

TRANSPORTATION RESEARCH

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## Airport Modeling and Simulation for Environmental Analyses

### TRB 80th Annual Meeting Workshop

*Sponsored by the Committee on Airspace and Airfield Capacity and Delay*

**January 7, 2001  
Washington, D.C.**

#### **Editors**

**Jasenka Rakas, University of California, Berkeley  
Saleh Mumayiz, MITRE Corporation**

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# **Airport Modeling and Simulation for Environmental Analyses**

## **TRB 80th Annual Meeting Workshop**

**January 7, 2001  
Washington, D.C.**

Sponsored by

COMMITTEE ON AIRSPACE AND AIRFIELD CAPACITY AND DELAY (A1J05)

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# Workshop Introduction

**SALEH MUMAYIZ**

*The MITRE Corporation  
Committee Chair*

The Workshop on Airport Simulation for Environmental Analysis was organized by the Transportation Research Board (TRB) Committee on Airfield and Airspace Capacity and Delay (A1J05) and cosponsored by the TRB Task Force on Environmental Impacts of Aviation (A1J052); the workshop took place on January 7, 2001. The primary objective of the workshop was to provide a forum to demonstrate and discuss state-of-the-practice airport and airspace environmental evaluations using modeling and simulation tools. Major state-of-the art environmental simulation models—mainly for assessing the impacts of aircraft noise and emissions—and the recent applications of environmental impact studies were presented.

The workshop provides a hands-on environment to better understand how simulation techniques could be used to improve the quality of environmental assessments for airport and airspace. Presentations and ensuing discussions facilitate the coverage of benefits, intricacies, and advantages to analysts for adopting the simulation approach to conduct environmental assessment. Technical details, data requirements, and analysis methods and results from case studies are elaborated on and demonstrated. The workshop is conducted in an interactive and one-on-one format, with panels of experts comprised of software developers, simulation users, airport managers, environmental planners and analysts, airport consultants, and environmental models' sponsoring agencies, namely, FAA. Discussions covered assumptions, simulation models' types and logic, data requirements, management of relevant databases, modeling approaches and analytical techniques, study results, and conclusions vis-à-vis the utilization and implementation of models.

The attendees of this workshop include airport managers and environmental planners, airport engineers and planners, aviation–airport and environmental consulting firms, university and aviation center researchers, state aviation and airport authorities, and FAA staff in aviation–airport and environmental planning. They came from the United States, North and South America, Europe, and the Middle East.

## ACKNOWLEDGMENTS

The TRB Committee on Airfield and Airspace Capacity and Delay and the Workshop Organizing Committee would like to express their appreciation and gratitude to the individuals who contributed to the organization and success of this workshop. Acknowledgements are extended to Joseph Breen and Nancy Doten of the TRB staff for their tireless efforts and attentive involvement in the different stages of the organization. Particular gratitude and appreciation goes to Jasenka Rakas, member of the committee and coeditor, for her outstanding work and tireless effort to document this workshop as a TRB E-Circular. Special appreciation goes to the speakers and moderators of the workshop sessions for their time and efforts in ensuring the success of this activity.

## NEW APPROACH TO ENVIRONMENTAL MODELS

# Using Microscopic Airport Simulators to Estimate Aircraft Emissions at Airports

ANTONIO TRANI  
HOJONG BAIK

*Virginia Polytechnic Institute and State University*

This presentation addresses the application of microscopic simulation models to estimate aircraft emissions at airports.

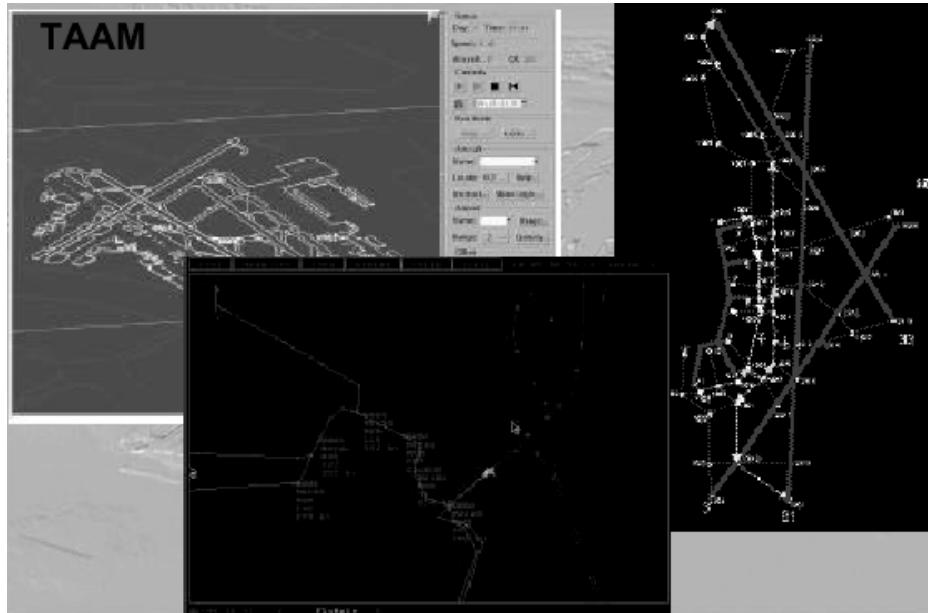
The primary goal of the research conducted at Virginia Polytechnic Institute and State University (Virginia Tech) is to quantify possible methods to compute aircraft emissions from various airport simulation models. The research team investigated two approaches (Figure 1): (a) microscopic aircraft modeling and (b) system dynamics lumped modeling.

The latest state-of-the-art emission models [such as the emission and dispersion modeling system (EDMS)] consider aggregated emissions of aircraft and ground service equipment (GSE) sources. However, better connections between airport simulation models and the EDMS are needed to estimate aircraft emissions around the airfield in a more dynamic and realistic way. Microscopic simulation models provide various outputs, which can be then used as inputs in an emission model (Figure 2). These outputs (Figure 3) include (a) aircraft operations for a given link, (b) aircraft queuing delays, (c) aircraft states such as speed and acceleration to estimate thrust setting and emission rates, and (d) gate times to derive the GSE and auxiliary power unit (APU) running times.

An aircraft emission rate model based on neural networks is discussed (Figure 4), and the application of the Gaussian dispersion model is presented (Figure 5). Several examples are

- The primary goal of this research effort was to quantify possible methods to quantify aircraft emissions from various airport simulation models
- Two approaches have been investigated:
  - Microscopic aircraft modeling
  - Systems Dynamics lumped model
- Due to time limitations in today's presentation, we will emphasize the use of microscopic airport simulation models

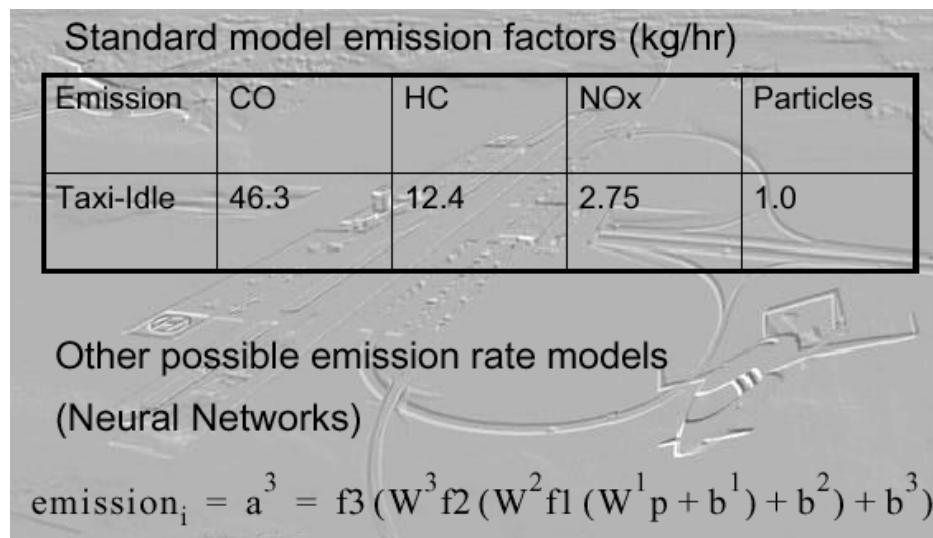
FIGURE 1 Virginia Tech's experimental models.



