ENVIRONMENT AND ENERGY

AEDT News

AVIATION ENVIRONMENTAL DESIGN TOOL

October 2008

Welcome

Ralph Iovinelli, FAA AEE

Greetings aviation environmental modelers! This edition of our newsletter is commensurate with the release of the Integrated Noise Model (INM) version 7.0a and Emissions and Dispersion Modeling System (EDMS) version 5.1. Not only are we happy to provide you with these enhanced tools (please see following articles about new enhancements), we're continuing the harmonization process that started with the releases of INM version 7.0 and EDMS version 5.0, which leads to our upcoming integrated noise and emissions model, the Aviation Environmental Design Tool (AEDT). This is part of our transition plan to provide you with elements of AEDT development in our existing tools while we develop and assemble the whole AEDT system.

Today's tools represent the final functional versions of INM and EDMS. From now until the release of AEDT in 2011, FAA will update our existing tools once a year, if updates are necessary to cover compliance requirements, bug fixes and other corrections. New functionalities and more robust capabilities are being developed, but will be saved for the inaugural release of AEDT.

The functional overview of AEDT is illustrated in **Figure 1** from a user's perspective. The user will have comprehensive databases of airports, fleet, movements, and non-aircraft activities to assemble the extent of the study area and operational details. Dynamic aircraft flight performance is modeled to derive fuel burn as well as used to simultaneously generate state information for modeling noise and emissions. The individual aircraft noise and emissions results are stored in the results database. Analyses can then be conducted on the results to generate emission inventories, noise and concentration grids, contours, supplemental noise metrics, and change analyses between different scenarios, allowing for interdependent analyses between noise and emissions.

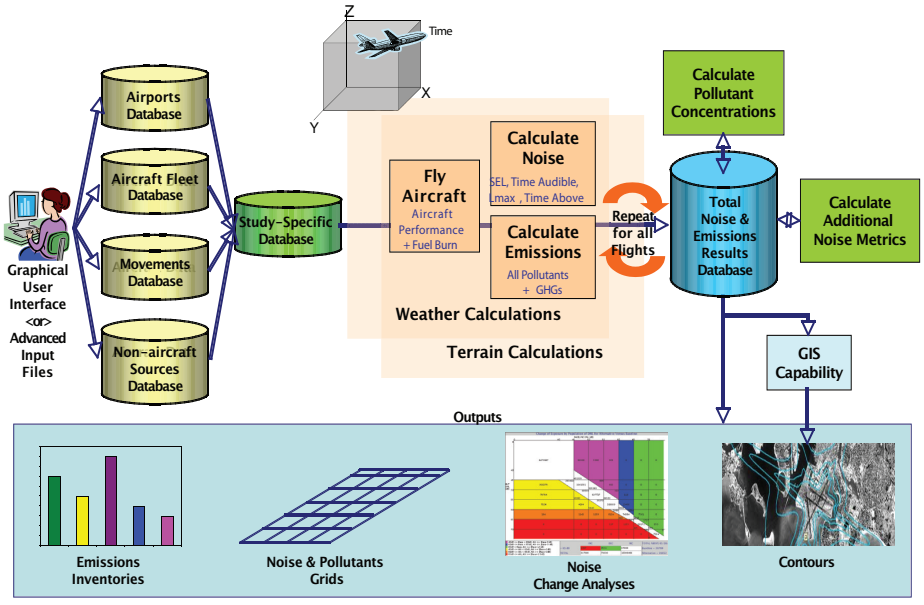

Figure 1: AEDT From A User's Perspecive

INM Version 7.0a Release

Eric Dinges, ATAC Corporation

INM version 7.0a was released September 17 and includes the following updates:

- Minor database updates including updated noise and flight performance data for the firstvery light jet (VJL) to be added to the INM database, the Cessna Mustang Model 510.
- Bug fixes, including corrections related to differences between runway end and airport elevations, behind start of takeoff roll directivity, version conversion for metric INM studies, and the handling of reference speeds for helicopter source noise adjustments due to advancing tip Mach numbers.

A detailed description of all of the updates for version 7.0a is included in the documentation distributed with the INM version 7.0a release. For more information, visit the INM website at:
http://www.faa.gov/about/office_org/headquarters_offices/aep/models/inm_model/.

