG, it is not currently possible to accurately speciate the emissions due to lack of data.

GSE/APUs

GSE provide service to aircraft while at an airport terminal and consist of (but are not limited to) the following types of equipment: baggage tugs, tow tractors, belt and cargo loaders and a variety of fuel, food and lavatory service trucks. The fleet of GSE utilized at an airport, their operating times and fuel types (gasoline or diesel) varies by aircraft type (commercial, commuter, GA, military), by airline, and by airport.

For air quality assessment purposes, GSE are generally classified as either “on-road” vehicles or trucks (e.g., an airline employee shuttle bus) and other similar vehicles or “non-road” vehicles/equipment such as tugs, tractors, loaders, etc. At many large metropolitan airports, portions of both the on- and non-road GSE fleets are being converted to engines powered with alternative fuels (propane or natural gas) or electricity.

For large commercial and cargo aircraft, APUs generate on-board electricity and air conditioning (A/C) while an airplane is taxiing or parked at the gate. In some cases, GPUs are used. APUs and GPUs are traditionally powered with jet fuel and diesel fuel, respectively. At many modern airports, gate furnished electricity and air conditioning are used to supplement and/or replace usage of APUs/GPUs.

Despite the continuing conversion of fossil-fueled GSE and APUs to low- or zero-emission fleets, these vehicles and equipment are still considered primary sources of HAPs at airports.

GAV

On-site GAV are the various fleets of public and privately-owned motor vehicles traveling on airport roadways, and in parking lots and parking garages by passengers, employees, commercial vehicles and cargo carriers. These fleets typically include cars, vans, taxis, shuttles, buses and trucks. GAV emissions vary by vehicle and fuel type (gasoline or diesel), travel distance, operating speed, and ambient temperature.

Within an airport’s property, emissions of OG from GAV are secondary to aircraft and GSE as sources of HAPs. Outside airport property, GAVs operate on the local and regional roadway networks while traveling to and from an airport. As such, they are difficult to distinguish from background (non-airport) traffic. Emission inventories should not include sources not related to an airport’s proposed project/action which may include, but not limited to, the non-airport related motor vehicle traffic the local/regional roadway networks.

Stationary Sources

Stationary sources typically include facilities that discharge emissions from a smokestack (i.e., power generators, steam boilers, space heaters, waste incinerators, etc.). However, this term can also include fire training facilities, engine test facilities and a variety of other aviation-related industrial sources (i.e., solvent degreasing, surface coating, etc.). In nearly all cases, these sources are regulated with individual operating permits or regulated collectively under Title V of the CAA (Permits).

Fuel storage/transfer facilities (tank farms and fuel hydrant systems) are also considered stationary source categories. OG emissions from these sources vary by fuel type and vapor pressure; containment vessel, emission control device, fuel throughput volumes, and local meteorological conditions. Jet fuel is stored in the greatest quantities at most major airports with aviation gas (Avgas[13] or 100-octane low lead (100LL)), gasoline and diesel fuel occurring in comparatively smaller amounts. Because jet fuel and diesel fuel have such a low vapor pressure (i.e., low evaporation rate), OG vapors generally remain well confined in the storage vessel without additional controls. In many cases, this negates the need for a regulatory permit (e.g. individual operating or Title V permit). Vapor pressures for Avgas and gasoline lead more readily to OG vapors.

Airport Rescue and Firefighting Facilities (ARFFs) are used to train personnel for fuel fire suppression. The types of fires simulated include engine fires; exterior pool fires involving the fuselage, the left wing, or the right wing; interior fires on the flight deck, cargo, or passenger areas; and other miscellaneous fires.

Construction Activities

Construction activities at airports generally represent a temporary source of air emissions associated with the site preparation, construction and/or demolition. Depending on the project requirements, the work can involve an assortment of both on-road vehicles (i.e., pick-up trucks, dump trucks, etc.) and non-road (i.e., scrapers, dozers, loaders, etc.) equipment. The exhaust from these vehicles and equipment contains OGs (including HAPs).

While it is recognized that construction equipment and some construction activities (e.g., equipment fueling) result in emissions of HAPs, it is not currently possible to accurately speciate the OG/HAP emissions of construction activities due to lack of data.

2.2.2 Emissions Inventory Protocol (Step 3)

The assembly of an airport-related HAPs emissions inventory is a multifaceted process and can become a complex undertaking potentially involving:

1) extensive data collection;
2) development of assumptions; and
3) a range of outcomes and endpoints.

For these reasons, when it is appropriate to provide such data under NEPA, it is recommended that the proposed approach and methodology be documented for review and, then once approved, included in the appendix of NEPA documents (it is suggested that approach/methodology be entitled *Air Quality Analysis Protocol*. Prior to distributing protocols

[13] Avgas is a portmanteau (a blend of two or more words) for aviation gasoline—a fuel that is used in piston and rotary engines.

to reviewers of the OG/HAPs inventories, the documents should be reviewed by FAA's AEE and/or Office of Airport Planning and Programming (APP). In this way, the means and objectives for accomplishing the work are clearly stated and understood before the work is begun and completed. Written approval of protocols by the reviewing office(s) is also required.

Any supporting materials (i.e., references, computer printouts, etc.) considered necessary to help explain and clarify the work should also be identified the appendix. The supporting materials should also reference this guidance document and the EDMS version used to prepare the OG/HAP inventories.

2.2.3 Agency Coordination (Step 4)

As discussed previously, other than California's CEQA, there are no current or former guidelines, regulations or directives on either the federal or state levels that address the preparation of an emissions inventory of airport-related speciated HAPs. Therefore, it is recommended that the project sponsor coordinate early with the appropriate FAA airports regional or district office. The FAA will aid the sponsor or its consultant in developing a process to contact federal, state and local governmental agencies involved in the review of the OG/HAP inventories. These agencies should include the FAA (e.g. AEE, APP, and regional offices) and may include the EPA, as well as the state and local agencies responsible for air quality management in the area where an airport project(s) are proposed.

Coordination with EPA and/or State Air Quality Agencies

Agency coordination should focus on defining the scope of the inventory and acceptability criteria. Any uncertainty about the approach or methodology should be resolved at this early stage so the inventory adequately addresses all concerns.

2.2.4 Prepare the Emission Inventory and Report the Results (Step 5)

After it is determined that an emission inventory of airport-related speciated OGs/HAPs is warranted (Step 1), the emission sources and OGs/HAPs to be evaluated are identified (Step 2), the methodology developed (Step 3) and coordination with reviewing agencies completed (Step 4), the final step involves preparing the inventories and reporting the results.