**FIGURE 2** Sample of microscopic simulation models  
(TAAM = total airport–airspace modeler).

- Aircraft operations for a given link (detailed time-space representation)
- Aircraft queueing delays (at links)
- Aircraft states (speed, acceleration, etc.) to estimate thrust settings and emission rates
- Gate times (to derive GSE and APU running times)

**FIGURE 3** Information from microscopic simulation models.

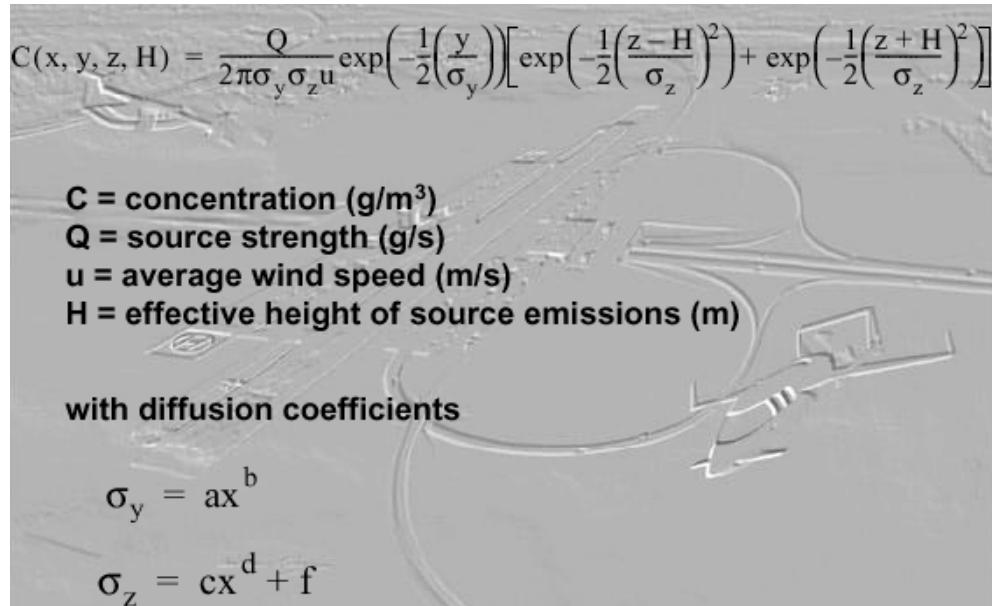


**FIGURE 4** Estimating aircraft emission rates (for a PW JT9-D engine).

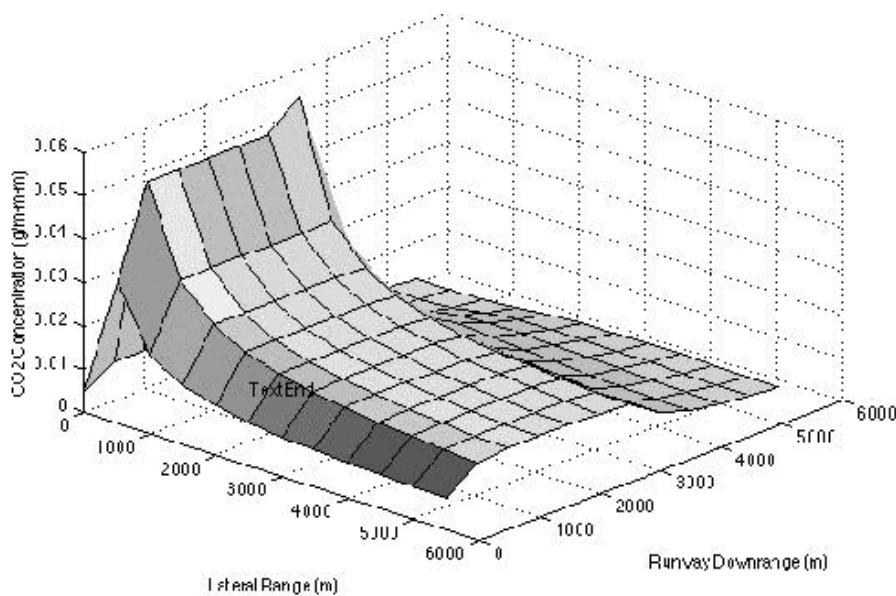
explained for aircraft landing operations. The examples show the sensitivity of airport pollution concentration during landing operations to a runway down range and lateral range (Figure 6).

The presentation ends with the conclusion (Figure 7) that there is a need to establish stronger ties between mesoscopic airport emission models and their microscopic counterparts.

Microscopic simulation models offer a wealth of information that, if properly parsed, contains all the inputs to mesoscopic emission models. Microscopic simulators offer the best alternative for quantifying aircraft dwell times and delays (over time and space) at an airfield, which would improve input in such models as the EDMS.



**FIGURE 5 Application of the Gaussian dispersion model.**



**FIGURE 6 Airport pollution computational examples during landing operations of a B747-200.**

- There is a clear need to establish stronger ties between mesoscopic airport emission models and their microscopic counterparts
- Microscopic simulation models offer a wealth of information that, if properly parsed, contains all the inputs to mesoscopic emission models
- Microscopic simulators offer the best alternative to quantify aircraft dwell times and delays over time and space at an airfield--this improves the input to models like EDMS

**FIGURE 7 Conclusions.**

[Click here to see Trani and Baik's entire slide presentation.](#)

## NEW APPROACH TO ENVIRONMENTAL MODELS

### Airport Simulation Model and Integrated Noise Model *A Simple Interface*

TUNG LE

LeTech, Inc.

This presentation describes the interface between LeTech's total airport simulation model (TASM) and FAA's integrated noise model (INM). The flow between the TASM and the INM is explained conceptually and applied to the Honolulu Airport (Figure 1). After that, two applications of the TASM-INM are discussed.

The first application describes a single wind scenario of the Honolulu Airport (Figure 2). First, Honolulu Airport routes are created and simulated using the TASM (or SIMMOD) (Figure 3). In the next step, INM tracks and flight operations from simulation results are generated using the TASM-INM export module (Figure 4). These tracks and flight operations are loaded into the INM, and the INM is used to generate INM noise contours (Figure 5). At the end, the noise contours are imported back to the TASM, using the TASM-INM import module (Figure 6).

The second application presents combined INM contour results for the Honolulu Airport for two wind scenarios: the TradeWind, which is present 95% of the time, and the KonaWind, which is present 5% of the time (Figure 7).

