Advanced Aviation Environmental Modeling Tools to Inform Policymakers

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Aviation environmental models which conform to international guidance have advanced over the past several decades. Enhancements to algorithms and databases have increasingly shown these models to compare well with gold standard measured data. The Federal Aviation Administration's Aviation Environmental Design Tool (AEDT) brings these enhancements into a new capability to investigate interdependencies within a single modeling environment. It provides an interactive environment to iterate noise modeling results relative to contributing aircraft events, as well as understand the fuel burn and emissions consequences of model scenarios. This paper presents an overview of the tool, including its capabilities to analyze the implications of technology and operational improvements planned for the next generation airspace system. An example is provided that illustrates how the tool may better inform aviation policymakers as they prepare for the significant growth expected in the aviation industry.

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1 INTRODUCTION

International guidance to support the modeling of aviation noise in the vicinity of airports has been in place for almost thirty years [1],[2]. Over those three decades, a number of models have been developed conforming to the guidance [3],[4],[5],[6]. In response to the needs of the user community, as well as advances in science and computational processing, these tools have been updated to add new algorithms and features, as well as to improve existing capabilities.

At the same time, advances have been realized within the aviation noise modeling community [7] [8] and a number of key factors have pointed to the need for more interdependent environmental modeling. In particular, there is now a need to better understand the interdependencies between noise in the vicinity of airports, the contributions of the operations to air quality, and impacts on greenhouse gas emissions. For instance, technology advancements such as nacelle modifications may reduce noise but increase fuel burn and CO_2. Moreover, analysis of a takeoff procedure at a U.S. airport which significantly reduces power to mitigate noise impacts has the converse effect on other environmental consequences- increasing the amount of fuel burned and therefore CO_2 as well as emissions that affect air quality. This particular location, like other regions in the U.S., also happens to have concerns about air quality.

These factors contribute to the need for environmental modeling systems that facilitate comprehensive analysis of multiple effects simultaneously. Further, analysts who previously worked within a specific domain now need to not only have consideration for other technical disciplines, but are required to actively engage in the subtleties of those areas. Policymakers' jobs will now be aided by modeling data derived consistently in an integrated manner.

2 AVIATION ENVIRONMENTAL DESIGN TOOL

The Federal Aviation Administration's Aviation Environmental Design Tool (AEDT) has been developed to address this gap in environmental interdependency modeling. AEDT Version 2A [9], publicly released in March 2012, focuses on air traffic airspace and procedure action analysis – specifically study areas that are larger than the immediate vicinity of an airport, incorporate more than one airport, or include proposed air traffic airspace and procedure actions above 3,000 feet above ground level (AGL). The release of AEDT 2A officially sunsets the use of the Noise Integrated Routing System (NIRS) for these types of analyses. This section highlights the key features of AEDT 2A.

To easily support the import of the disparate data sources often required for aviation environmental modeling, AEDT utilizes an extensible markup language (XML) standard import file format (ASIF). The ASIF facilitates the import of all study data, including airport layouts, annualization, boundary, cases, fleet, receptor sets, scenarios, and track operation sets. To enable the often iterative nature of environmental planning and analysis, AEDT supports multiple partial ASIF imports in order to add individual elements of studies separately. Additionally, direct links to other FAA tools, including the Terminal Area Route Generation Evaluation & Traffic Simulation (TARGETS) and the Performance Data Analysis and Reporting System (PDARS), are being explored.

Given the effect of weather on aviation environmental impacts, AEDT supports the use of multiple types of high fidelity weather in modeling, in addition to average or user-defined airport weather conditions. These data sources include the National Oceanographic and Atmospheric Administration's Rapid Update Cycle (RUC), Goddard Earth Observing System Model (GEOS), as well as those from the National Center for Atmospheric Research (NCAR).

Given the focus of AEDT 2A on air traffic airspace and procedure actions, key features of the tool include *change analysis* and *impact evaluation*. Change analysis enables the comparison of noise levels at specified locations between two scenarios. In conjunction with impact set definitions and the results of the change analysis, impact evaluation supports the investigation of noise level based on operation and track assignment. Color-coded visual representations enable this to be done easily over a large area of interest. Table 1 shows the color scheme as a function of change in sound level. When impact evaluation is completed, the resulting changes in fuel burn and emissions are also computed.

AEDT 2B, which is currently in development, will enable more detailed analysis at the airport level. This version of the tool, which will sunset the use of the Integrated Noise Model (INM) and the Emissions and Dispersion Modeling System (EDMS), will include a number of other capabilities, including aircraft queuing and delay modeling, as well as pollutant dispersion analysis.