2.2.4.1 Conducting the Emission Inventory

As discussed in Section 1, these guidelines focus on the preparation of an emission inventory: a common and universally-accepted method of quantifying the amounts (or mass) of OG/HAP emissions. This method comprises a multifaceted process involving airport operational data or activity levels, appropriate emission indices, and other source-specific OG/HAP emission characteristics. This procedure is the emphasis of this document. As such, detailed guidance for preparing an emission inventory of airport-related speciated HAPs is provided in Section 4 of this document.

2.2.4.2 Reporting the Results

Typically, the results of an OG/HAP emission inventory are expressed in units of tons/year for each individual OG/HAP evaluated (i.e., formaldehyde, benzene, etc.). For comparative purposes, the results may also be segregated by emissions source (i.e., aircraft, GSE, motor vehicles) and/or project/action, or alternative (i.e., build/action, no-build/no-action). Recommendations (including table templates) for presenting these data are also presented in Section 4.

Because the topic of speciated OGs/HAPs is not included among the categories of environmental impacts called for under FAA Orders 1050.1E or 5050.4B [FAA, 2006a; FAA, 2006b], it is recommended that the results be reported separately or in an appendix for a NEPA document.

2.3 Other Agency Guidelines and Requirements for Airport-related OG/HAP Emissions

Although it is recognized that other federal, state and local agencies may have their own procedures and requirements for quantifying airport-related speciated OGs/HAPs, it is not the intent of these guidelines to address or supersede them. As stated above, these guidelines are specifically developed in support of NEPA documents prepared by, or on behalf of, the FAA and airport sponsors.

If additional, or alternative, analyses are conducted for airport-related speciated OGs/HAPs for other purposes, the objectives, methods and results should likewise be treated and published separately from the NEPA analysis. In this way, the outcomes from the different analyses also remain independent and unconfused.

3 SPECIATION PROFILES

Speciation profiles provide estimates of the chemical composition of plume emissions. A profile, or set of profiles, may be used to prepare an emission inventory and/or determine the contributive amount of a particular pollutant for air quality assessment purposes. This guidance recommends the use of profiles to prepare emission estimates (inventories) of individual (speciated) OGs, which include HAPs.

The FAA recommends that estimates of plume emissions of OGs be speciated to individual HAPs using the profiles (mass fractions) provided in the EDMS. Because it is the intent of the FAA/EPA to update the profiles for turbofan, turbojet, and turboprop engines as additional data becomes available, and the profiles for other sources may also be modified/change, air quality practitioners should verify that they have the most recent version of EDMS before beginning an evaluation.

With the exception of the speciation data recommended for aircraft equipped with turbofan, turbojet, or turboprop engines, APU's and the profiles for on-road motor vehicles, the OG speciation profiles for airport sources in EDMS were obtained from the EPA's SPECIATE database (http://www.epa.gov/ttn/chief/software/speciate/index.html). Each airport-source/profile combination was selected using the EPA's Source Classification Codes (SCCs). The applicability of these judgment-based profile assignments was confirmed by assessing SPECIATE's data quality ratings, surrogate data sources, and documentation for each chosen profile, which are directly available in the SPECIATE database. SPECIATE's data quality ratings for the airport-related profiles are provided in Table 1**.** The speciation profile data for aircraft equipped with turbofan, turbojet, or turboprop engines and APU's was recently updated in a joint coordination effort between the FAA and EPA. This data will be included in EPA's intended update to SPECIATE as Profile No. 5565. Speciation profile data for on-road motor vehicles can be obtained from EPA's MOBILE motor vehicle emission rate model.

3.1 Airport-Related/EPA-Identified HAPs and Toxic Compounds

Under Section 112 (*Hazardous Air Pollutants*) of the federal CAA, the EPA classified 188 air pollutants as HAPs. In 2005, the EPA modified the list to classify only 187 air pollutants to be HAPs (methyl ethyl ketone (MEK, also known as 2-butanone) was removed from the list). The EPA also maintains a database of substances found in the environment and their potential to cause human health effects. This database is known as IRIS. Additionally, pursuant to their continuing National Emissions Inventory (NEI) program, the EPA developed a program to address OG emissions with potential human health effects emitted by mobile (motor vehicle) sources. The compounds that the EPA identified as being emitted from motor vehicles are referred to as the "Mobile Source Air Toxics" (MSATs).

A list of the airport-related OGs that are EPA-designated HAPs and/or are identified in IRIS is provided in **Table 3**. There are 45 individual airport-related OGs. Thirty of the OGs are EPA-designated HAPs and/or identified in the IRIS database. Fifteen of the OGs are listed in IRIS (but not designated by the EPA to be HAPs). As shown, the number and type of OGs varies by airport source (e.g., piston engine aircraft emit 16 of the 45 OGs and gas-powered ground support equipment emit 8 of the 45 OGs).

For the purpose of preparing NEPA documents, the FAA recommends that, when warranted, EISs and EAs only report project-related OGs/HAPs in NEPA documentation unless the EPA or a State or local air quality agency requests in writing that the FAA or airport sponsor publishes the full EDMS output report of 394 OGs (including HAPs).

Each substance is readily identified in the current version of EDMS as being a HAP or IRIS-identified substance. It is important to note that these OGs do not have NAAQS (i.e., the EPA has not established standards for concentrations of these pollutants in the ambient (outdoor) air).

Table 3 - Airport-Related OGs Identified in Section 112 of the Clean Air Act and/or IRIS