EDMS Version 5.1 Release

Debbie Wilson and Philip Soucacos, CSSI, Inc.

EDMS version 5.1 was released September 19 with the following new technical enhancements:

- The new ability to calculate and report total organic gases (TOG) for aircraft and airport emission sources.
- Updated conversion factors for hydrocarbons (HC) to volatile organic compounds (VOC) to non-methane hydrocarbons (NMHC) for all airport sources including aircraft, auxiliary power units (APUs), ground support equipment, motor vehicles, stationary sources and training fires.
- The new ability to estimate speciated HCs, including hazardous air pollutants (HAPs) for all airport sources.
- The ability to estimate aircraft CO2 emissions.
- Proper implementation of turbo-fan (TF) and mixed turbo-fan (MTF) distinctions in the application of FOA3 and FOA3a methodologies for computing nonvolatile PM emissions from certified aircraft engines
- Updated methodology for main engine startup HC emissions.
- Update to Fleet Database based on ICAO Databank 15c supplement
  - This includes new data to reflect the engine type (turbine, piston), the ICAO engine type (TF or MTF), and updating the emission factors, rated output (thrust), and smoke number values.
  - Additional aircraft and engines were added to help relationships between noise and emissions.
- Additional APU PM emission factors based on military aircraft were added to help determine the importance of programs like the Voluntary Airport Low Emissions (VALE) program and emission reductions between using APUs and 400Hz power at the gates.
- Various bug fixes and enhancements were completed. Additional information on these fixes and enhancements will be provided in the Release Notes for EDMS version 5.1.

A detailed description of all of the updates for version 5.1 (relative to version 5.02) will be included in the documentation that will be distributed with the EDMS version 5.1 release. For more information, visit the EDMS website at:
http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model.

How AEDT Is Being Used Right Now...

Christopher Roof, Volpe National Transportation Systems Center

AEDT version 2.0 will be released for public use in 2011. Upon its release, AEDT will replace the FAA's EDMS, INM and NIRS, as well as include the capabilities to do national and potentially global analyses. During AEDT's development, however, a pre-released version has been utilized for several important analyses. Two noteworthy types of analyses include continuous descent arrivals (CDA) and environmental goals analysis. These efforts highlight the strengths of a single, integrated tool, provide insight into challenging issues facing the domestic and international airspace systems, and also provide the FAA with valuable feedback during a complex, multi-year development effort.

CDA operations at airports have the potential for significant environmental benefits, including reductions in noise, emissions and fuel burn. Operational trials have been undertaken by several groups; the environmental analysis of those efforts, however, has typically made use of disparate (separate noise and emissions), sometimes proprietary tools and data. To demonstrate the use of a single, integrated tool, AEDT was used to investigate the implementation of CDAs at a major U.S. airport; results were presented at a recent Air and Waste Management Association (AWMA) conference (http://www.faa.gov/about/office_org/headquarters_offices/aep/models/history/media/AWMA2008_Paper_CDA.pdf). The analysis illustrated that there can be significant noise, fuel burn, and emissions benefits resulting from the implementation of CDAs. Several data and analysis capability gaps were also identified during the exercise which will be addressed through the AEDT development process.

In support of the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) Modeling and Database Task Force (MODTF), AEDT has been exercised for several other analyses illustrating the interdependencies between noise and emissions. Multiple sample scenarios were modeled for nitrogen oxides (NOx) stringencies in preparation for an actual NOx stringency assessment. A sample reduced thrust analysis was undertaken to exercise model readiness and AEDT was used to compute noise and emissions results in support of CAEP's Environmental Goals. Also, in support of NextGen, AEDT was used to quantify the fuel savings associated with recent military airspace openings for commercial aircraft during busy, holiday travel time periods.

Throughout the remainder of the development of AEDT version 2.0, the tool will continue to be exercised for interdependency analyses. Results will be published in a variety of forums, as appropriate.

INM Version Comparison Available on the Web!

In the last newsletter, there was an article on the version comparison between INM version 6.2a and version 7.0. The full report is available at: http://www.faa.gov/about/office_org/headquarters_offices/aep/models/inm_model/
Just scroll down to the "Previous Versions of INM" section and click the link.