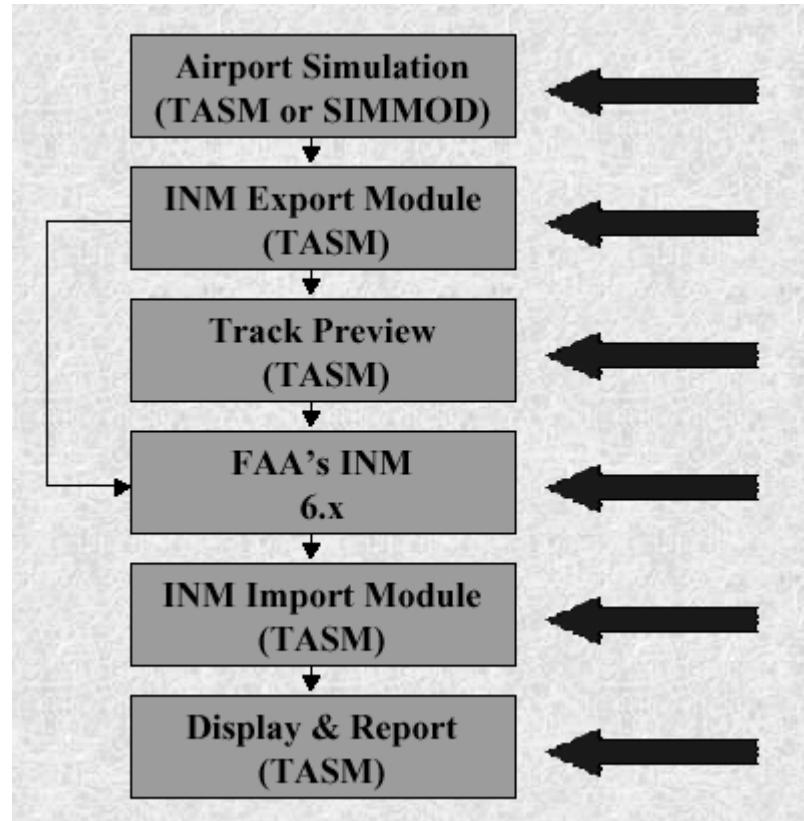
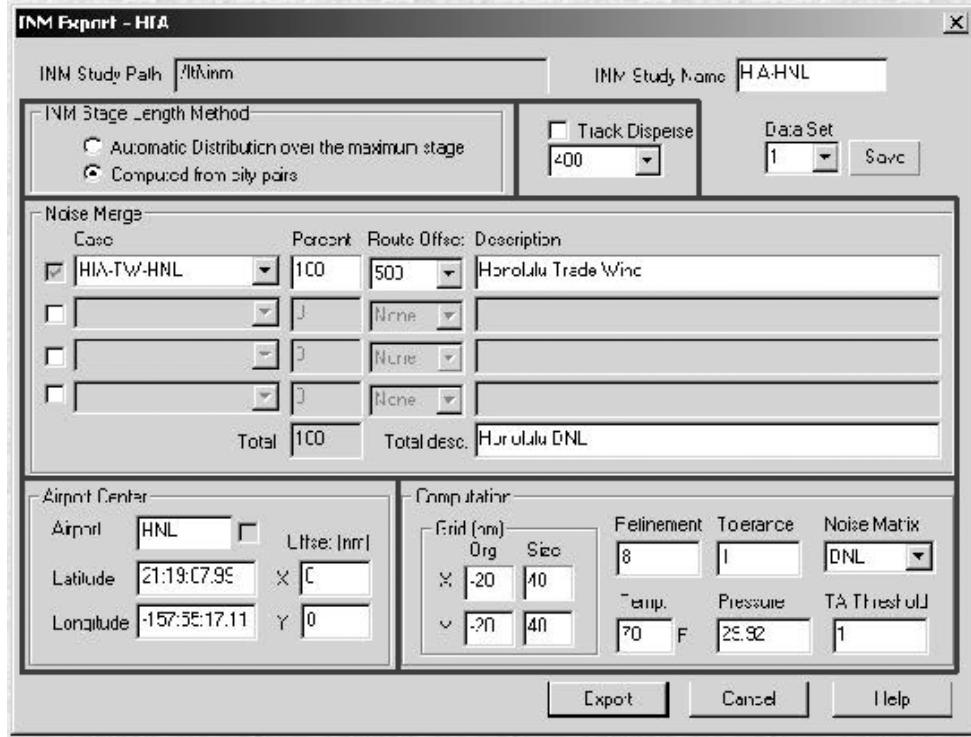
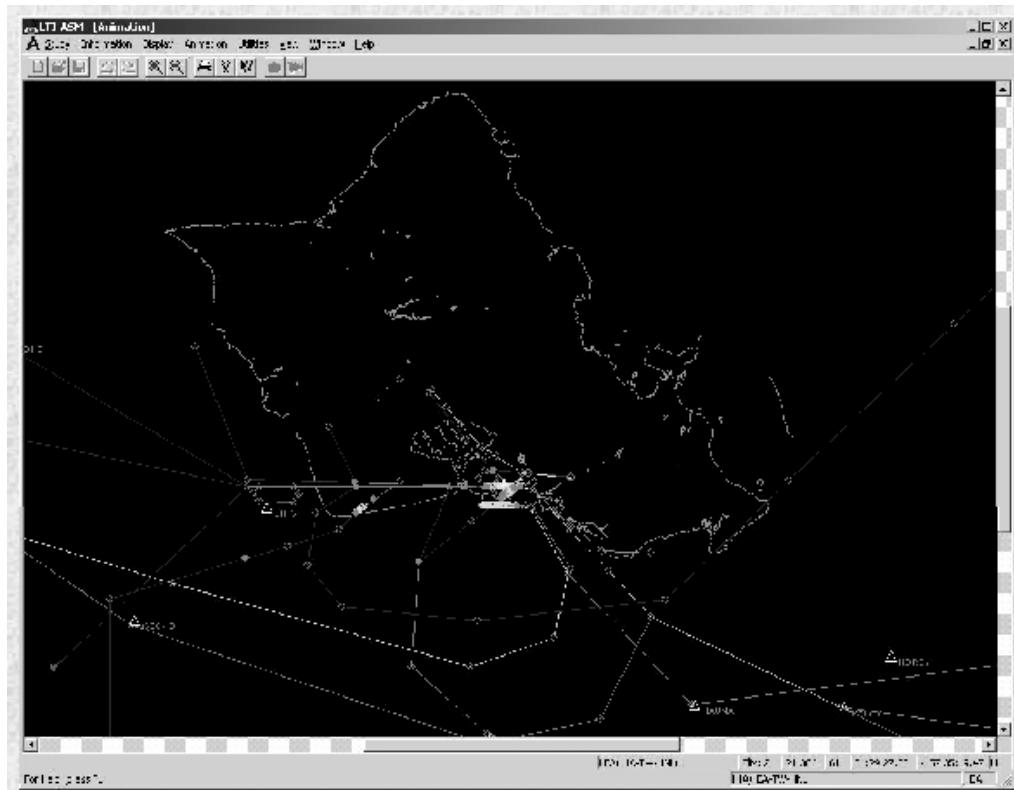


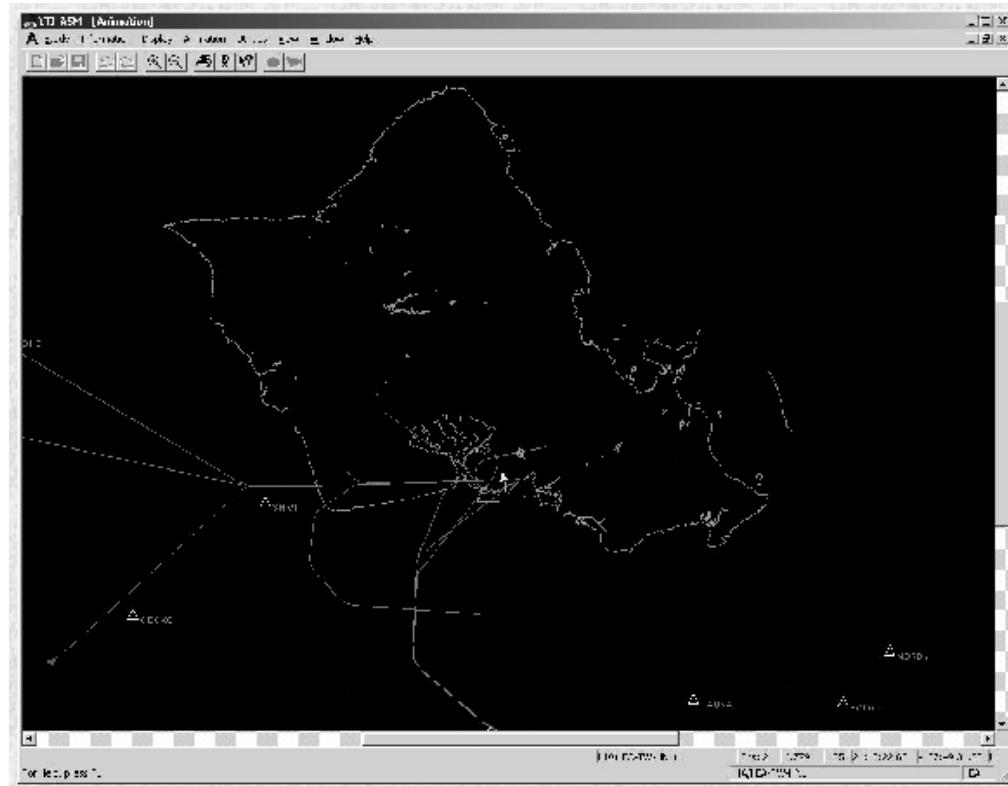
FIGURE 1 Flow process between TASM and INM.