								Stationary Source																							
		Identified in:		Aircraft		GSE		Boilers/Space Heaters				Fuel Storage Tanks			Surface Coatings									Emergency Generators							
CAS	Species Name	CAA ?	IRIS ?	Pis-ton	Turbo/ APU	Gas, Natural Gas and LPG	Diesel	Coal	Re-sidual Fuel	Dis-tillate Fuel	Natural Gas and LPG	JP-4	Jet Kerosene, Distillate and Residual Oil	Gas	Sol-vent Base	Water Base	Ena-mel	Lac-quer	Primer	Varnish / Shellac	Ad-hesives	Thinner	Solvent De-greasers	Gas	Diesel	Kero-sene / Naphtha	Natural Gas and LPG	In-cinerators	De-icing	Fire Training	On-Road Motor Vehicles[a]
71556	1,1,1-trichloroethane	Yes	Yes																				x						x		
106990	1,3-butadiene	Yes	Yes	x	x																			x	x						x
540841	2,2,4-trimethylpentane	Yes	Yes			x																		x							
110805	2-ethoxyethanol (cellosolve) (egee)		Yes																										x		
91576	2-methylnaphthalene		Yes		x																										
75070	acetaldehyde	Yes	Yes	x	x		x																	x			x				x
67641	acetone		Yes	x	x				x						x		x			x	x		x						x		
107028	acrolein (2-propenal)	Yes	Yes	x	x																			x							x
100527	benzaldehyde		Yes	x	x		x															x		x							
71432	benzene	Yes	Yes	x	x	x		x			x		x	x		x							x	x	x		x	x		x	x
111762	butyl cellosolve (2-butoxyethanol) (egbe)		Yes												x				x										x		
108907	chlorobenzene		Yes											x																	
110827	cyclohexane		Yes								x				x		x						x	x			x				
75092	dichloromethane (methylene chloride)	Yes	Yes													x						x	x								
141786	ethyl acetate		Yes												x		x				x								x		
75003	ethyl chloride	Yes	Yes													x															
60297	ethyl ether		Yes																				x								
100414	ethylbenzene	Yes	Yes	x	x	x		x						x	x		x					x		x			x				
106934	ethylene dibromide	Yes	Yes																			x									
107211	ethylene glycol	Yes	Yes													x													x		
50000	formaldehyde	Yes	Yes	x	x		x		x	x	x													x		x	x				x
1330207	isomers of xylene	Yes	Yes												x		x	x	x				x				x		x		
98828	Isopropylbenzene (cumene)	Yes	Yes		x									x									x								
108383; 106423	m & p-xylene	Yes	Yes	x	x			x						x																	
67561	methyl alcohol	Yes	Yes		x																										
74873	methyl chloride	Yes	Yes													x															
78933	methyl ethyl ketone (2-butanone)		Yes												x		x			x	x	x	x						x		
108101	methyl isobutyl ketone	Yes	Yes												x		x			x	x								x		
1634044	methyl tert butyl ether (MTBE)	Yes	Yes																												x
108383	m-xylene	Yes	Yes			x																x					x				
91203	naphthalene	Yes	Yes	x	x									x									x								
71363	n-butyl alcohol		Yes													x															
142825	n-heptane		Yes	x	x	x		x		x		x	x	x	x		x	x	x		x	x	x	x			x				
110543	n-hexane	Yes	Yes			x		x	x	x			x	x									x	x			x				
95476	o-xylene	Yes	Yes	x	x	x		x						x	x		x	x	x				x	x			x				
127184	perchloroethylene		Yes																				x								
108952	phenol (carbolic acid)	Yes	Yes	x	x																										
85449	phthalic anhydride		Yes																			x									
123386	propionaldehyde	Yes		x	x		x																	x							
106423	p-xylene	Yes	Yes																			x	x	x							
100425	styrene	Yes	Yes	x	x									x																	
108883	toluene	Yes	Yes	x	x	x		x			x		x	x	x		x	x	x		x	x	x	x			x		x		
79016	trichloroethylene	Yes	Yes																				x								
76131	trichlorotrifluoroethane-F113		Yes																				x								
108054	vinyl acetate	Yes	Yes													x															

[a] Only the HAPs for which the MOBILE6 emissions rate model has programmed emissions factors are included in this listing.

4 EMISSION INVENTORIES

This section describes the recommended procedures to prepare emission inventories of airport-related OGs, including those compounds identified as either HAPs in the CAA and/or potentially toxic compounds in the IRIS database. Emission inventories provide estimates of the total amounts (or masses) of pollutants or pollutant precursors associated with an airport, a proposed project or action, or an individual emission source. In this section, procedures for speciating OGs are provided for the following airport-related sources:

- Aircraft engines,
- APUs,
- GSE,
- GAV, and
- Stationary sources (i.e., boilers, emergency generators, incinerators, training fires, aircraft engine testing, etc.).

A previously stated, the FAA is not currently recommending procedures to estimate speciated OGs (including HAPs) from non-road construction equipment and/or construction-related activities due to a lack of data for this source and activity. Additionally, speciated OG/HAP data for on-road (motor) vehicles should be obtained from the FAA's EDMS.

Because the primary topic of this document is speciated OG, the discussion and methodologies for obtaining/calculating the total mass of OG to be speciated is limited. If additional detail/information is required to develop this mass OG emission estimate for a particular source, analysts should refer to support documentation for the EDMS and/or the FAA's Air Quality Handbook (both can be obtained from FAA's website (www.FAA.gov)).

Airport operational functions can be conveniently divided between the airside (the restricted area of the airfield including runways, taxiways and aprons) and the landside (the public area of the airport including the terminal buildings, airport access/egress roadways and parking facilities).

On the airside, the airfield operational characteristics of primary significance to an air pollutant inventory are the number of aircraft operations (i.e., landings and takeoffs), the fleet makeup (i.e., commercial, GA, military), the aircraft engine types and the TIMs (i.e., approach, taxi/idle, takeoff, etc.). Some of these airfield data are available from airport planning and design documents. Other operational data for aircraft can be acquired from aircraft performance manuals or the EDMS. The GSE fleet, the types of APUs, their fuel types and operating times are also important to know when preparing an estimate of air pollutants. These data are often obtained from on-airport surveys and supplemented with information contained in the EDMS database.

On the landside, the volume of GAV, the fleet mix, engine type (i.e., gasoline or diesel), operating speed, and distances traveled play key roles in an air pollutant inventory. For fuel storage facilities, live-fire training equipment and other stationary sources, the fuel types (i.e., jet fuel, avgas, gasoline, etc.) and throughput volumes are important. Again, this information can be obtained from airport planning documents, on-site surveys, and be augmented with EDMS data.

Input Data, Assumptions and Limitations

The sources of the data and information, important limitations to the materials and any other elements of the airport or its environs that could have an effect on the outcome of the analysis should be recorded and discussed in the *Air Quality Analysis Protocol* (see Section 2.2.2).

The overall approach to preparing an emissions inventory of speciated OG should attempt to make use of airport-specific data/information wherever possible and utilize suitable substitutes, surrogates, and assumptions only to bridge gaps in the data/information. For these reasons, the documentation for any OG/HAPs inventory should include a thorough explanation of how the data were obtained or derived, why they are appropriate for the application, and what the potential limitations may be.

EDMS computes emission inventories of airport-related carbon monoxide, nitrogen oxides, sulfur oxides, OG and PM emissions. The current version (Version 5.1), also provides estimates of speciated OG**.** The following discusses the process used in the EDMS to speciate estimated OG for each of the airport-related sources. A case study, which demonstrates the procedures described in this guidance and used in the EDMS, is provided in **Appendix A**.

