# FAA's Airport Air Quality Model: Aviation Sector's Tool for Analysis of Criteria and Hazardous Pollutants


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## ABSTRACT

The Federal Aviation Administration (FAA) requires the use of the Emissions and Dispersion Modeling System (EDMS) for air quality analyses of airport emission sources (63FR18068)[1]. Such an analysis may include an emissions inventory and/or a dispersion analysis for both aviation and non-aviation sources at the airport. The FAA considers aviation sources to include aircraft, auxiliary power units and ground support equipment. EDMS also offers the capability to model other airport emission sources that are not aviation-specific, such as power plants, fuel storage tanks and ground access vehicles.

This paper presents recent model development activities and those planned for the near future. The latest publicly available model version is EDMS5.1, and includes significant enhancements such as: replication of real aircraft movements, estimation of emissions of speciated TOG (including known hazardous air pollutants) and $PM_{2.5}$ for all airport emission sources and $CO_2$ emissions from aircraft activities within the landing take off (LTO) cycle; interface to MOBILE version 6.2; databases and methodology for NONROAD source emissions and the latest versions of AERMET, AERMOD and AERMAP. EDMS has also been configured to provide digital outputs for enhanced data analysis and tabulation.

In the next 3 years, the FAA plans to replace EDMS with the Aviation Environmental Design Tool (AEDT), a comprehensive software compliance tool to assess the interdependencies between aviation-related noise, criteria/HAPs/GHG emissions, and fuel consumption. For this transition, FAA will work closely with EPA to ensure that MOBILE and NONROAD capabilities are replaced by the MOVES model for ground-based mobile source emissions and fuel consumption.


## INTRODUCTION

The Federal Aviation Administration (FAA) originally developed the Emissions and Dispersion Modeling System (EDMS) in the mid-1980s as a complex source model capable of quantifying changes in pollutant emissions and ambient pollutant concentrations due to proposed airport projects. EDMS was accepted as an U.S. Environmental Protection Agency (USEPA) "Preferred Guideline" model in 1993 under

Title 40 CFR part 51 Appendix W. In 2005 the FAA and USEPA recognized that EDMS utilizes a suite of stand alone compliance models already listed in the "Preferred Guideline" such as MOBILE6.2, NONROAD, AERMOD, AERMET, and AERMAP. Consequently, EDMS was relocated to section 6.2.4 "*Modeling Guidance for Other Governmental Programs*" in 40CFR51 Appendix W to coincide with FAA's policy that EDMS is the required model to assess changes in airport emissions and air pollutant concentrations from airport development projects as well as for routine air quality analysis related to emissions from airport activities involving aviation sources (63FR18068)[1], which include aircraft, auxiliary power units (APU) and ground support equipment (GSE)[2].

This paper presents recent EDMS model development activities[3] and provides a summary of FAA's plan to replace EDMS with an integrated noise and emissions model called the Aviation Environmental Design Tool (AEDT).[4]

## WHAT DOES EDMS DO?

EDMS is a multiple emissions source model that calculates total airport emissions that vary both in space and time. The four dimensional approach allows for airport emissions to be dispersed for compliance demonstrations with local and national ambient air quality standards.

### Emissions Inventories

EDMS can be used to create an emissions inventory for any individual airport emission source or combination of emission sources. To create an aircraft emissions inventory, the modeler inputs the aircraft fleet present at an airport and the number of landing and takeoff (LTO) cycles for each aircraft within the timeline of the desired study period. The modeler can specify each aircraft's taxi and queue time, as well as the takeoff weight and approach glide slope angle, which are used in conjunction with meteorological data to determine the aircraft's trajectory. The aircraft performance calculations originate from methodology presented in the Society of Automotive Engineers (SAE) Aerospace Information Report (AIR) 1845[5] and account for aircraft-engine specific performance. Similar to aircraft, the modeler has the ability to define and include adjunct APU and GSE activity, roadway traffic, parking lot throughput, and stationary source and training fire operations.