3 ANALYSIS

The following example demonstrates some of the unique capabilities of AEDT 2A. In this study, three commercial airports in a single geographic region are analyzed. A baseline scenario is modeled representing “current” departure operations at those airports. Figure 1 presents the three airports and associated flight ground tracks color coded by departure airport. An alternative scenario is created to represent growth in aviation activity utilizing AEDT’s annualization feature, a weighting factor representing a percentage of the year where the configuration in the scenario is considered typical. An analysis is then conducted in AEDT utilizing the impact set feature to determine areas of interest. Through this analysis potential noise impacts for aircraft departures from a single airport runway (Airport 2, Runway 1) are identified. These areas might be considered typical of noise sensitive areas, whether defined based on cumulative noise complaints made to the airport or for other reasons such as the presence of schools or other noise sensitive receivers. Figure 2 presents the departure tracks and the U.S. census population centroids in the study area. Population centroids represent the number of people in a defined area. Change analysis and impact evaluation are then employed to investigate the modeled noise levels at the population centroids and explore different scenarios.

Figure 3 presents proposed track utilization (essentially consolidating all Airport 2, Runway 1 departures to utilize one of the existing ground tracks) in green and the existing tracks in purple. The purpose of reassigning the departure operations to different tracks is to route the operations (and in turn noise impacts) away from the majority of the population. However, this type of ground track consolidation has implications for the nearby population presented in Figure 3. To understand the magnitude of the population at each point the population centroids are presented using the color scheme outlined in Table 2.

Table 2 – Population Color Levels

Color	Level Ranges		
	200	<=X	
	150	<=X<	200
	100	<=X<	150
	75	<=X<	100
	50	<=X<	75
	35	<=X<	50
	22	<=X<	35
	15	<=X<	22
		X<	15

Figure 4 presents the population centroid-based noise impacts for the growth scenario (a) and the growth scenario with new track assignments (b). As shown in Figure 5a, the growth in operations scenario alone results in 1,644 people with a significant increase in noise exposure. If, however, the track utilization is changed to the alternative scenario that number is reduced to 185 (Figure 5b). This alternative scenario also results in noise reductions for 399 people; modeled noise levels do not change for 1,440 people, as summarized in the table on the bottom center portion of Figure 5b. Moreover, the proposed track utilization results in a 0.3% reduction in fuel burn (almost 97 kg of fuel for the scenario analyzed), as well as reductions of 0.23% and 0.53% for NOx and CO, respectively.

4 DISCUSSION AND CONCLUSIONS

AEDT 2A, a tool developed to assist in the examination of environmental interdependencies, has been exercised to demonstrate its utility in the examination of alternative scenarios. Given the expected operational growth in the aviation system, this type of analysis is crucial to manage potential aviation environmental impacts. AEDT demonstrates that airspace and environmental planners now have at their fingertips the ability to systematically and comprehensively assess environmental tradeoffs and interdependencies. This facilitates more careful and accurate assessment of the numerous environmental consequences, including noise, air quality and greenhouse gas emissions. In doing so, policymakers have more and better information at their disposal. Having this information paints a more complete picture for policymakers; it does not, however, necessarily make their jobs any easier.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

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Table 1 - Color Coding Based on Change in Sound Level

<table>
<tr><th rowspan="2">Baseline DNL</th><th colspan="2">Change in Noise Level
from Baseline to Alternative</th></tr>
<tr><th>Increase</th><th>Decrease</th></tr>
<tr><td>< 45 dB</td><td>No color</td><td>No color</td></tr>
<tr><td>45-<50 dB</td><td rowspan="3">+ 5 dB
(yellow)</td><td rowspan="3">- 5 dB
(purple)</td></tr>
<tr><td>50-<55 dB</td></tr>
<tr><td>55-<60 dB</td></tr>
<tr><td>60-<65 dB</td><td>+ 3 dB
(orange)</td><td>- 3 dB
(blue)</td></tr>
<tr><td>> 65 dB</td><td>+ 1.5 dB
(red)</td><td>- 1.5 dB
(green)</td></tr>
</table>