4.1 Aircraft Engines

Regardless of the type of aircraft engine (e.g., turbofan, turboprop, turbojet, piston), estimates of OG and speciated OGs for aircraft engines are derived using estimates of:

1) the fuel consumed in each aircraft operating modes (i.e., approach, takeoff, climbout, and taxi) which is a function of the fuel flow rate and the TIM, derived using a high-fidelity model within the EDMS (i.e., BADA, BFFM2) for each operating mode;
2) an OG emission index;
3) a factor that converts the estimated level of OG to TOG[14]; and
4) a speciation profile.

4.1.1 Fuel Consumption

To compute speciated OG for aircraft engines, the quantity of fuel consumed by aircraft type (e.g., Boeing 777-200) and operational mode (e.g., takeoff, climbout, etc.) are first calculated. The calculation to derive fuel consumption for an individual operational mode is provided in **Equation No. 1**.[15]

[14] The speciation profiles discussed in this document and provided in the companion spreadsheet to this guidance are representative of TOG emissions.
[15] Notably, THC emissions are greatest during the taxi and idle aircraft operational modes and emissions attributable to the approach and climbout modes will vary depending on the scenario specific atmospheric mixing height.

Equation No. 1:

Fuel Consumption By Aircraft Operational Mode

$$A_i \text{ x } B_i \text{ x } D = C_i$$

Where:
A = Fuel flow rate for operational mode per engine (kg/sec)
B = Time in operational mode (sec)
C = Total fuel consumed for operational mode (kg)
D =Number of engines
i = Operational mode of interest (approach, takeoff, climbout, taxi, etc.)

4.1.2 OG Emission Indices

Aircraft OG emission indices are specific to aircraft engine types and operational modes and are typically expressed in units of grams/1,000 kilograms of fuel consumed.[16] At the time of this writing, the FAA is finalizing a Recommended Best Practice for quantifying speciated OGs from aircraft equipped with turbofan, turbojet, and turboprop engines.[17] Analysts should refer to the final documentation for additional detail on the development of the OG speciation profile for these types of engines.

Using an OG emission index specific to the operational mode of interest and the results from **Equation No. 1** for the mode of interest, estimates of the mass of OG are derived as shown in **Equation No. 2**:

Equation No. 2:

Estimated Mass of OG

$$C_i \text{ x } D_i \text{ x } 1/453.6 = E_i$$

Where:
C = Total fuel consumed for operational mode (kg)
D = THC emission index obtained from EDMS (g/1000 kg of fuel consumed)
E = Mass of OG (lbs)
i = Operational mode of interest (approach, takeoff, climbout, and taxi)
1/453.6 = g to lbs conversion factor

Equations No. 1 and 2 should be used to calculate the estimated mass of OG for each of the aircraft operational modes (i.e., approach, takeoff, etc.) and the results summed to derive the total mass of OG attributable to an entire aircraft landing-takeoff cycle.

[16] Emission indices can be obtained from the EDMS and/or ICAO database.
[17] *Recommended Best Practice for Quantifying Speciated Gas-Phase Hydrocarbon Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, FAA, EPA August 5, 2008 (Draft)

4.1.3 Conversion Factors

The speciation profiles included in the EDMS database for the purpose of preparing airport-related inventories of speciated OGs/HAPs are representative of TOG. Therefore, before applying the speciation profile data to a mass estimates of OG, the OG must first be converted to TOG. This application is detailed in **Equation No. 3**.

Equation No. 3: **Conversion to TOG** *E x F = G* *Where:* *E = Mass of OG emissions (lbs)* *F = TOG conversion factor (unitless)* *G = Mass of TOG (lbs)*

4.1.4 Applying Speciation Profile Data

To speciate the mass of TOG emissions, air quality practitioners obtain the latest speciation profile data and derive the levels of individual OGs by multiplying the profile values by the total amount of TOG (these values are also included in the EDMS). Notably, with respect to aircraft engines, the FAA intends to collaborate with EPA to update the profiles in EDMS as subsequent validated and verified aircraft engine test data becomes available.

Using a speciation profile specific to the type of engine being considered, the calculation for obtaining the estimated level of an individual OG/HAP is provided in **Equation No. 4**.

Equation No. 4: **Speciated OG Emissions - Aircraft** *G x H = I* *Where:* *G = Mass of TOG (lbs)* *H= Speciation profile for individual OG of interest (mass fraction)* *I= Mass of OG of interest (lbs)*

4.2 APUs

With one exception, the procedure for calculating speciated OG for an APU is the same as the procedure used to calculate the amount of speciated OG for an aircraft engine. For APUs, the amount of fuel consumed is not based on the amount of time in each of the aircraft operational modes. Rather, the amount of fuel consumed is based on the run time of an APU prior to engine start up on departure and the run time after an aircraft engine is shut down on arrival and, if available, connected to ground power at an airport. Notably, if ground power is not available, an APU may be used the entire time an aircraft is at an airport's gate (if passenger comfort is a concern).

The required data input to obtain an estimate of a speciated OG for an APU is:

1) the APU run time (for a complete landing-takeoff cycle);
2) an OG emission index specific to the APU model;
3) a factor that converts the estimated level of OG to TOG; and
4) a speciation profile.

Equation No. 5 demonstrates how to derive a speciated OG emission for an APU.

Equation No. 5:

Speciated OG Emissions - APU

$$A \times B \times D \times F \times H \times 1/453.6 = I$$

Where:
A = Number of LTO cycles performed by assigned aircraft
B = Time in operation (sec)
D = OG emission index (g/kg fuel consumed)
F = TOG conversion factor (unitless)
H= Speciation profile for individual OG of interest (mass fraction)
I= Mass of OG of interest (lbs)
1/453.6 = g to lbs conversion factor

4.3 GSE

For conventional and alternatively fueled GSE, the factors that determine the amount of speciated OG are:

1) the brake horsepower of the equipment;
2) the load factor;
3) equipment usage (equipment operating time);
4) OG emission indices;
5) a TOG conversion factor specific to the equipment fuel type; and
6) a speciation profile that is also specific to the fuel type.

Equation No. 6 can be used to calculate the pollutant emissions from an individual piece (or type) of equipment.