EDMS includes emission factors for the various airport sources. For example, it incorporates all aircraft engine emissions data contained in the most recent version of the International Civil Aviation Organization's (ICAO) Engine Exhaust Emissions Data Bank[6], representing over two-thirds of EDMS's aircraft engine emissions data. The remaining third of EDMS's aircraft engine emission data originate from U.S. military reports, shared manufacturer data, and USEPA documents.[7,8] Since January 2007, EDMS has utilized ICAO's refined First Order Approximation version 3.0 (FOA3) for aircraft particulate matter (PM) emissions[9]. GSE emissions are derived from emission factors from the latest version of USEPA's NONROAD[10] model. EDMS also includes USEPA's on-road models: PART5[11], MOBILE5a, MOBILE5b[12] and MOBILE6.2[13].

**Dispersion Analyses**

For dispersion analyses, EDMS generates input files to be processed by USEPA's AERMOD[14], which has been bundled with EDMS since May 2001. Currently, EDMS5.1 uses AERMOD build 04300 which became USEPA's promulgated, preferred air dispersion model on December 9th, 2005[15]. The manner in which AERMOD is applied by EDMS is based on guidance from the American Meteorological Society/USEPA Regulatory Model Improvement Committee (AERMIC), which is responsible for developing AERMOD and introducing state-of-the-art modeling concepts into USEPA local-scale air quality models.

AERMOD is a steady-state plume model, but has many state-of-the-art improvements. AERMOD has better characterization of the planetary boundary layer (PBL) and allows dispersion to be accomplished using continuous functions rather than with discrete stability classes that do not change with height. Instead of a Gaussian distribution for both the horizontal and vertical directions, AERMOD uses a bi-Gaussian probability density function to characterize the dispersion in the vertical direction. Additionally, AERMOD incorporates a new method to model airflow and dispersion in complex terrain.

AERMOD can be run from within EDMS, however the user may choose to run AERMOD external to EDMS with the generated input files. Because AERMOD requires both surface and upper air meteorological data, AERMET is also bundled with EDMS. AERMET is AERMOD's meteorological preprocessor which transforms many different formats of "raw" weather data into an "AERMOD-ready" format. Similar to AERMOD, AERMET can be run either internally or externally to EDMS. EDMS also includes an interface to AERMAP, the terrain processor for AERMOD. Once the dispersion analysis is initiated within EDMS, the execution and control of AERMET, AERMAP and AERMOD is entirely transparent to the user.

## EDMS SOURCES AND POLLUTANTS

The current version EDMS5.1 quantifies total airport emissions from all sources within airport environs. This includes aircraft main thrust engines, APUs, GSE, mobile surface transportation sources on roadways and parking facilities, boilers, fuel storage tanks, emergency generators, and training fires. The pollutants quantified are NOx, CO, VOC, NMHC, total organic gases (TOG), SOx, $PM_{10}$, $PM_{2.5}$, and up to 400 individual speciated hydrocarbons including up to 44 known hazardous air pollutants (HAPs) across all airport emission sources. Speciated hydrocarbon profiles for all airport emission sources were obtained from the latest version of the USEPA's SPECIATE database, with the exception of turbofan, turbojet, and turboprop aircraft engines (see below). In addition, fuel burn and $CO_2$ emissions are quantified for aircraft engines only.

Lead (Pb) is a criteria pollutant that is emitted from small general aviation (GA) aircraft that employ piston engines fueled by aviation gasoline that includes a leaded anti-knock additive (also known as "100LL" meaning 100 octane low lead). EDMS5.1 does not report Pb emissions directly, but many practitioners calculate Pb emissions as a post-processing step to running EDMS5.1. They use EDMS5.1's fuel consumption information (only for GA aircraft piston engines that run on aviation 100LL) coupled with assumptions of how much Pb is in the fuel and how much Pb remains in the engine.