Figure 1 – Baseline Scenario Airports and Tracks

Figure 2- Airport 2, Runway 1 Departure Tracks and Population Centroid Data

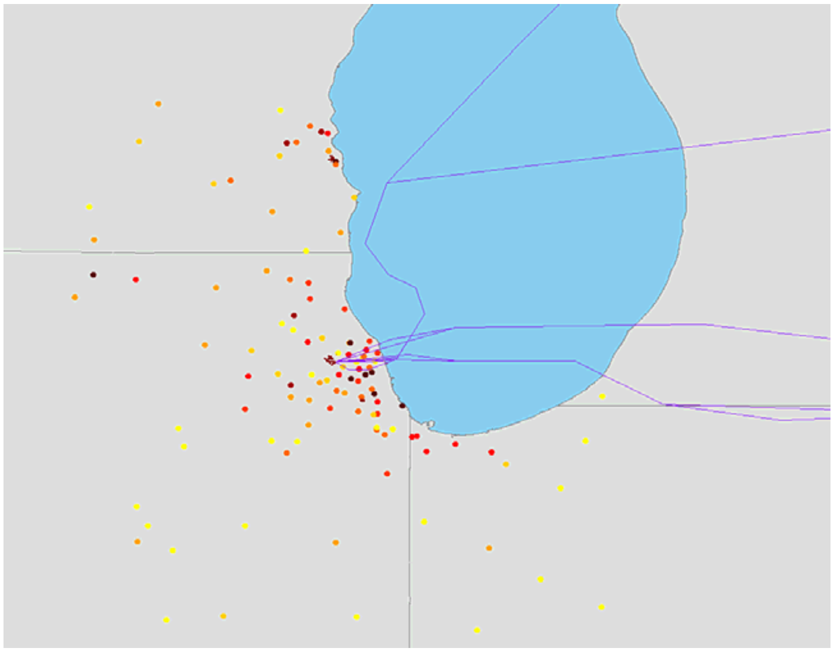
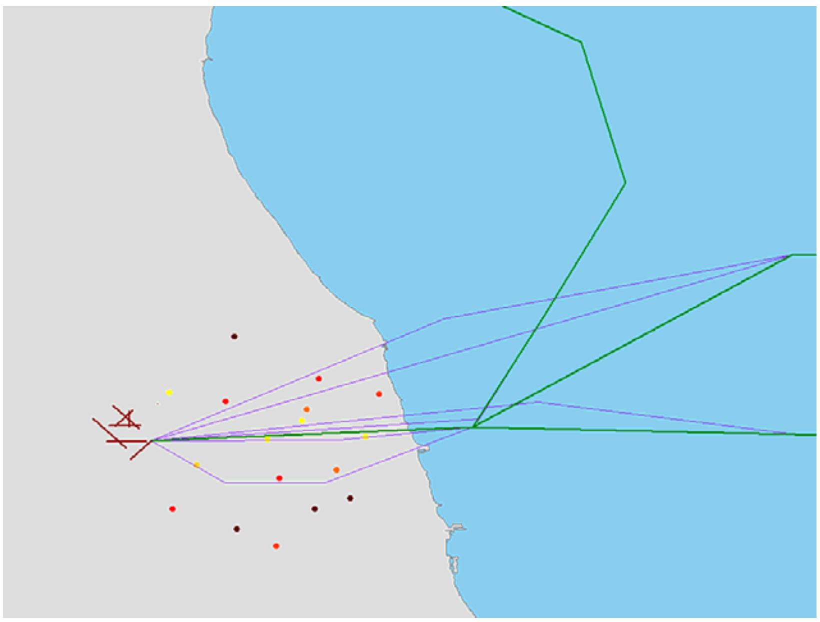


Figure 3- Airport 2, Focused on Runway 1 Departure Tracks and Population Centroid Data, including Current (purple) and Proposed (green) Track Utilization



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	15	<=X<	22
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Figure 4 - Distribution of Population Noise Impacts: (a) Baseline vs. Growth, and (b) Baseline vs. Growth with New Ground Track Configuration

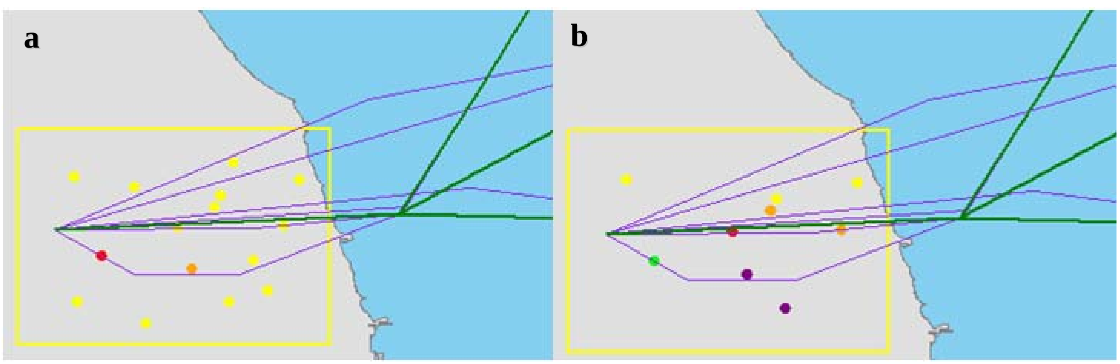

Figure 5 - Quantitative Population Noise Impacts: (a) Baseline vs. Growth, and (b) Baseline vs. Growth with New Ground Track Configuration