Equation No. 6:

Speciated OG Emissions - GSE

$$L \times M \times B \times D \times F \times H \times 1/453.6 \times 1/60 = I$$

Where:
L = Average rated brake horsepower
M = Load factor (percentage)
B = Time in operation (min)
D = OG emissions index (g/hp-hr)
F = TOG conversion factor (unitless)
H= Speciation profile for individual OG of interest (mass fraction)
I = Mass of OG of interest (lbs)
1/453.6 = g to lbs conversion factor
1/60 = min to hr conversion factor

4.4 GAVs

EPA's MOBILE6.2 emission rate model provides both exhaust and evaporative emission indices for six OGs that the EPA considers the most common HAPs associated with highway motor vehicles[18] [EPA, 2002b,c]. The MOBILE6.2 output is expressed in units of grams/vehicle-mile and can be segregated by vehicle type (e.g., light duty gas, heavy duty diesel, etc.) or combined into a composite value representative of the entire ground access vehicle fleet. MOBILE6.2 also allows the user to enter ratios for other substances that are not among the six pollutants pre-coded into the model.[19] For OGs, these ratios are expressed as fractions of VOC or TOG.

MOBILE6.2 reports highway motor vehicle emission rates in grams or milligrams of pollutant per vehicle mile traveled. These emission rates, when considered with estimates of travel activity (vehicle-miles-traveled or VMT), provide estimates of the mass of OG. The mass of OG is then converted to TOG and speciated as shown in **Equation No. 7.**

Equation No. 7:

Speciated OG Emissions - Ground Access Vehicles

$$D \times N \times F \times H \times 1/453.6 = I$$

Where:
D = OG emission index (g/mi)
N = Vehicle-miles-traveled (mi)
F = TOG conversion factor (unitless)
H= Speciation profile for individual OG of interest (mass fraction)
I = Mass of OG of interest (lbs)
1/453.6 = g to lbs conversion factor

[18] The six HAPs are: 1,3-butadiene, acetaldehyde, acrolein, benzene, formaldehyde and methyl tertiary butyl ether.
[19] The additional HAPs include: naphthalene, styrene, toluene, xylene, and ethylbenzene.

Notably, the EPA is currently developing a new motor vehicle emission rate model, Mobile Vehicle Emission Simulator (MOVES). Like MOBILE, the MOVES model will also provide emission indices for some OGs. When appropriate, the FAA will incorporate MOVES in to the EDMS.

4.5 Stationary Sources

Airport-related stationary sources of HAPs include a variety of sources including power generators, steam boilers, space heaters, engine test facilities, and other aviation-related industrial sources (solvent decreasing, paint booths, etc.). Live-fire training facilities and fuel storage/transfer facilities are also considered to be stationary sources. In nearly all cases, the types and amounts of HAPs emitted by these sources depend on the type and quantity of the fuel used, operating times, and the existence of emission control equipment.

Some stationary sources may be regulated under Section 112 (*Hazardous Air Pollutants*) of the CAA. Depending on the types and amounts of HAPs emitted, they are potentially subject to the permitting and discharge limitations of the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) program. As a result, speciated OG/HAPs emissions data may already exist for some sources (in their operational permits).

The calculation input for stationary sources is generally the same regardless of the type of source (data units may vary). Generally, the required input is:

1) the throughput of the fuel/paint/solvent/deicing fluid used (where applicable, the required input equals the diluted amount of the fluid) ;
2) an OG emission index;
3) a factor that converts the estimated level of OG to TOG; and
4) a speciation profile.

4.5.1 Combustion Sources

Potential airport-related stationary combustion sources are boilers/space heaters, emergency generators, incinerators, fire training facilities, and aircraft engine testing. The data required to prepare an emission inventory of speciated OG for these sources are:

1) the amount of fuel consumed over a given time period;
2) a THC emission index for the type of fuel;
3) a THC-to-TOG conversion factor; and
4) a speciation profile.

Equation No. 8 provides an estimate of speciated OG/HAP emissions for an individual stationary combustion source.

Equation No. 8:

Speciated OG Emissions - Stationary Combustion Sources

$$C \times D \times F \times H = I$$

Where:
C = Total fuel consumed (e.g., gallons, million cubic feet, or tons)
D =THC emission index ((e.g., lbs / gal, lbs/million cubic feet, or lbs /ton)
F = TOG conversion factor (unitless)
H = Speciation Profile for individual OG of interest (mass fraction)
I = Mass of OG of interest (lbs)

4.5.2 Non-Combustion Sources

Airport-related non-combustion stationary sources are fuel storage tanks, coating and painting operations, deicing, and the use of solvent degreasers. While the final steps in preparing an estimate of speciated OG/HAP emissions remains the same for each source (apply a conversion factor and speciation profile data), the methodologies for calculating the amount of THC vary.

4.5.2.1 Fuel Storage Tanks

Fuel storage and the handling of jet and diesel fuel does not produce significant OG/HAP emissions because these fuels have a relatively low vapor pressure and the emissions remain well confined within the containment vessels and the distribution system. However, OG emissions from Avgas and gasoline storage can be more significant as their vapor pressures are higher than that of jet and diesel fuel. To estimate speciated OG emissions from storage tanks, the data required are:

1) an estimate of the standing storage and working OG emissions[20];
2) a conversion factor; and
3) a speciation profile.

Estimates of OG and the resultant levels of speciated OG from this source will vary depending on the type of fuel that is stored (e.g., gasoline, jet kerosene, etc.). The general methodology for calculating storage tank OG emissions (including speciated OG emissions) is expressed in **Equation No. 9**:

[20] Estimates of standing storage and working HC emissions may be obtained from EDMS, the EPA's TANKS program, and/or using methodologies described in Section 7.1 of Volume I of *Compilation of Air Pollutant Emission Factors*. Information specific to the type of tank (i.e., fixed or floating roof) may be obtained from the airport operator, fueling contractor, or by visual inspection.

Equation No. 9:

Speciated OG Emissions - Fuel Storage Tanks

$$(O + P) \times F \times H = I$$

Where:
O = Standing storage emissions (lbs)
P = Working storage emissions (lbs)
F = TOG conversion factor (unitless)
H = Speciation profile for individual OG of interest (mass fraction)
I = Mass of OG of interest (lbs)

4.5.2.2 Coating and Painting Operations

Emissions of OGs/HAPs from coating and painting activities (use of enamel, primer, varnish, adhesive, etc.) vary depending if air pollutant control measures can/are used and, if so, the type of control measure. **Equation No. 10** provides the general method of calculating and then speciating OG emissions from this source.