**HAPs Emissions for Turbofan, Turbojet, and Turboprop Engines**
The FAA and the USEPA, with assistance and review from the California Air Resources Board, recently collaborated on a unique speciated hydrocarbon profile for turbofan, turbojet, and turboprop aircraft engines by combining four recent measurement campaigns with an existing commercial aircraft profile from the 1980s. The measurement data were direct exhaust measurements made by the scientific community and the USEPA Office of Research and Development (ORD), covering modern engines from all major engine manufacturers, namely Pratt & Whitney, GE Aviation, and Rolls Royce. The new profile accounted for the full mass of TOG comprising of 77 identified compounds, of them 17 are known HAPs. The new profile also suggests that aircraft engines emit methane in lower amounts than found in ambient levels (i.e., a methane sink). The new aircraft speciated hydrocarbon profile is currently in EDMS5.1, and USEPA plans to place the new profile in the next version of the SPECIATE database later in 2009. In addition, FAA and USEPA have co-written a Recommended Best Practice document with an accompanying Technical Support Document for issuance on each agencies' website in the Spring of 2009.[16,17]

## TRANSITIONING TO AEDT
Within 3 years time, the FAA plans to replace EDMS with AEDT, a comprehensive software compliance tool to assess the interdependencies between aviation-related noise, criteria/HAPs/GHG emissions, and fuel consumption. There will be no loss in functionality or capabilities between EDMS and AEDT. Rather, an improved accuracy for quantifying aircraft fuel burn and emissions will be realized.

AEDT is under development to facilitate the analysis of tradeoffs between noise and emissions and to make the evaluation of air quality and noise seamless between the local, regional, and global domains. A phased development approach is being used to build AEDT, by progressively upgrading and integrating the current state-of-the-art emissions and noise models, including the associated common databases. AEDT leverages FAA's model development work already invested in developing EDMS, the System for assessing Aviation's Global Emissions (SAGE), the Integrated Noise Model (INM), the Noise Integrated Routing System (NIRS), and the Model for Assessing Global Exposure from Noise of Transport Airplanes (MAGENTA).

The transition to AEDT has already begun. EDMS5.1 incorporates many of the AEDT modules and databases, so the remainder of this paper will refer to the combination of AEDT/EDMS. In addition to the aircraft performance module and the aircraft emissions module discussed previously, AEDT/EDMS includes advanced Airport and Fleet Databases, never before created for aviation environmental consequence tools. The Airport Database contains data on all of the world's 30,000+ airports, including runway layouts and 30-year normal meteorological data. The Fleet Database contains data on the majority of the world's aircraft and engine types including the performance and emission data to support the performance and emissions modules, respectively. These core modules are the basis for AEDT development.

The development of AEDT takes advantage of the latest advances in information technology to support a more robust approach to aviation environmental modeling. AEDT is being built within the Microsoft® .NET environment and programmed in the C# language. The database support structure is in the relational structured query language (SQL) format to allow efficient data handling processes and support a broader array of information than the stand alone legacy EDMS model.

## GUIDING PRINCIPLES FOR AEDT/EDMS DEVELOPMENT

AEDT/EDMS supports environmental compliance, future environmental planning, and program support such as the FAA's Voluntary Airport Low Emissions (VALE) program[18] (see section titled "Multiple Years, Scenarios and Airports" below), so the model must match the fidelity of various study scales ranging from a singular emissions source on an airport to all emission sources across multiple airports. FAA's policy is to continually update and refine the AEDT/EDMS model to capture the latest advancements in emissions quantification algorithms, scientific data, and improved accuracy in estimating aviation emissions as well as the incremental contribution to ambient pollutant concentrations. FAA supports this policy on many levels: scientific research, coordination with stakeholders, assessment of uncertainties, and linkages with other analytical tools.