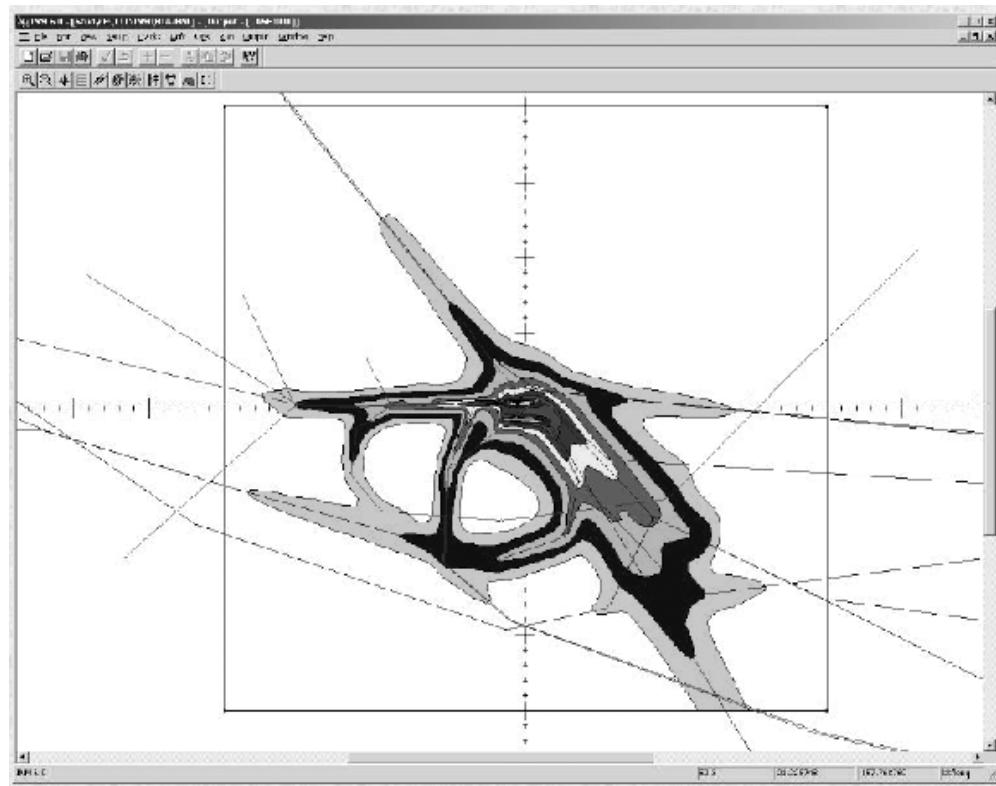
**FIGURE 2** INM export module: single scenario.



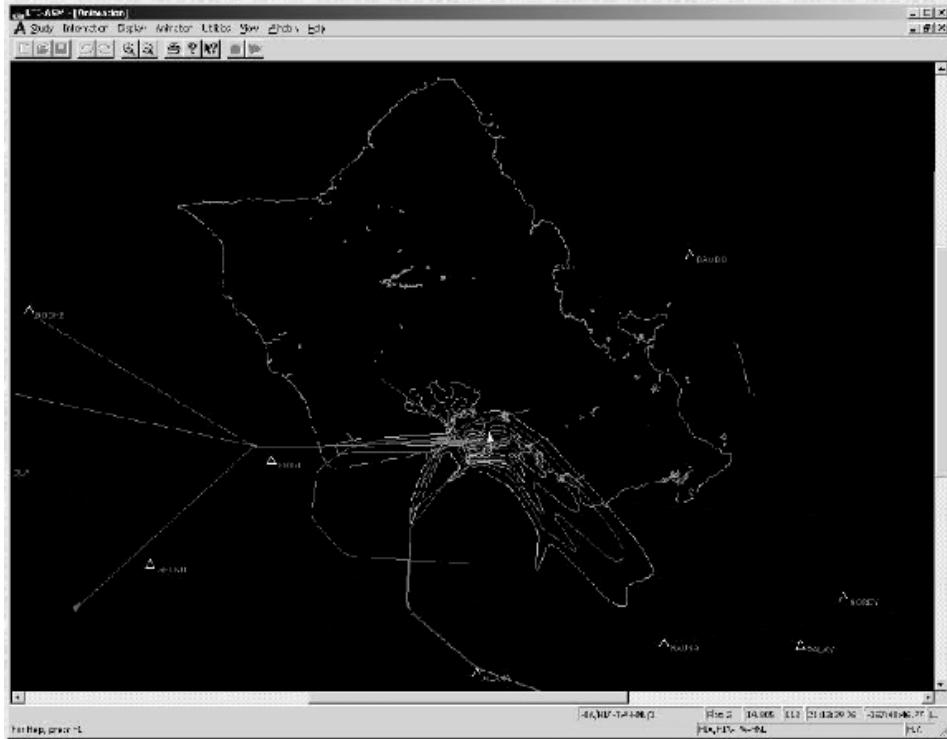
**FIGURE 3** Simulating routes and results in TradeWind scenario.



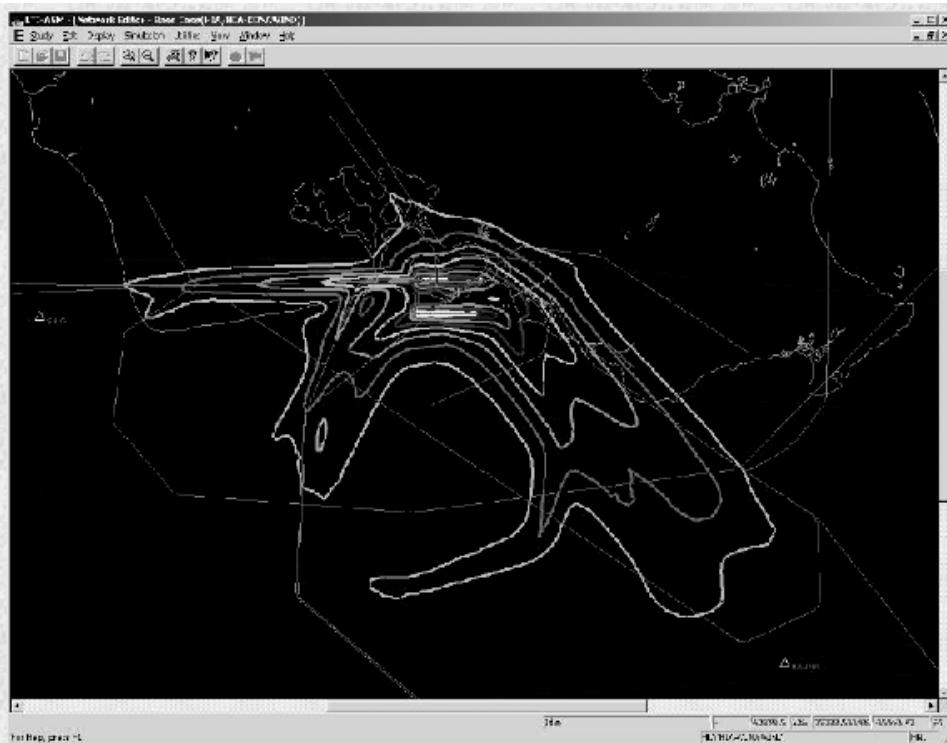
**FIGURE 4** Generation of INM tracks and flight operations from simulating results.



**FIGURE 5** Use of INM to generate noise contours.



**FIGURE 6 Import of INM contours for Honolulu Airport in TradeWind [day-night (sound) level (DNL)] scenario.**



**FIGURE 7 Combined noise contours for Honolulu Airport in TradeWind (95%) and KonaWind (5%) scenarios.**

- Noise at point using mouse cursor
- Population at point (grid area) using mouse cursor
- Demographics and population overlay (similar to INM)
- Noise contours area and population impact reports (similar to INM's reports)

**FIGURE 8 TASM's special tools.**

The presentation ends with a discussion about TASM's special tools (Figure 8), such as (a) the display of noise results at a specific point using a mouse cursor, (b) the display of the population count at a specific point (i.e., the grid area) using a mouse cursor, (c) demographics and population overlay (similar to the INM), and (d) noise contours area and population impact reports (similar to INM's reports).

[Click here to see Le's entire slide presentation.](#)

## NEW APPROACH TO ENVIRONMENTAL MODELS

# Application of Automobile Emissions Modeling to Airport System Planning

HESHAM RAKHA

KYOUNGHO AHN

ANTONIO TRANI

*Virginia Polytechnic Institute and State University*

This presentation discusses the use of the Metropolitan Model Deployment Initiative (MMDI) to evaluate automobile fuel consumption and emissions. The evaluation approach is explained in great detail, and the MMDI results are analyzed and compared with the field data.

A comprehensive analysis of the previously developed models indicates that the existing off-the-shelf tools cannot be used to compute automobile fuel consumption and emissions to support the MMDI (Figure 1). Instead, new tools have been developed to capture the complexity of the intelligent transportation system (ITS) impacts on traffic flows and to better model the interaction between traffic flow dynamics and demand (Figure 2).

The MMDI suggests computing second-by-second instantaneous speed and acceleration instead of computing vehicles miles traveled (VMT) by average speed and average speed emission factors [which is found in the existing model of MOBILE5 (vehicle emission modeling software) and the existing emission factor model (EMFAC)] (Figure 3).