Equation No. 10:

Speciated OG Emissions - Coating/Painting Operations

$$Q \times R \times S \times F \times H = I$$

Where:
Q = Quantity of Coating/Paint (gallons)
R = VOC content (lb VOC/gallon)
S = Air pollutant control factor (percentage)
F = TOG conversion factor (unitless)
H = Speciation profile for individual OG of interest (mass fraction)
I = Mass of OG of interest (lbs)

4.5.2.3 Deicing Activities

The level of speciated OG emissions from deicing activities varies depending on the specific chemical present in the deicing fluid (i.e., propylene glycol, ethylene glycol, or other organic compounds) and the amount of diluted fluid used. **Equation No. 11** expresses the methodology for deriving and speciating OG emissions from deicing activities (aircraft or runway).

Equation No. 11:

Speciated OG Emissions - Deicing

$$Q \times T \times U \times D \times F \times H = I$$

Where:
Q = Quantity of Deicing Fluid (gallons)
T = Density of Deicing Fluid (lbs/gallon)
U = Concentration of deicing chemical (percent by weight/100)
D = THC emission index (lbs/lb of chemical consumed)
F = TOG conversion factor (unitless)
H = Speciation profile for individual OG of interest (mass fraction)
I = Mass of HC of interest (lbs)

4.5.2.4 Solvent Degreasers

Emissions of OGs/HAPs that result from the use of organic solvents are estimated by calculating the difference between the volume of solvent consumed and the liquid volume disposed, and then multiplying this difference by the density of the solvent. The resultant emissions are then speciated as shown in **Equation No. 12**:

Equation No. 12:

Speciated OG Emissions – Solvent Degreaser

$$(Q - V) \times T \times F \times H = I$$

Where:
Q = Quantity of solvent consumed (gallons)
V = Quantify of solvent disposed of (gallons)
T = Density of solvent (lbs/gallon)
F = TOG conversion factor (unitless)
H = Speciation profile for individual OG of interest (mass fraction)
I = Mass of OG of interest (lbs)

4.6 Presentation of Results

The outcome of the emissions inventory provides an estimation of the amount of OGs/HAPs generated by the airport, the airport project/action or the individual source. For consistency with the criteria air pollutant emissions inventory, the results are expressed in units of tons/year, pounds/day or as equivalent metric system units. However, because the output data can be overly complex and voluminous, they are most conveniently presented in tabular form, arranged according to the individual OG/HAP selected as pertinent to the inventory, and emission source. **Table 4** provides a sample template for presenting the data.

Table 4
Recommended Tabular Format for Reporting
Estimated Airport OG, by Pollutant and Source
(tons/year)

Pollutant	**Sources**				**Totals**
	Aircraft	**GSE**	**GAV**	**Other**	
Formaldehyde	39.21	7.51	15.71	0.07	62.50
Acetaldehyde	1.71	3.22	6.22	0.01	11.16
Benzene	6.32	7.42	28.31	0.02	42.07
Toluene	3.22	4.14	23.21	0.01	30.58

Depending on the purpose and scope of the assessment, the results can be further segregated by inventory year, airport operational level or project alternative.

For reviewing purposes, the results should be accompanied by:

1) Summary explanations of how the inventory was conducted (information and data sources, major assumptions, computational methods);
2) How the results are interpreted or compared (between alternatives or any applicable significance criteria); and
3) Any significant limitations to the understanding and application of the outcome.

5 SUMMARY

Inventories of airport-related speciated OGs (which include the OGs identified by the EPA to be HAPs and the OGs listed in the EPA's IRIS) are not required by current EPA regulations. In cases where it is necessary to prepare such an airport-related inventory, the inventory must be prepared following the approach described in this document to ensure consistency. The following summarizes the main points of these guidelines with respect to preparing/reporting an airport-related OG/HAP emission inventory:

- Airport-related OG inventories are to be prepared using the most current version of FAA's EDMS model.
- If conditions warrant that an inventory be prepared, EAs and EISs should only report emission levels for the airport-related OGs identified in Section 112 of the CAA (as amended) as being a HAP and/or included in the EPA's IRIS database.
- EIS documents must include project/action-related OG/HAP emission inventories if an EIS must also include an emissions inventory of criteria air pollutant emissions or the precursors to the criteria air pollutants.
- EA documents must only include OG inventories if one of the following conditions is met:
    - The proposed project/action is "major" (e.g., a new airport or heliport, a new runway) and the level of operations/level of activity at the airport is such that the proposed project/action could result in more than a minimal change in the type/level of OG/HAP emissions, or
    - The airport is in an area that is designated by the EPA to be non-attainment or maintenance for either ozone, particulate matter 10 microns or less in diameter, or particulate matter 2.5 microns or less in diameter, or
- The EA/EIS reporting requirements with respect to OGs/HAPs are limited to emission inventories only. No other assessment methodologies, including methodologies that involve dispersion, toxicity weighting, exposure, and/or health risk quantifications, should be undertaken--except when required by CEQA.

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APPENDIX A

Example Case Study for Preparing an Emission Inventory of Airport-Related Speciated OGs

1. Introduction

This case study is provided as an instructional aid for preparing a speciated OG emission inventory for an airport. For this demonstration, two types of aircraft/engine combinations and one stationary source (a boiler) are inventoried. For the purpose of this case study, the list of speciated OG is limited to only two compounds--benzene and formaldehyde.

Notably, while the intent of this case study is to provide methodologies, formulae, and results that mirror those within or that would be provided by the EDMS, for certain sources (e.g., aircraft), the results presented in this example case study cannot be recreated in EDMS due to the complexity of the calculations that are used in the EDMS to derive emission estimates..

2. Aircraft Data, Calculations, and Emissions

This case study assumes that an analyst is charged with estimating airport-related OG for an Airbus A320-100 aircraft equipped with two CFM56-5A1 (turbofan) engines[21] and a Cessna 150 aircraft equipped with one Continental 0-200 (piston) engine. Over the time period of interest, there will be 20,000 and 5,000 LTO cycles for the A320-100 and Cessna 150, respectively. Additionally, based on the configuration of the airport and in-the-field surveys, each aircraft type has a combined taxi/idle (delay) time of 26 minutes per LTO (EDMS default times-in-mode for approach, takeoff, and climbout are assumed for the other operational modes). **Table A-1** summarizes the aircraft-related data for this case study.

Table A-1
Aircraft: Case Study Data

Aircraft	Aircraft Type	Engine	Number of Engines	Number of LTO's[a]	Time in Mode	
					Mode	Time (min)
Airbus A320-100	Turbofan	CFM56-5A1	2	20,000	Taxi/Idle	26.00
					Approach	4.12
					Takeoff	1.51
					Climbout	0.53
Cessna 150	Piston	0-200	1	5,000	Taxi/Idle	26.00
					Approach	4.45
					Takeoff	5.69
					Climbout	3.20

[a] LTO = Landing and takeoff cycle (one LTO is equal to one arrival plus one departure).