AEDT and Regional Noise Analysis

Mike Graham, Metron Aviation, Inc

As AEDT development has been progressing, the question of how AEDT would support regional airspace projects has been discussed in the AEDT Design Review Group (DRG) meetings. NIRS, developed in support of the FAA's Air Traffic Organization (ATO) in coordination with AEE, is the current FAA model for performing regional noise analysis. FAA Order 1050.1E, Appendix A, Section 14, identifies NIRS as an approved FAA noise model and specifies when to use NIRS:

14.5e. For air traffic airspace actions where the study area is larger than the immediate vicinity of an airport, incorporates more than one airport, or includes actions above 3,000 feet AGL, noise modeling will be conducted using NIRS. For those types of studies, NIRS will be used to determine noise impacts from the ground to 10,000 feet AGL. This noise analysis will focus on the change in noise levels as compared to populations and demographic information at population points throughout the study area. Noise contours will not be prepared for the NIRS analysis. However, NIRS will be used to produce change-of-exposure tables and maps at population centroids using the following criteria:

DNL 60-65 dB ± 3 dB
DNL 45-60 dB ± 5 dB

INM and NIRS are very similar tools, both sharing a common set of aircraft performance and noise data, as well as a single noise computation module. The principle capabilities found within NIRS include:

- Imports and displays track, event, population, and community data.
- Enables user to easily define and track large numbers of airspace design elements.
- Filters data based on user definition of study area and maximum altitude.
- Enables user to specify the altitude profiles flown, including hold-downs, etc.
- Applies several layers of data checking and quality control.
- Calculates noise impacts at all population points (or other specially defined points) in the study area.
- Provides automated means of annualizing noise impact based on different operational configurations and/or runway usage statistics.
- Provides automated quantitative comparison of noise impacts across alternative airspace designs.
- Identifies and maps all areas of change in noise impact.
- Quantifies mitigation goals and identifies mitigation opportunities.
- Identifies traffic elements that are the principal causes of change in noise impact in each area of change.
- Assembles maps, tables, and graphs for noise-impact report generation.

An Integration Plan detailing the implementation of NIRS capabilities within AEDT will be finalized this year. In particular, the goal will be to define NIRS functional requirements in terms of AEDT components or modules, and to develop a plan for how those requirements will be met within the AEDT development process. Two specific topics of interest are: support of custom or non-standard flight profiles and the ability to analyze and identify sources of change. These capabilities currently exist in NIRS and are critical to supporting projects that include airspace changes and the cumulative effect of multiple or competing air traffic procedures.

User Defined Flight Profiles

In addition to using the standard or default profiles that come packaged with the aircraft performance database, an analyst using NIRS can take advantage of altitude controls. Altitude controls offer the option of specifying certain airspace altitude restrictions while allowing the use of the aircraft standard profiles when permitted. Note that aircraft standard profiles are not static, fixed paths, but are a set of parameters to be input into NIRS, which, when combined with other inputs such as the stage length, airport elevation, and altitude controls, are used to compute the flight path. **Figure 2** illustrates a standard profile, along with the three profiles affected by altitude control capabilities in NIRS.

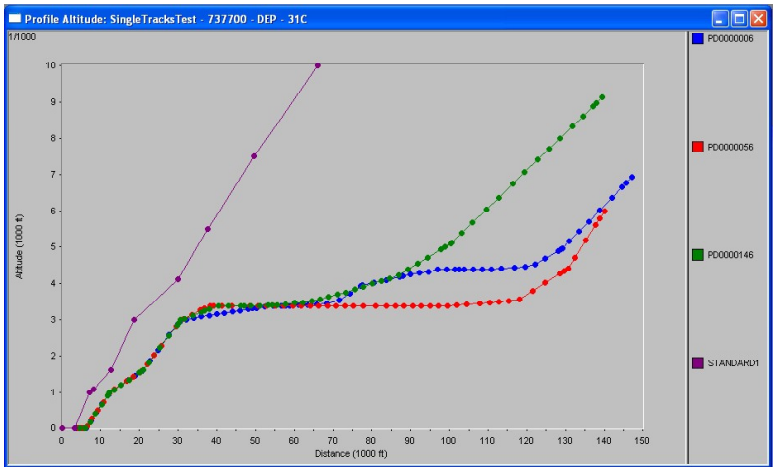

Figure 2. Possible NIRS Profiles

Impact & Change Analysis

Within the NIRS user interface the NIRS user can visualize both the exposure and impact as it relates to a baseline and/or alternative scenario. (See **Figure 3**) In addition to displaying the metrics on a map, the user can overlay other aspects which can assist in understanding the cause of modeled exposure and impacts. NIRS also introduces a capability known as "Change" analysis that allows the user to query a set of impacted locations and receive a list of primary and secondary causes for the change. Having this capability built into the tool aids the analyst in two respects. Primarily it allows the analyst to identify and report on the causes for the change, but also provides a valuable quality assurance tool.