Instantaneous fuel and emissions models are used for both field data and simulation analyses (Figure 4). The INTEGRATION 2.20 model is used for trip-based microscopic modeling of corridor-scaled networks with an ITS consideration (Figure 5). The mesoscopic traffic simulation model was used for the analysis of the MMDI in Seattle (Figure 6). The mesoscopic model produces average speed and number of stops per kilometer but does not produce instantaneous speed and acceleration. The microscopic fuel–emissions model is used to derive the mesoscopic

- Previous approaches that were deemed to be not acceptable for MMDI:
  - Computation/measurement of Vehicle Miles Traveled (VMT) by average speed followed by cross multiplication by average speed emissions factors (MOBILE5 & EMFAC).
  - Microscopic simulation of facility impacts without feedback to analysis of network demand.
- Bottom line:
  - Evaluation:
    - could not be performed with off-the-shelf tools.
  - Instead:
    - required development of new tools.

**FIGURE 1 Background: implications for MMDI.**

- Assessment of state-of-the-art was performed at expert panel held in January 1997:
- Main conclusions:
  - Complexity of ITS impacts on traffic flow:
    - requires analysis of second-by-second speed and acceleration
  - Corridor/Regional scope of ITS impacts on demand:
    - requires network rather than facility analysis
  - Interaction of traffic flow dynamics and demand:
    - requires feedback loop between second-by-second analysis and network demand analysis

**FIGURE 2 Background: state-of-the-art before MMDI.**

- In order to support consideration of second-by-second instantaneous speed and acceleration:
  - instrumented floating cars (with GPS) were driven through study area during before and after condition.
  - Second-by-second speed and position were measured directly.
  - Second-by-second acceleration were estimated from differences in successive speed measurements.
- In order to track network demand impacts:
  - mid-block as well as turning movement specific traffic counts were collected for the before and after condition.

**FIGURE 3 Evaluation approach: field data collection (GPS = Global Positioning System).**

- MMDI Evaluation budget/time frame limited:
  - Fuel and emissions instrumentation on floating cars:
    - at actual MMDI sites
    - in off-site lab setting
- Alternative experimental data sets considered:
  - Oak Ridge National Lab
  - Georgia Tech
  - UC Riverside
- Within MMDI evaluation time frame:
  - only ORNL data were made available for third party use.
- Instantaneous fuel and emissions models:
  - Used for both field data and simulation analysis.

**FIGURE 4 Evaluation approach: fuel consumption and emission estimations.**

- Trip-based microscopic modeling of corridor scaled networks while considering ITS:
  - INTEGRATION 2.20 simulation model:
    - Only practical option available at time of study.
- Implementation of energy/emissions relationships:
  - Every second during the simulation:
    - Determine speed and acceleration of every vehicle, and
    - Determine instantaneous fuel consumption and emissions.
- Additional extensions:
  - Fraction of vehicles considered as cold-starts, and
  - Fraction of vehicles considered as high emitters.

**FIGURE 5 Evaluation approach: microscopic modeling.**

- Microscopic model:
  - Utilized for MMDI evaluation in Phoenix/San Antonio.
- Analysis of MMDI in Seattle by Mitretek:
  - Utilized mesoscopic traffic simulation model,
  - Coupled to regional demand model.
  - Mesoscopic model produced:
    - Average speed and number of stops per km, but
    - Not instantaneous speed and acceleration.
- To improve consistency of results for Seattle:
  - Microscopic fuel/emissions model was utilized to derive mesoscopic fuel/emissions model:
    - Similar fleet and similar assumptions.

**FIGURE 6 Evaluation approach: mesoscopic modeling.**

fuel-emissions model (which has a similar fleet and similar assumptions) and to improve result consistency in the Seattle case study.

The presentation concludes that the microscopic energy and emission models are consistent with the Oak Ridge National Laboratory (ORNL) data, sensitive to instantaneous speed and acceleration, and consistent with the Environmental Protection Agency's (EPA) fuel consumption estimates (Figure 7). These models can be applied directly to Global Positioning System (GPS) field data or incorporated into the INTEGRATION 2.20 model. Number of vehicle stops and average speed are considered in the mesoscopic model and are consistent with the microscopic model.

- Micro energy and emission models:
  - sensitive to instantaneous speed and acceleration
  - consistent with ORNL data
  - consistent with EPA fuel consumption estimates
  - emission estimates of same order of magnitude as MOBILE5a
  - differences in trends associated with different driving cycles between MOBILE5a and model under investigation
  - can be applied directly to GPS field data:
    - data smoothing may be required
  - incorporated within INTEGRATION 2.20
- Meso model:
  - considers number of vehicle stops and average speed
  - consistent with micro model

**FIGURE 7 Conclusions.**

[\*\*Click here to see Rakha, Ahn, and Trani's entire slide presentation.\*\*](#)

## NEW APPROACH TO ENVIRONMENTAL MODELS

### Recent Advances in Aviation Noise Modeling

KENNETH PLOTKIN

*Wyle Laboratories*

This presentation discusses recent advances in aviation noise modeling, reviews the traditional approaches to noise modeling (Figure 1), lists current simulation models for the analysis of noise, and demonstrates the NoiseMap simulation model (NMSIM) and NMSIM-generated animation of air tour aircraft noise over the Grand Canyon.

The traditional approach to noise modeling relies on (a) integrated models [such as the integrated noise model (INM) and NMSIM], (b) a database of noise from complete straight-line flyovers (with real measurements and preparation of noise-power-distance (NPD) curves that are fairly sophisticated), (c) a basic sound exposure level (SEL) metric, (d) complex paths that apply “noise fraction” to segments (based on highly idealized sources and propagation), and (e) physics in models that are surprisingly unsophisticated [Society of Automotive Engineers (SAE) 1845, 1751].

Suggested general improvements to technology include the following: (a) replace simple algorithms (e.g., 1751 lateral attenuation) with modern models, (b) make use of modern air absorption standards, (c) incorporate spectra in routine use of models, (d) account for terrain and topography, and (e) account for the weather (Figure 2).

The presentation also classifies current simulation models by different categories (Figure 3). Some models are used for airport noise analysis, such as FLULA (developed in Switzerland). Other models are used for research and development (R&D) but are commonly used in airport studies [e.g., the Danish airport noise simulation model (DANSIM)]. The Rotorcraft noise model (RNM), developed by Wyle Laboratories for NASA and the Department of Defense (DoD), is used for helicopter noise analysis. The NMSIM is now used directly for noise analyses.

- Integrated models (INM, NoiseMap)
- Database of noise from complete straight line flyovers
  - Real measurements
  - Preparation of NPD curves fairly sophisticated
- Basic metric is SEL, sum to  $L_{dn}$
- Complex paths apply “noise fraction” to segments
  - Based on highly idealized source, propagation
- Physics in models is surprisingly unsophisticated
  - SAE 1845, 1751

**FIGURE 1 Traditional approach to noise modeling.**

- Replace simple algorithms (e.g., 1751 lateral attenuation) with modern models
- Make use of modern air absorption standards
- Incorporate spectra in routine use of models
- Account for terrain, topography
- Would like to account for weather

**FIGURE 2 General improvements to technology.**

- FLULA (Switzerland) – used for airport noise analysis
- DANSIM (Denmark) – used for R&D, airport studies
- RNM (Rotorcraft Noise Model) – Developed by Wyle for NASA and DoD for helicopter noise analysis
- NMSIM (NoiseMap Simulation Model) – Originally R&D adjunct to NoiseMap, now used directly for noise analysis

**FIGURE 3 Current simulation models.**

NMSIM (Figure 4) began as a test bed for the validation of algorithms for propagation over terrain and was then used in the planning of the INM validation studies. The model was directly applied to complex situations in national parks to support studies of aircraft noise on wildlife. The model is also used for aircraft accident investigations.

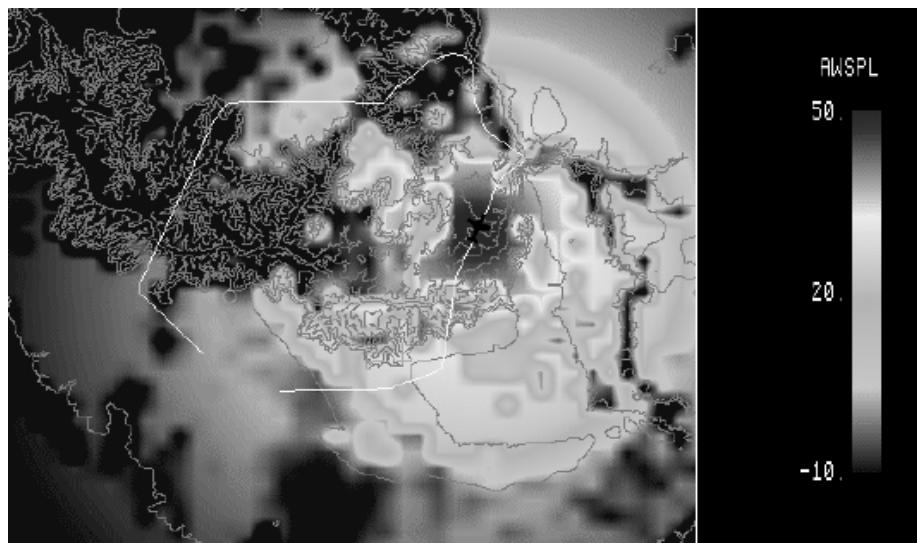
At the end of this presentation, a demonstration of the NMSIM for an air tour flight over the Grand Canyon is presented (Figures 5 and 6).