### Scientific Research

FAA closely coordinates with the science community regarding research that supports the latest emissions data from aircraft engines and APUs. Through the research conducted by the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), a NASA/FAA/Transport Canada funded research Center of Excellence, the FAA coordinates with the USEPA and other organizations to advance aviation environmental scientific topics. The FAA also funds the Airport Cooperative Research Program (ACRP), managed by the National Academies' Transportation Research Board, which carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. Through these efforts and other FAA-initiated activities, research is matured into fully validated and verified algorithms. Then the research is incorporated into FAA tools.

### Coordination with Stakeholders

AEDT/EDMS model development oversight and guidance are provided by a Design Review Group (DRG) comprised of air quality and aircraft noise professionals from the industry, USEPA, and other related affiliations. Typically once a year, the DRG assembles to discuss the usability of AEDT. Each member provides invaluable feedback regarding the interface between the users and the model. Data input, output and analytical functionality are shaped by the needs of the DRG, couched within the context of using AEDT/EDMS to fulfill environmental compliance, reporting and disclosure activities. The most important role of the DRG is to beta test the model prior to a public release.

**Building Confidence in AEDT/EDMS**

An important FAA priority is that environmental analyses conducted with our models are informed with the associated uncertainty, inputs and assumptions used in the analysis process. As part of the development of AEDT/EDMS, a formal parametric sensitivity and uncertainty analyses is being undertaken. This analysis is being completed on individual components of the tool as well as the whole tool. The analysis consists of a process of quantify uncertainties of AEDT/EDMS and rank ordering of the most important assumptions and limitations. Gaps in functionality will potentially be identified that significantly impact the requirements of AEDT/EDMS, leading to the identification of high-priority areas for further research and development. In addition, how model factors contribute to model output uncertainty will also be determined. To determine how well the model is performing, comparisons are being made to gold standard industry data, when possible and when data becomes available. Finally, capability demonstrations and sample problems will help contribute to the development of external understanding of AEDT.

**AEDT/EDMS Linkages with Other Tools**

Efforts are underway to link the environmental consequence capabilities of AEDT/EDMS with the simulation tools used to analyze capacity, safety, and system performance of an airport or airspace. Model linkages are provided either by incorporating individual modules and databases of AEDT/EDMS directly into other models, or more commonly, by developing stand alone processes that can modify outputs from a simulation tools and correctly format it as input into AEDT/EDMS.

Another important link is with USEPA's current development on the MOVES model. Figure 1 depicts a notional linkage that will evolve as both MOVES and AEDT are being developed over the coming years. In phase 1, the onroad vehicle emissions within airport environs can be output from MOVES and into AEDT/EDMS. In phase 2, the nonroad vehicles emissions from airport GSE and construction activities can be output from MOVES and into AEDT/EDMS. In phase 3, the aircraft emissions can be output from AEDT/EDMS and into MOVES. Together, these tools can interact with each other in support of SIP budgets, NEPA environmental review, and other related analyses. Exact details of how AEDT/EDMS and MOVES will communicate together are yet to be determined by the FAA's Office of Environment and Energy and USEPA's Office of Transportation and Air Quality.