[21] It is recognized that A320-100 aircraft typically operate with APUs which also emit OG. However, for the purposes of this case study, emissions from APUs were not calculated.

The first step is to estimate the total mass of OG emitted by the aircraft--a value that is calculated using fuel flow rates and OG emission indices that are specific to the type of engine and operational mode.[22] Using the base data (number of engines, number of LTOs, times-in-mode), and the fuel flow rate, the total fuel consumed is calculated as discussed in Section 4.1 of this document and detailed in **Equation No. 1** (reproduced below for convenience).

Equation No. 1:

Fuel Consumption By Aircraft Operational Mode

$$A_i \ x \ B_i \ x \ D = C_i$$

Where:
A = Fuel flow rate for operational mode per engine (kg/sec)
B = Time in operational mode (sec)
C = Fuel consumed per operational mode (kg)
D = Number of engines
i = Operational mode of interest (approach, takeoff, climbout, taxi, etc.)

The fuel flow rates for the aircraft in this case study and the calculated total fuel consumed by each aircraft in each operational mode is provided in **Table A-2**.

Table A-2
Aircraft: Fuel Usage Rates and Fuel Consumption Summary

Aircraft	Engine Model/ Number of Engines	Fuel Consumption		Time in Mode (min)	Fuel Consumption/ LTO (kg)
		Operational Mode	Rate/ Engine[a] (kg/sec)		
A320-100 (Turbofan)	CFM56-5A1/ 2	Taxi/Idle	0.105319	26.00	328.60
		Approach	0.052100	4.12	25.76
		Takeoff	1.598940	1.51	289.73
		Climbout	1.139159	0.53	72.45
Cessna 150	0-200 / 1	Taxi/Idle	0.001083	26.00	1.69
		Approach	0.003217	4.45	0.86
		Takeoff	0.003217	5.69	1.10
		Climbout	0.003217	3.20	0.62
[a] For illustrative purposes, the fuel flow rates are EDMS “Step 1” rates.					

To obtain the final estimate of the total OG mass, emission indices, specific to each aircraft operational mode, are multiplied times the amount of fuel consumed in each operational mode. This procedure is detailed in **Equation 2** (repeated below). The fuel consumed (repeated from Table B-2), the OG emission indices (obtained from the EDMS), and resultant amounts of mass

[22] The EDMS provides both aircraft fuel flow rates and HC emission indices.

OG emitted by the aircraft in this case study are provided in **Table A-3** (estimates of mass OG are provided for a single LTO and for all LTOs evaluated for a particular aircraft).

Equation No. 2:

Estimated Mass of OG

$$C_i \times D_i \times 1/453.6 = E_i$$

Where:
C = Total fuel consumed for operational mode (kg)
D = OG emission index (g/kg of fuel consumed)
E = Mass of OG (lbs)
i = Operational mode of interest (approach, takeoff, climbout, taxi, etc.)
1/453.6 = g to lbs conversion factor

Table A-3
Aircraft: Fuel Usage Rates and Total Fuel Consumption Summary

Aircraft	Engine Model/ Number of Engines	Fuel Consumption		OG Emission Indices (g/kg) [a]	Mass OG/LTO (lbs)
		Operational Mode	Per LTO (kg)		
A320-100 (Turbofan)	CFM56-5A1 / 2	Taxi/Idle	328.60	1.475004	1.07
		Approach	25.76	1.541144	0.09
		Takeoff	289.73	0.242322	0.15
		Climbout	72.45	0.247953	0.04
Total/LTO					1.35
Total Mass OG: A320-100 - 20,000 LTOs					27,000
Cessna 150 (Piston)	0-200 / 1	Taxi/Idle	1.69	30.553653	0.11
		Approach	0.86	34.489826	0.07
		Takeoff	1.10	33.932279	0.08
		Climbout	0.62	34.077689	0.05
Total OG/LTO					0.31
Total Mass OG: Cessna 150 - 5,000 LTOs					1,550
[a] For illustrative purposes, OG emission indices are EDMS “Step 1” indices.					

The emission indices obtained from EDMS are representative of THC as shown in **Equation 3** using simple multiplication.

Equation No. 3:

Conversion to TOG

$$E \times F = G$$

Where:
E = Mass OG emissions (lbs)
F = TOG conversion factor (unitless)
G = Mass TOG (lbs)

The THC-to-TOG conversion factor for turboprop aircraft is 1.16 and the THC-to-TOG conversion factor for piston aircraft is 0.90 (analysts should always verify that they have the latest speciation profile and conversion factor data before completing any evaluation). These conversion factors and the resultant amount of TOG from each aircraft are provided in **Table A-4.**

Table A-4
Aircraft: Estimated TOG

Aircraft/Engine	Mass OG (lbs)	THC-to-TOG Conversion Factors	Mass TOG (lbs)
A320-100 / CFM56-5A1/2	27,000	1.16	31,320
Cessna 150 / 0-200	1,550	0.90	1,395

The final step in estimating emissions of benzene and formaldehyde is to apply the mass fractions obtained from the appropriate speciation profiles for these particular compounds (**Equation No 4** repeated below). The mass fractions for benzene and formaldehyde from the speciation profiles for turbofan and piston engines are provided in **Table A-5**.

Equation No. 4:

Speciated OG Emissions - Aircraft

$$G \times H = I$$

Where:
G = Mass TOG (lbs)
H= Speciation profile for OG of interest (mass fraction)
I= Mass of OG of interest (lbs)

Table A-5
Aircraft: Mass Fractions and Estimates of Speciated OGs

Aircraft/Engine	Mass TOG (lbs)	Speciation Profile	Speciation Profile (mass fraction)		Estimated Speciated OG (lbs)	
			Benzene	Formaldehyde	Benzene	Formaldehyde
A320-100 / CFM56-5A1/2	31,320	Turbofan, turbojet, and turboprop aircraft	0.01681	0.12308	526	3855
Cessna 150 / 0-200	1,395	Piston aircraft	0.0179	0.1414	25	197
Total					551	4,052

3. Boiler Data, Calculations, and Emissions

This case study assumes that an analyst is charged with estimating airport-related OG for a boiler fueled by natural gas. To estimate speciated OG emissions for the boiler, a stationary combustion source, the required data (repeated from Section 3.5.1 of this guidance) is 1) the amount of fuel consumed over the time period of interest, 2) an OG emission index, 3) a conversion factor (if applicable), and 4) a speciation profile.