- Began as a test bed for validation of algorithms for propagation over terrain
- Used in planning of INM validation studies
- Test of integrated model algorithms, such as noise fraction
- Analysis of weather effects on footprints
- Direct application to complex situations in National Parks
- Support of studies of aircraft noise on wildlife
- Accident investigation

**FIGURE 4 NMSIM origins, evolution, and applications.**

- A demonstration of NMSIM for an air tour flight over the Grand Canyon was presented
- A NMSIM-generated animation of air tour aircraft noise over the Grand Canyon was played. The final slide shows a frame from that animation.

**FIGURE 5 NMSIM applied to the Grand Canyon.**



**FIGURE 6 NMSIM-generated animation of air tour aircraft noise over the Grand Canyon.**

[Click here to see Plotkin's entire slide presentation.](#)

## AIRPORT ENVIRONMENTAL ANALYSIS: FAA PERSPECTIVE

### Aviation Noise Abatement Policy 2000

PATRICIA CLINE

*Office of Environment and Energy, FAA*

This presentation reviews the original Aviation Noise Abatement Policy (ANAP), published by the Department of Transportation (DOT) in 1976, and discusses the latest ANAP issues and goals. On the basis of DOT's policy statement, these issues and goals will help create the FAA's aviation noise policy guidelines.

The original ANAP, which provided the first course of action for reducing the impact of aviation noise on neighboring communities, caused a dramatic reduction in the number of Americans adversely exposed to aviation noise. As aircraft traffic increased and airports expanded over the years, airport noise increased at many airports. As a result, DOT reviewed the previous policy and issued a new policy statement. This new statement broadly addresses noise concerns and was used as a basis for FAA's aviation noise policy guidelines (Figures 1 and 2).

On July 14, 2000, FAA published a proposed policy document in the *Federal Register*; by the end of October, it had obtained approximately 500 comments. In the next step, these comments were evaluated and used in the development of a comprehensive DOT policy statement and in the FAA guidance document.

- In 1976, DOT published its Aviation Noise Abatement Policy.
  - Provided a course of action for reducing aviation noise impact.
  - Resulted in dramatic reduction in the number of Americans adversely exposed to aviation noise.
- DOT undertaking a review of the policy:
  - DOT will issue policy statement broadly addressing noise concerns.
  - FAA will issue aviation noise policy guidelines based on DOT's policy statement.

**FIGURE 1 Background on the policy and the review.**

- July 14, 2000 - FAA published proposed policy document in Federal Register
  - Comment period extended to October 23, 2000.
  - Approximately 500 comments received.
- Comments will be evaluated, along with other inputs, in the development of a comprehensive DOT policy statement and FAA guidance document.

**FIGURE 2 Requesting and evaluating comments.**

- Reaffirms and incorporates major tenets of the 1976 policy.
- Seeks to build upon the Airport Noise and Capacity Act of 1990 and meet challenges of 21st century.
- Reaffirms Day/Night Sound Level (DNL) as appropriate measure.

**FIGURE 3 Major points of proposed policy.**

The major points of the proposed policy document (Figure 3) were to (a) reaffirm and incorporate major tenets of the 1976 policy, (b) seek to build on the Airport Noise and Capacity Act of 1990 and meet the challenges of the 21st century, and (c) reaffirm the day-night (sound) level (DNL) as an appropriate measure.

The 2000 ANAP defined six goals (Figures 4, 5, and 6). The first goal is to continue aircraft source-noise reduction and develop more stringent noise standards. The second goal is to use new technologies to mitigate noise impacts, such as the Global Positioning System (GPS), automated flight guidance, and free flight. The third goal encourages the development of

- Continue aircraft source-noise reduction
  - Secretary's flagship initiative - to develop more stringent noise standards
- Use new technologies to mitigate noise impacts
  - GPS, automated flight guidance, free flight
- Encourage development of compatible land use in areas of significant noise exposure
  - Prevent new noise sensitive land uses from becoming established in these areas through stronger state & local land use commitments

**FIGURE 4 First three goals of the 2000 ANAP.**

- Design air traffic routes and procedures to minimize aviation noise impacts
  - Areas beyond legal jurisdiction of airport proprietor
  - Consistent with safe and efficient use of the navigable airspace
- Provide specific consideration to locations with unique noise sensitivities
  - National Parks
  - National wildlife refuges
  - Other Federally managed areas

**FIGURE 5 Next two goals of the 2000 ANAP.**

- Ensure strong financial support for noise compatibility planning and mitigation projects
  - 1976 Policy opened door to Federal funding
    - CFR Part 150 Programs
    - Noise set-aside in AIP funding
  - Use of PFCs to fund noise mitigation
  - Future reliable sources of funding
  - Exploration of innovative finance programs & public/private partnerships

**FIGURE 6 Final goal of the 2000 ANAP (CFR = *Code of Federal Regulations*; PFCs = passenger facility charges).**

compatible land use in areas with significant noise exposure. Such a development prevents new noise sensitive land uses from becoming established in these areas through stronger state and local land use commitments. The fourth goal is to design air traffic routes and procedures to minimize aviation noise impacts in areas beyond the legal jurisdictions of the airport proprietor, which is consistent with the safe and efficient use of navigable airspace. The fifth goal provides specific consideration to locations with unique noise sensitivities, such as at national parks, national wildlife refuges, and other federally managed areas. The last goal ensures strong financial support for noise compatibility planning and mitigation projects.

For the next steps, the FAA will need to summarize comments, identify and respond to major issues, and formulate a final policy document (Figure 7). The presentation ends with the conclusion that the quality of the final policy document depends on technological advances, solid airport noise-compatibility programs, strong land use commitments, noise-responsible airspace management, and adequate financial resources (Figure 8).

- Summarize comments
- Identify major issues
- Respond to major issues
- Formulate final policy document

**FIGURE 7 Next steps.**

- Comprehensive update to 1976 Policy
- Task to be shared by government, aviation industry & citizens
- Solutions depend on:
  - technological advances
  - solid airport noise compatibility programs
  - strong land use commitments
  - noise-responsible airspace management
  - adequate financial resources

**FIGURE 8 Summary.**

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## AIRPORT ENVIRONMENTAL ANALYSIS: FAA PERSPECTIVE

### Integrated Noise Model

JOHN GULDING

*Office of Environment and Energy, FAA*

The main objective of this presentation is to provide information about the efforts, policy studies, and products of the Noise Division in the FAA's Office of Environment and Energy (AEE-100).

The AEE-100 (Figure 1) develops aviation noise standards, provides measurements, and predicts aviation noise by developing tools for quantifying the predicted impact. In addition, this division evaluates new aircraft engines and operating procedures and formulates research and development (R&D) objectives to reduce aviation noise.

The AEE-100 divides its policy studies into three groups (Figure 2). The first group of studies includes research that reduces noise at the source. These studies involve NASA's R&D of engine-airframe technology and its transition to a Stage 3 aircraft fleet. The second group

- Develop Aviation Noise Standards
- Measurement and Prediction of Aviation Noise
  - Develop Tools for Quantifying the Predicted Impact
- Evaluate New Engines and New Procedures
- Formulate R&D Objectives to Reduce Noise
  - Source Noise
  - Operating Procedures
  - Land Use Planning

FIGURE 1 Noise Division (AEE-100) main objectives.

- Reduce Noise at the Source
  - NASA R&D Efforts, Engine/Airframe Technology
  - Transition to Stage 3 fleet
- Operational Mitigation Strategies
  - Noise Abatement Departure Procedures
  - Preferential Flight Tracks and Runways
- Land Use Planning
  - Identify Non-Compatible Land Use

FIGURE 2 Quantifying noise exposure: example of policy studies.

includes studies of operational mitigation strategies and develops improved noise-abatement departure procedures and preferential flight tracks. The third group focuses on land use planning and helps with the better identification of noncompatible land use.