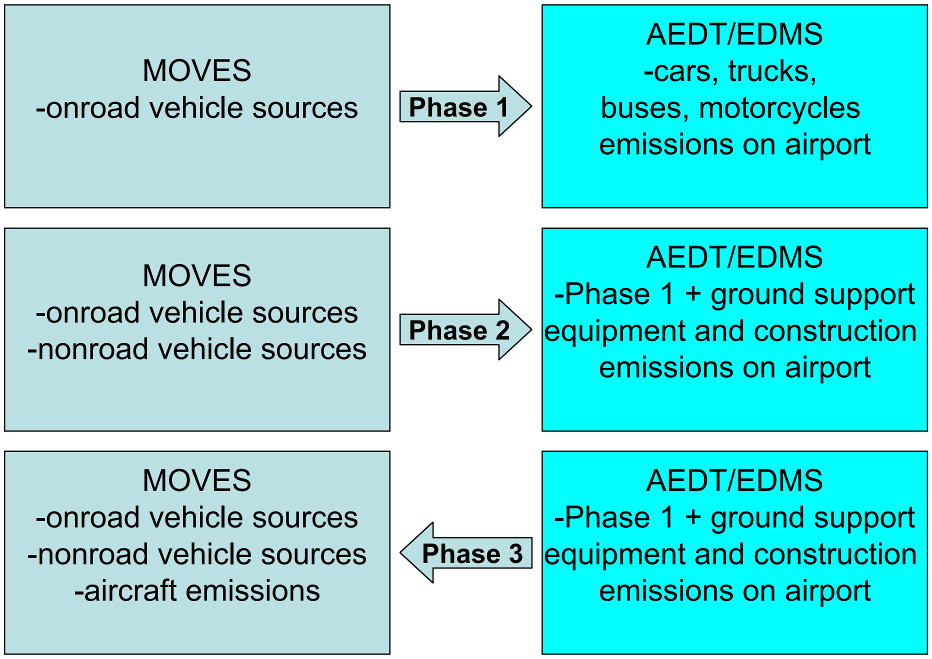



**Figure 1. Future notional interactions between USEPA's MOVES model and FAA's AEDT/EDMS model.**

## RECENT AEDT/EDMS DEVELOPMENTS

AEDT/EDMS has been re-engineered to include the following technical enhancements: the previously mentioned incorporation of an updated FOA3 aircraft PM estimation methodology, the introduction of a departure queuing model, the employment of an advanced airport configuration model, and the use of an aircraft performance model in conjunction with the Boeing Fuel Flow Method 2 methodology. These technical improvements are supported by the many user interface enhancements, such as the ability to model and evaluate multiple scenarios and analysis years within a single study, and the ability to prepare an Airport Emissions Reduction Credit (AERC) report within AEDT/EDMS.

### First-Order Approximation for Aircraft Particulate Matter Emissions

AEDT/EDMS includes ICAO's FOA3 methodology for aircraft particulate matter estimation, which represents substantial research over the previous PM estimation methods. Specifically, FOA3[9] introduces both a better fidelity for estimating volatile PM emissions based on sulfur conversion chemistry and condensed organic gases, as well as a predictive capability for non-volatile PM based on a relationship between mass and the smoke number (SN) reported in the ICAO Engine Emissions Databank[6]. This relationship has been further refined by developing separate equations for engines with a SN less than or equal to 30 and for those with a SN greater than 30. Also, a methodology has been applied to include mode-specific SNs when values are missing in the ICAO Engine Emissions Databank. These advancements have led to a more science-based approximation method which provides a flexible foundation for future improvements as aircraft PM science matures.

**Aircraft Queuing and Taxi Delay**

Previous versions of EDMS only allowed users to enter aircraft operations as annual or peak-hour LTO cycles. AEDT/EDMS5.1 enhances user-flexibility by allowing departures and arrivals to be entered separately and by allowing users to build operation schedules. After users have specified a taxiway network, assigned aircraft to follow given taxiway paths, and provided an aircraft schedule or operation profiles, AEDT/EDMS5.1 has sufficient information to model runway queuing. This replaces the runway queues that users manually defined in previous versions. AEDT/EDMS5.1 implements runway queuing by incorporating the Worldwide Logistics Management Institute Network Queuing Model (WWLMINET)[19], which models airport-level delays by using two dependent queue processes, one for arrivals and another for departures. This enhances the dispersion model fidelity by more accurately modeling aircraft queues.