Current NIRS functionality, like those described above, will be available in AEDT Version 2.0. With the integration of regional and local noise computation, additional capabilities will be available to both user groups. These capabilities will lead to more flexibility when completing environmental studies.

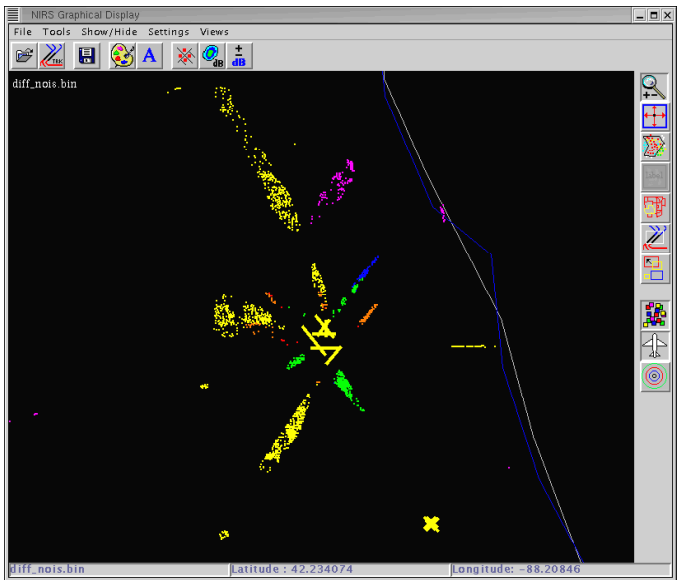

Figure 3. NIRS Impact Map

AEDT Assessment

Rebecca Cointin, FAA AEE

As part of AEDT development, a rigorous assessment of the tool is being done. The assessment will identify gaps in functionality, provide quantitative evaluation of the performance of AEDT, and provide sensitivity analyses of output response to uncertainties in input parameters and assumptions. The assessment is in four-part: parametric sensitivity and uncertainty analyses, comparisons to gold standard data, expert reviews, and capability demonstrations/sample problems.

The parametric sensitivity and uncertainty assessments use Monte Carlo simulations (MCS). To do a MCS, a distribution is determined for an input. A random draw for that input is then chosen and ran through the model. The drawing and running through the model is done a large number of times (hundreds to thousands). The results are probability distributions which can be used to calculate means, standard deviations and confidence intervals. Parametric sensitivity studies and uncertainty assessments allow for the quantification of uncertainty in AEDT outputs. In addition, they provide the ability to create a rank order of the most important assumptions, limitations, and model inputs. This in turn provides a roadmap upon which further AEDT model research and development will be based.

By completing sample problems and capability demonstrations (see also AEDT Analysis - How AEDT is being used right now above), AEDT is exercised to ensure it can perform the analyses it is expected to perform. Throughout the development process, the tool is exercised to help identify capability gaps and identify further development needs.

Gold standard data provide a benchmark that is regarded as the most reliable, representative and/or complete information available. The AEDT development team utilizes computer flight data recorder information and airline-reported fuel burn "gold standard" data. These data have been compared to AEDT predictions to estimate the accuracy of AEDT data. In addition, data gathered from the Society of Automotive Engineers (SAE) A-21 Committee have also been used to verify AEDT computations.

The final aspect of AEDT assessment is expert review. AEDT is going through constant review. Such groups as the Transportation Research Board (TRB), the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP), and the AEDT Design Review Group (DRG) are informed regularly on AEDT development. In these forums, issues and concerns are raised by all parties and guidance and feedback are provided.

Startup Emissions Methodology for AEDT and EDMS Version 5.1

Kojoe Yirenkyi and Debbie Wilson, CSSI, Inc.