Noise analysis is measured in day–night (sound) levels (DNLs), in which night operations include an additional 10-dB penalty (Figure 3). The calculation of noise for an average annual day includes three types of modeling. The first type includes all airport configurations and captures noise intensity and frequency of occurrence. The second type involves the modeling of specific airframe engine combinations, such as Stage 2, HushKit Stage 3, and Stage 3. The third type of modeling includes changes in the aircraft climb power setting and involves aircraft weight and procedures.

Environmental noise analyses (Figure 4) offer the disclosure of the noise impacts and identify any significant impacts (e.g., increase in number of people subjected to a DNL of 65 or higher, 1.5-dB changes above 65). These analyses can also identify controversial actions, such as environmental impacts outside the 65 DNL zone, 3-dB changes from 60 to 65, and 5-dB changes from 45 to 60.

- Impact Measured in Day/Night Sound Level (DNL)
  - 10 dB Penalty for Night Operations
- Average Annual Day
  - All Airport Configurations Modeled
  - Capture Noise Intensity & Frequency of Occurrence
- Model Specific Airframe Engine Combinations
  - Stage 2, HushKit Stage 3, Stage 3
- Model Changes in Aircraft Climb Power Setting
  - Aircraft Weight, Procedures

**FIGURE 3** Noise analysis basics.

- Disclosure of the Noise Impacts
  - Base Case Versus Alternative for Various Out-Years
- Identify any Significant Impacts
  - Increase Number of People Above 65 DNL
  - 1.5 dB changes above 65
- Identify any Controversial Actions
  - Impacts Outside 65 DNL
  - 3 dB Changes from 60-65, 5 dB Changes 45-60

**FIGURE 4** Environmental noise analyses.

The FAA's noise modeling tools include the integrated noise model (INM) and the heliport noise model (HNM) (Figure 5). The INM has a wide distribution and is available in Windows 95, 98, and 2000 (Figures 6 and 7). The FAA provides (a) the user's guide and technical manual, (b) a web page, (c) model updates, (d) technical support, and (e) commercial training courses.

The latest version of the INM includes several new types of aircraft manufactured by Aerospatiale, Embraer, Gulfstream, Cessna, and Boeing (Figure 8). The recent updates include (a) associate noise-power-distance (NPD) data with a spectral class (separate NPD takeoff and approach curves and the atmospheric absorption rate based on SAE-ARP-866A); (b) expanded sets of performance coefficients (performance after the engine breakpoint temperature); and (c) an expanded set of procedures for A320, A330, and A340 aircraft (Figure 9).

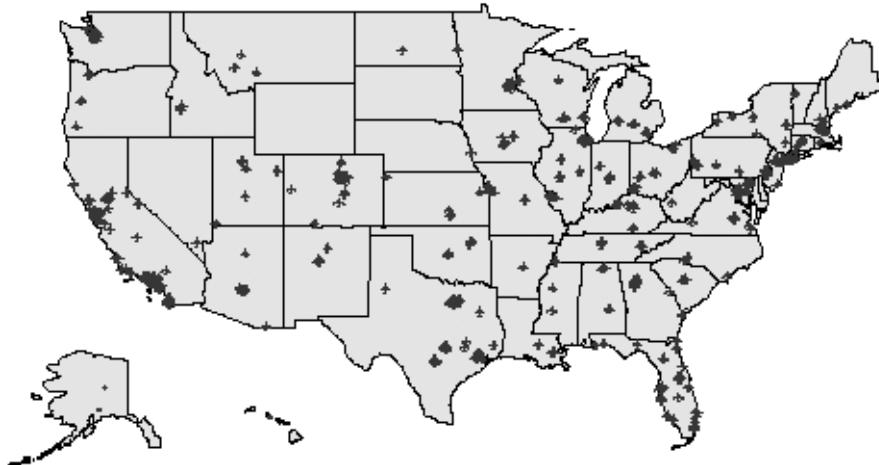
The Noise Division's new goals for the INM and the HNM are discussed at the end of this presentation (Figure 10). Future work will (a) reaffirm and update the Society of Automotive Engineers (SAE) documents, (b) expand the INM database, (c) begin assessing noise monitor data, and (d) continue research in modeling helicopter operations.

- **Integrated Noise Model (INM)**
  - Model Specified in FAA Part 150 and FAA Order 1050
  - Lead Technology for Other Models
  
- **Heliport Noise Model (HNM)**
  - Helicopter Specific Propagation Algorithms

**FIGURE 5** FAA noise-modeling tools.

- Wide Distribution
- Available in Windows 95, 98, 2000
- User's Guide and Technical Manual
- Web Page for Information and Model Updates
  - <http://www.aee.faa.gov/aee-100/inm>
  - Technical Support Provided
- Commercial Training Courses Available

**FIGURE 6** INM benefits.



**FIGURE 7** Distributed to over 650 organizations, INM is the most popular model of its kind in the world.

- **Aerospatiale, Embraer, Gulfstream – Full Program**
  - A320, A330, A340 in INM 6.0b
  - Fully Developed Gulfstream Fleet
- **Cessna**
  - Citation Bravo, CNA172, and CNA206 Models in INM 6.0b
- **Boeing**
  - 737-700 Included in INM 6.0b
- **NASA/FAA Research Project**
  - Bombardier, Cessna Business Jets, and SAAB

**FIGURE 8** New aircraft.

- **Associate NPD Data with a Spectral Class**
  - Separate NPD Takeoff and Approach Curves
  - Atmospheric Absorption Based on SAE-ARP-866A
- **Expanded Sets of Performance Coefficients**
  - Performance After the Engine Breakpoint Temperature
- **Expanded Set of Procedures**
  - A320, A330, and A340 Provided ICAO A and ICAO B for same weight

**FIGURE 9** Recent updates.

- Reaffirm and Update the SAE Documents
- Expand INM Database - Projects with Industry
- Begin Assessing Noise Monitor Data
- Continued Research in Modeling Helicopter Operations

**FIGURE 10 INM goals.**

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## AIRPORT ENVIRONMENTAL ANALYSIS: FAA PERSPECTIVE

### Emissions and Dispersion Modeling System *Current Status and Future Plans*

JULIE ANN DRAPER

*Office of Environment and Energy, FAA*

This presentation reviews the emissions and dispersion modeling system's (EDMS) current capabilities and discusses future research and development plans for the EDMS.

Version 3.22 of this model is currently used for emissions inventory and dispersion modeling of airport sources (Figure 1). The model mainly focuses on aviation sources, which include aircraft, auxiliary power units (APUs), and ground support equipment (GSE). The model compiles with Environmental Protection Agency (EPA) methodologies and with publicly available data issued by the International Civil Aviation Organization (ICAO), EPA, manufacturers, airlines, and FAA. The latest version of this model has a sound–user interface and guidance and is highly automated.

Year 2001 capabilities include (a) improved aircraft performance data, (b) new EPA air dispersion model (AERMOD) algorithms, (c) the AERMOD meteorological preprocessor (AERMET) wizard, (d) updated and expanded manufacturers' APU data, (e) the calculation of hydrocarbon (HC) concentrations, (f) a redesigned aircraft landing–takeoff (LTO) window, and (g) an updated user manual (Figure 2).

The 5-year research and development plan ([www.aee.faa.gov](http://www.aee.faa.gov)) outlines the model development and local air-quality research activities (Figure 3). The short-term plan includes enhanced GSE data and source coverage, advanced data import capability, aircraft particulate matter (PM) estimates, and increased user flexibility. The long-term plan includes enhanced modeling accuracy, aircraft PM estimates, dynamic flight profile generation, and enhanced chemistry (Figure 4).

This 5-year plan focuses on five research and analysis areas (Figures 5 and 6). The first area includes further evaluation of the AERMOD algorithms for the EDMS. The short-term evaluation involves rigorous testing of algorithmic performance; the long-term involves advanced evaluation and refinement and alternative modeling concepts. The second research

- Emissions Inventory & Dispersion Modeling
- All Airport Sources w/ Focus on Aviation Sources (Aircraft, APUs, GSE)
- Compilation of EPA Methodologies & Publicly Available Data
  - Methodology: EPA
  - Data: ICAO, EPA, Manufacturers, Airlines, & FAA
- Automation, User Interface, & Guidance

FIGURE 1 Current EDMS capability.

- Aircraft Performance Data
- New EPA AERMOD Dispersion Algorithms
- AERMET Wizard
- Updated and Expanded Manufacturer APU Data
- Calculation of HC Concentrations
- Redesigned Aircraft LTO Window and Other User Flexibility Improvements
- Updated User Manual

FIGURE 2 Year 2001 capabilities.