In computing emissions inventories, users are not required to input an airport taxiway layout or assign aircraft to any paths. The queuing and taxi delay module is capable of generating taxi delays based on an aircraft operations schedule, unimpeded taxi times and airport capacity curves. However, the full runway queuing methodology will be used for emissions inventories, if all of the requisite data are provided. WWLMINET includes the capacity curves for 5 broad meteorological conditions of 257 major airports world-wide, of which 102 are in the United States. Users are required to input a capacity curve for airports not included in WWLMINET. Hourly weather observations can also be used to more precisely determine airport configuration and capacity as described later. This enhances the emissions model fidelity by more accurately modeling taxi delay.

**Taxiway Paths**

As referenced in the above paragraph, in addition to defining an airport's taxiway layout, users are able to define outbound pathways for every gate-runway pair and inbound pathways for every runway exit-gate pair, as necessary. Inbound taxiway paths are defined for each runway exit to allow aircraft of different sizes to take the first available runway exit. AEDT/EDMS5.1 automatically determines the pathway to be followed based on an aircraft's gate and runway assignments, and flight profile; thereby, rendering taxiway segment based assignments obsolete.

**Airport Configurations**

AEDT/EDMS5.1 offers users the flexibility to represent airport configurations based on either (1) meteorological activation parameters, or (2) user-defined distributions expressed as annual percentage of time a configuration is used. Both of these methods are discussed in detail below. The user is able to choose the appropriate configuration method based on the goals of the study and the data available to represent airport operations.

Each configuration assigned to the study airport will include a corresponding range for at least one of the activation parameters. Runway configurations are selected by comparing the surface weather data for the hour and time of day with the activation parameters. The configurations can change only on an hourly basis, with at most 24 changes per day, which is consistent with the hourly weather information available.

The activation parameters are as follows, ranked based on their importance as suggested by terminal area air traffic controllers:

1. Wind direction
2. Wind speed
3. Time of day when the configuration applies
4. Ceiling
5. Visibility
6. Temperature

**Configuration Selection by Ranking**
The user supplies AEDT/EDMS5.1 with a list of configurations beginning with the higher capacity and stricter constraints with respect to weather conditions (e.g., visual monitoring conditions (VMC) limitations for the airport). For example, if under calm weather conditions an airport uses more than one configuration due to a significant difference in the traffic flows for different daily time intervals (e.g. a stronger departure flow in the morning and stronger arrival flow in the afternoon or restrictions imposed for noise abatement) then the user can assign ranges for not only weather-related activation parameters but also a time of day. Not all of the activation parameters need to have both the upper and lower bounds defined (e.g. for VMC conditions, the ceiling parameter could be set to greater than 5,000 feet with visibility greater than 5 miles).

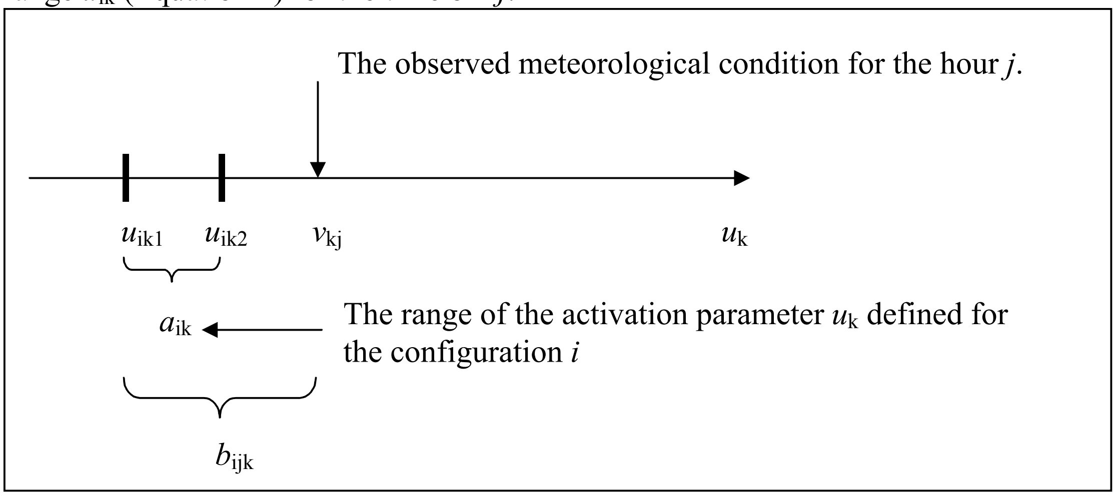
The configuration selection algorithm scans the list of configurations starting from the top of the list until it finds the first configuration for which the activation parameters fit the current meteorological condition. If the current weather condition fits with multiple configurations, the first viable configuration (closest to the top of the list) will be assigned. Consequently, the screen enables the user to rank configurations based on their utilization preferences and the user is encouraged to do so for optimal reflection of airport activity.