One of the revisions to EDMS version 5.1 is a new methodology for calculating aircraft startup emissions from certified turbine jet engines.

In a simplistic description, the aircraft engine startup process begins with fuel flowing into the annular combustor. At this point, any emissions are unburned, raw fuel vapor. Once the combustors are ignited, partially combusted and pyrolized fuel is released until the engine stabilizes in idle mode, when the combustor is operating at greater than 90 percent combustion efficiency.

Based on studies developed by engine manufacturers participating in ICAO CAEP technical emission discussions, a methodology has been developed based on an engine starting emissions analysis and predictions provided by engine manufacturers.

Assumptions and Formula

It is assumed that the overall magnitude of starting HC emissions is similar given constant ambient operating conditions; this allows for some spread between different sized engines.

Starting emissions are attributable to fuel flow and combustion efficiency during the starting sequence. For the post ignition start phase, it is assumed that remaining combustion inefficiencies will lead to the production of HC emissions alone, neglecting carbon monoxide (CO) emissions; such a starting emissions prediction is therefore conservative. The starting fuel flow is proportional to the 7% idle fuel flow, which is inherently linked to the engine thrust, both of which can be obtained from the ICAO Engine Emissions Databank.

Based on the assumptions:
- that all combustion inefficiency has been conservatively attributed alone to HC with no correction for starting CO
- speciation of HC emission will not be performed
- the analysis is based on testing results for typical day engine starting conditions
- engines analyzed are of a current production standard based on modern combustor architecture
- engine start NOx emissions are negligible compared to LTO NOx emissions

A simple first order linear relationship between engine starting HC emissions and engine thrust rating has been derived based on calculated results from engine testing; the equation is:

STARTING EMISSIONS (grams) = Number of Engines *
(0.5* Thrust Rating (KiloNewtons) + 80)

The constants "0.5" and the "80" are empirically derived from proprietary engine cycle decks from Rolls Royce, Pratt and Whitney, and General Electric.

This methodology is based on certified jet engines and should therefore only be applied to those aircraft engines. Therefore, EDMS version 5.1 results come with the caveat that "Startup emissions are not included for all aircraft".

Using this formula, the following tables show an example of emissions associated with startup and the other EDMS modes. Table 1 uses the above formula to compute the startup emissions (grams) for the 1000 operations shown. Table 2 than shows the difference between the start up emission methodology in EDMS version 5.1 and that used in EDMS version 5.02. Note that for some engines this methodology will increase HC startup emissions and for others it will reduce HC startup emissions, as compared to what was calculated in EDMS version 5.02.

Table 1: Example Startup Calculation for B737-300-CFM56-3-B1 with 1000 Operations

Aircraft	Engine	Thrust Rating (kn)	Operations	Number of Engines	EDMS 5.1 Startup Emissions (grams)
B737-300	CFM56-3-B1	89.41	1000	2	249,410

Table 2: Grams of HC per mode for B737-300 – CFM56-3-B1

EDMS 5.02 Startup Emissions	EDMS 5.1 Startup Emissions
921,487	249,410

EDMS Version 5.1 Released Twice

Ralph Iovinelli, FAA AEE

Two is a magic number. Yes it is, it's a magic number.

Shortly after the September 19th release of EDMS version 5.1, two small bugs were detected that affected a very small percentage of users: those that wished to convert a EDMS version 5.0.2 study that contains 3 or more airport scenarios, and those that wished to print out a Voluntary Airport Low Emissions (VALE) emissions report. These bugs were simple and quick to fix and important enough to warrant a re-release.

On September 30th, we reposted the revised EDMS version 5.1 update file on our website. If you installed EDMS version 5.1 prior to September 30th, then we kindly recommend you download the conversion file again from our website and re-install EDMS version 5.1. We apologize for the minor inconvenience. Happy modeling!

Websites to Visit

These three websites provide information regarding AEE tools, including AEDT and the other tools in the AEDT Tool Suite.

AEE Tools FAQ:
http://www.faa.gov/about/office%5Forg/headquarters%5Foffices/aep/models/toolsfaq/

AEE Conference Presentations:
http://www.faa.gov/about/office_org/headquarters_offices/aep/models/history/

AEE Research and Development
http://www.faa.gov/about/office_org/headquarters_offices/aep/research/

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