During the evaluated year, 20,000 cubic meters of natural gas are used to fuel the boiler. The OG emission index for a natural gas boiler is 0.18 kilograms per 1,000 cubic meters of natural gas burned. This OG emission index is representative of THC. As such, a factor (2.27) is required to convert the VOC to TOG prior to applying the speciation profile mass fractions for benzene (0.04) and formaldehyde (0.08) to the mass OG estimate. The required operational and other data is summarized in **Table A-6**.

Table A-6
Boiler: Case Study Data

Item		Factor
Natural Gas Burned		20,000 cubic meters
Emission Index		0.18 kilograms of THC/1,000 cubic meters of natural gas burned
Speciation Profile (mass fractions)	Benzene	0.04
	Formaldehyde	0.08

Equation No. 8 (repeated below) provides an estimate of speciated OG emissions from the natural gas boiler. Using this calculation, the estimated amounts of benzene and formaldehyde emitted by the boiler are 0.072 lbs and 1.44 lbs, respectively (e.g., benzene = 20,000 cubic meters x 0.18 kilograms/1000 cubic meters x 2.27 x 0.04 x 2.2046 (conversion from kilograms to lbs) = 0.72 lbs).

Equation No. 8:

Speciated OG Emissions - Stationary Combustion Sources

$$C \times D \times F \times H = I$$

Where:
C = Total fuel consumed (e.g., gallons, million cubic feet, or tons)
D = OG emission index ((e.g., lbs / gal, lbs/million cubic feet, or lbs /ton)
F = TOG conversion factor (unitless)
H = Speciation profile for OG of interest (mass fraction)
I = Mass of OG of interest (lbs)

4. Reporting the Results

Depending on the magnitude of the emissions, estimate levels of individual OG could be reported as lbs/year or tons/year (or a metric equivalent). For the purpose of this case study, **Table A-7** presents the estimate levels of the speciated OG for the evaluated aircraft and the boiler in tons/year. As stated in the main body of this guidance, depending on the purpose and scope of the project, the results can be further segregated by inventory year, airport operational level, or individual project.

Table A-7
Case Study Estimated OG, by Pollutant and Source
(tons/year)

Pollutant	Sources		Total
	Aircraft	Stationary	
Benzene	<1	<1	<1
Formaldehyde	2	<1	2

APPENDIX B

DEFINITIONS

Term	Definition
Aircraft engine standards	Requirements controlling the fuel efficiency and emissions characteristics of aircraft engines.
Aircraft fleet mix	Represents the types of airframes and assigned engines in use at an airport or aviation facility.
Airport-related emissions inventories	A listing, by source, of the amount of air pollutants discharged into the atmosphere of a community; used to establish emission standards.
Airside	The area of an airport property within which aircraft operations occur, including gates, services areas, cargo facilities, etc.
Atmospheric photochemical reactions	Reactions that occur in the atmosphere that convert compounds to different forms in the presence of sunlight. For example, NOx reacts with VOC in the presence of sunlight to form Ozone.
Auxiliary power units	Small on-board engines on an aircraft used to power the craft when normal engines are powered down, such as when the aircraft is at the terminal gate or queued for take-off
Conversion factor	A number used to convert one series of units to another.
Build alternative	One of a series of implementation options of a proposed project.
Emission standards	The maximum amount of air polluting discharge legally allowed from a single source, mobile or stationary.
Environmental assessment	An environmental analysis prepared pursuant to the National Environmental Policy Act to determine whether a federal action would significantly affect the environment and thus require a more detailed environmental impact statement.
Environmental impacts	The results of a proposed action that alter the quality or nature of the environment surrounding the area.
Environmental impact statement	A document required of federal agencies by the National Environmental Policy Act for major projects or legislative proposals significantly affecting the environment. A tool for decision making, it describes the positive and negative effects of the undertaking and cites alternative actions.
Flame ionization detector	A device that measures the number of atoms in a specific chemical species to determine its mass. The precision by which this device measures oxygenated species is low, resulting in the reporting of inaccurate masses.
Greenhouse gas	A gas, such as carbon dioxide or methane, which contributes to potential climate change.
Ground access vehicles	Public and private on-road motor vehicles traversing the airport property and surrounding roadways.
Ground support equipment	Non-road motor vehicles, such as baggage tractors and aircraft tugs, used to service and move aircraft at the gate and on the airside.
Hazardous Air Pollutants	Air pollutants which are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride.
Health risk quantifications	The results of a human health risk assessment by which air emissions have been prioritized, using toxicity weighting, in terms of potential detriment to human health.
Human health risk	The likelihood that a given exposure or series of exposures may have damaged or will damage the health of individuals.
Landside	The area of an airport property intended for public use, through which airport patrons are allowed to travel.

Term	Definition
Low reactivity compounds	Compounds that do not readily react with other chemicals under standard atmospheric and environmental conditions.
National Ambient Air Quality Standards	Standards established by EPA that apply for outdoor air throughout the country.
No-action alternative	The alternative when evaluating a proposed project, that represents the conditions if the project were not to occur.
Non-attainment	Area that does not meet one or more of the National Ambient Air Quality Standards for the criteria pollutants designated in the Clean Air Act.
Operational modes	The divisions within a cycle of operation. For example, the modes of operation within an aircraft LTO cycle include landing, take-off, climb-out, approach, etc.
Organic compounds	Naturally occurring (animal or plant-produced or synthetic) substances containing mainly carbon, hydrogen, nitrogen, and oxygen.
Plume emissions	The cloud of pollutants emitted from the exit plane of an emissions source (i.e. exhaust from a tail pipe)
Plume evolution	The process by which a cloud, or plume, of emissions travels from its source and disperses vertically and laterally in the ambient air.
SPECIATE data quality ratings	A rating scheme developed to assess the completeness, accuracy, validity and utility of data in the SPECIATE database.
Speciated Organic Gas	A single chemical species in an emissions plume whose mass has been derived based on the total mass of the plume.
Speciation profiles	A representation of the mass contribution of a single pollutant relative to the total mass of pollutants in an emissions plume.
Stationary source	A fixed-site producer of pollution, mainly power plants and other facilities using industrial combustion processes.
Surrogate data sources	Data that is used as a proxy for one or more parameters when the parameter(s) are otherwise missing.
Toxicity weighting	The process by which factors are applied to air emissions during health risk assessments, to prioritize those compounds that have documented negative impacts on human health.
Unit risk values and reference concentrations	Factors evaluated when performing toxicity weighting in human health risk assessments
Volatile organic compounds	Any organic compound that participates in atmospheric photochemical reactions except those designated by EPA as having negligible photochemical reactivity.