If there is no configuration that fits the current conditions, the model will find a configuration that matches the conditions most closely. This method ensures that some configuration will be selected for each time bin and thus no flight will be cancelled due to bad weather. Since wind direction is the parameter that affects dispersion results the most, the model will first try to find a configuration that most closely matches the current wind direction. If none of the configurations have a range of wind directions specified, then the configuration selection algorithm will try to match the current conditions based on the remaining activation parameters.

**Matching Configurations to Weather / Time Conditions**
Comparing the current conditions to the individual configurations to find the best match will only be done if the current conditions do not fit in any of the configurations (otherwise the configuration will be selected by the ranking discussed above). For each

activation parameter, the matching will be done by examining how much the observed weather condition or time of day is outside the bounds specified in each configuration relative to the range of the bounds. If this ratio is small for a particular configuration, then the weather condition or time of day is not far from the bounds relative to the length of the bounds and is thus more favorable. Each activation parameter is weighted equally.

For a mathematical explanation of the method for finding the best matched configuration, let $a_{ik}$[1] be a range specified for the configuration $i$ and activation parameter $k$, and $b_{ijk}$[2] the distance of observed value of the activation parameter $k$ from the further boundary of the range $a_{ik}$ (Equation 1) for the time bin $j$.




**Equation 1.** The meteorological condition reported for the hour and/or time of day and its allowed range for a particular configuration.

Let $\delta_{ijk}$ be the measure on how closely the configuration $i$ matches the conditions based on activation parameter $k$, expressed as follows:

$$\delta_{ijk} = \begin{cases} \dfrac{b_{ijk}}{a_{ik}}, \text{ for } b_{ijk} > a_{ik} > 0 \\ C, \quad \text{for } b_{ijk} > a_{ik} = 0 \\ 0, \quad \text{for } b_{ijk} \le a_{ik} \end{cases} \qquad (1)$$

where $C$ is a large constant.

The selected configuration is the one with the smallest total value $\delta_{ij} = \sum_k \delta_{ijk}$ .

**Configuration Selection by User-Defined Distributions**

Using airport configurations in the method discussed so far does not guarantee that any particular configuration will be used for any particular amount of time throughout the year, since the selection of the active configuration is based solely on the current weather

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[1] $a_{ik} = u_{ik2} - u_{ik1}$

[2] $b_{ijk} = \max\{|u_{ik1} - v_{kj}|, |u_{ik2} - v_{kj}|\}$

conditions. However, AEDT/EDMS5.1 provides the flexibility to explicitly specify the percentage of time that each configuration will be used throughout the year. When operating in this mode, AEDT/EDMS5.1 includes an algorithm that will select a configuration for each hour during the study period, such that the overall time distribution of configurations corresponds to the specified percentages of time used and so that the selected configuration is reasonable given the wind direction.

The configuration assignment algorithm ranks all available configurations based on how closely their assigned wind ranges match the observed wind direction from the surface weather file, for each one hour time bin. The matching is done by examining how much the observed wind direction is outside the bounds specified in each configuration, which is the same method used to determine the closest match for the observed data with no fitting configuration discussed earlier.

The configuration assignment algorithm consists of the three steps, as follows:

1. Based on the user-defined time that the configuration is used, apportion to each configuration the appropriate number of time bins throughout the study year.
2. For each time bin, rank each configuration in ascending order in terms of how closely it matches the current wind direction. The matching is done similar to the method discussed earlier.
3. Assign a configuration to each time bin sequentially while taking into account the total number of bins each configuration is to be assigned (determined in Step 1).

The algorithm allows for a frequent change of the airport configuration (the configuration may be changed in each time bin throughout the study year). The total number of configuration changes will be reduced by assigning the configuration to the next time bin that has been already assigned to the previous time bin, if possible. The configuration will be extended to the next time bin if it is at the top of its list of ranked configurations. Multiple configurations may be ranked equally because $\delta_{ijk}$ can take value 0, which indicates that the observed wind direction is within the range or the range is not specified for the configuration.

## Dynamic Flight Profiles

To enhance AEDT/EDMS5.1 modeling accuracy and increase consistency between the Integrated Noise Model (INM) and EDMS, the two tools now use a common aircraft performance module based on SAE AIR 1845 methodology. Previously, aircraft flight profiles were stored statically as points in a data table that was based on default assumptions and nominal conditions. With a shared algorithm, aircraft performance and flight paths are modeled identically in both the INM and EDMS. The dynamic aspect of the algorithm allows aircraft to be modeled under airport-specific meteorological conditions. Because some runway exits have speed limitations, when modeling landings, output from the Aircraft Performance Module is also used to select the inbound taxiway path that an aircraft follows as it returns to its gate.

**Boeing Fuel Flow Method 2 (BFFM2)[20]**
The ICAO Engine Exhaust Emissions Databank stores fuel flows and emission indices that have been corrected to standard day for any ambient atmospheric effects at the engine testing facilities. BFFM2 adjusts aircraft engine emissions based on a standard day (such as those derived from ICAO's Engine Exhaust Emissions Databank) for the airport-specific conditions of ambient temperature, pressure and humidity, as well as aircraft speed and installation effects. Presently, BFFM2 is included in AEDT/EDMS.

**Multiple Years, Scenarios and Airports**
Airport Emission Reduction Credit (AERC) analyses require examination of airport operations over several years under two or more scenarios (e.g., baseline and proposed, or build and no build). All prior versions of EDMS have only had the capability to model a single year of airport operations under one scenario at a time. The ability to conduct AERC analyses has been the primary motivation to include multi-year and multi-scenario capability within EDMS. AEDT/EDMS5.1 is capable of modeling a set of years under multiple scenarios, thereby increasing flexibility by providing users with the ability to generate the required reports for submission under the FAA's VALE program. This increased functionality is also useful to the typical EDMS user who must often compare the environmental impacts of proposed airport projects over several years into the future, even if they are not submitting an application under the VALE program. The VALE program is a cooperative effort between FAA and the USEPA via state agencies that is intended to establish permanent emission reductions at airports that are surplus to the SIP. In turn, the state agencies provide emission reduction credits to the airport for future use under the General Conformity rule, if desired.

## CONCLUSIONS
FAA is committed to building a comprehensive environmental tool for the aviation sector that relies on advanced algorithms and supported by the latest scientific knowledge. AEDT/EDMS5.1 marks a significant advancement in airport emissions modeling through multiple technical and user flexibility enhancements. These include improved aircraft PM and HAPs estimation methods, the ability to dynamically compute aircraft trajectories with their corresponding fuel burn and emissions, a sophisticated airport configuration capability, and the flexibility to model multiple airports, scenarios, and analysis years within the same study.

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**KEY WORDS**

Aviation, airport, aircraft, auxiliary power units, APU, ground support equipment, GSE, Emissions and Dispersion Modeling System, EDMS, Aviation Environmental Design Tool, AEDT, Voluntary Airport Low Emissions, VALE, Airport Emissions Reduction Credit, AERC, Federal Aviation Administration, FAA