**Outlines model development and local air quality research activities planned over the next 5 years**

**3 Fiscal Year Time Periods:**

- 2001
- 2002-2003
- 2004-2005

FIGURE 3 Five-year plan: research and development.

<b><u>Short-Term</u></b>	<b><u>Long-Term</u></b>
<b>Enhanced GSE Data &amp; Method</b>	<b>Enhanced Modeling Accuracy</b>
<b>Enhanced Source Coverage</b>	<b>Aircraft PM</b>
<b>Advanced Data Import Capability</b>	<b>Enhanced/Dynamic Flight Profile Generation</b>
<b>Aircraft PM Estimate</b>	<b>Enhanced Chemistry</b>
<b>Increased User Flexibility</b>	

FIGURE 4 Five-year plan: model development.

- **Evaluation of AERMOD Dispersion Algorithms for EDMS**
  - Short-term: rigorous testing of algorithmic performance
  - Long-term: advanced evaluation/refinement & alternative modeling concepts
- **Validation of EDMS with AERMOD Dispersion**
  - Short-term: rigorous exercising of EDMS & 2 field measurement efforts
  - Long-term: analysis, refinement, additional measurements

FIGURE 5 Five-year plan: research and analysis.

- **Enhanced Aircraft Performance Methodologies**
  - Short-term: refinements to static approach in 4.0
  - Long-term: dynamic flight profile generation
- **Methods for Computing Aircraft PM Emissions**
  - Short-term: first order approximation
  - Long-term: activity/coordination aimed at filling EF gap
- **Air Quality Screening Tool**
  - Short-term: prototype
  - Long-term: review, refinement, release

FIGURE 6 Five-year plan: more research and analysis.

area includes the validation of the EDMS with AERMOD. The short-term validation includes rigorous exercising of the EDMS and two field measurement efforts; the long-term validation involves further analysis, refinement, and additional measurements. The third research area deals with enhanced aircraft performance methodologies. Its short term includes refinements to the static approach in Version 4.0, but the long-term focuses on dynamic flight profile generation. The fourth area involves methods for computing aircraft PM emissions. The short-term deals with first-order approximations; the long-term contains activity and coordination aimed at filling the emission factor (EF) gap. The last research area focuses on the development of the air-quality screening tool. It is anticipated that in the short term, the prototype of this tool will be developed; in the long-term, this tool will be reviewed, refined, and released.

[Click here to see Draper's entire slide presentation.](#)

## AIRPORT ENVIRONMENTAL ANALYSIS: FAA PERSPECTIVE

### Airport Noise–Land Use Compatibility Initiative

**ASHRAF JAN**

*Community and Environmental Needs, FAA*

This presentation reviews the Land Use Planning Initiative (LUPI) and discusses the FAA's policy on airport noise and land use compatibility.

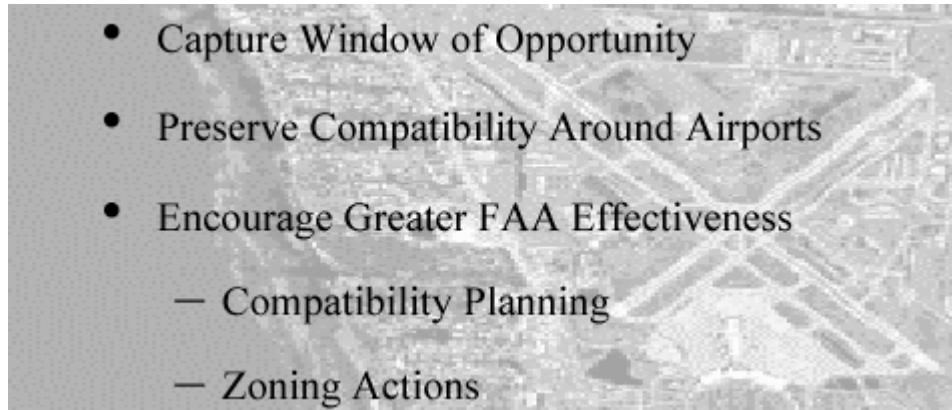
The LUPI's purpose is to develop processes to better influence land use planning and zoning around airports (Figure 1). Its team consists of (a) members from the FAA's Office of Environment and Energy (AEE), the Community and Environmental Needs Division (APP), the Planning and Analysis Division (ATA), and the General Council Office (AGC); and (b) the Management Oversight Committee (MOC). The objectives of this initiative are to preserve compatibility around airports and encourage greater FAA effectiveness in compatibility planning and zoning actions (Figure 2).

The short-term recommendations (Figure 3) deal with (a) the LUPI package for FAA regions and state aviation agencies, (b) land use information, and (c) the revision of FAA Order 1050.1D. Proposed mid-term recommendations (Figure 4) include (a) refined procedures on noise inquiry referrals, (b) effective means of promoting airport noise compatibility through land use planning and zoning, (c) enhanced performance of FAA personnel through additional information and training.

The short-term recommendations are documented in the FAA's Airport Noise Compatibility Planning Toolkit (Figure 5). This document was prepared by several agencies and FAA offices (Figure 6), including AEE, the Office of Airport Planning and Programming, the Air Traffic

- LUPI's Purpose - to develop processes to better influence land use planning & zoning around airports
- Team consisting of members from AEE, APP, ATA, AGC
- Management Oversight Committee (MOC)
- Federal Register Notice

**FIGURE 1 Land use planning initiative background.**

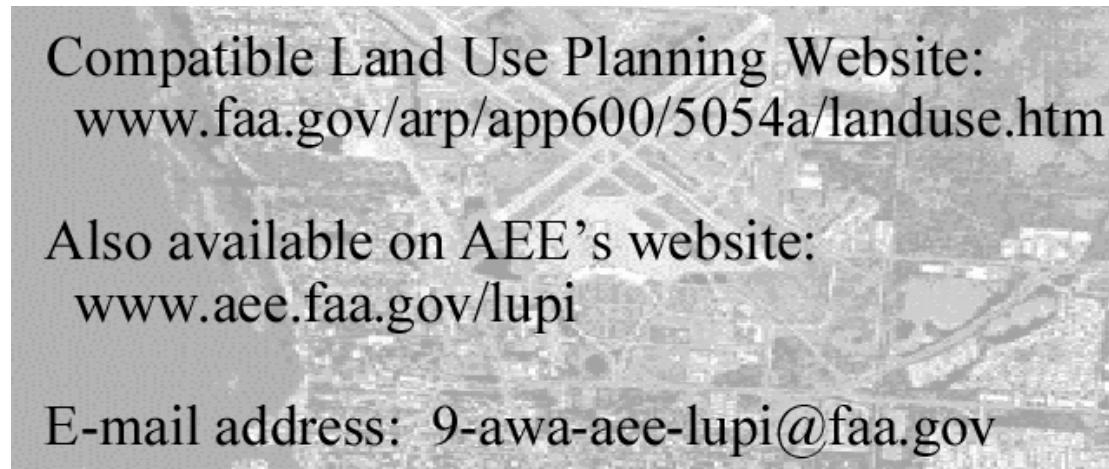
**FIGURE 2 Objectives.**

<u>Recommendation</u>	<u>Product</u>
S-1: Land Use Planning Information Package for FAA Regions	Airport Noise Compatibility Planning Toolkit [April 2000]
S-2: Land Use Planning Information Package for State Aviation Agencies	Airport Noise Compatibility Planning Toolkit [April 2000]
S-3: Land Use Information Clearinghouse	Website [September 1999] <a href="http://www.faa.gov/arp/app600/5054a/landuse.htm">www.faa.gov/arp/app600/5054a/landuse.htm</a>
S-4: Rapid response procedures to communicate FAA policies to public	Noise Inquiry Referral Procedures [Phase 1 - May 2000]
S-5: Revision to FAA Order 1050.1D to update & expand guidance	Change 4 to FAA Order 1050.1D [June 1999]

**FIGURE 3 Short-term recommendations.**

- M-1: Refine procedures on noise inquiry referrals.
- M-2: Amend 14 CFR part 150.
- M-3: Identify effective means of promoting airport noise compatibility through land use planning and zoning.
- M-4: Enhance performance of FAA personnel through additional information and training.
- M-5: Provide information about planning grants and clarify noise mitigation funding eligibility requirements.
- M-6: Routinely consult with airport noise issue stakeholders to improve compatible land use planning.

**FIGURE 4 Proposed mid-term recommendations  
(CFR = *Code of Federal Regulations*).**



**FIGURE 5** Compatibility land use planning toolkit Internet links.

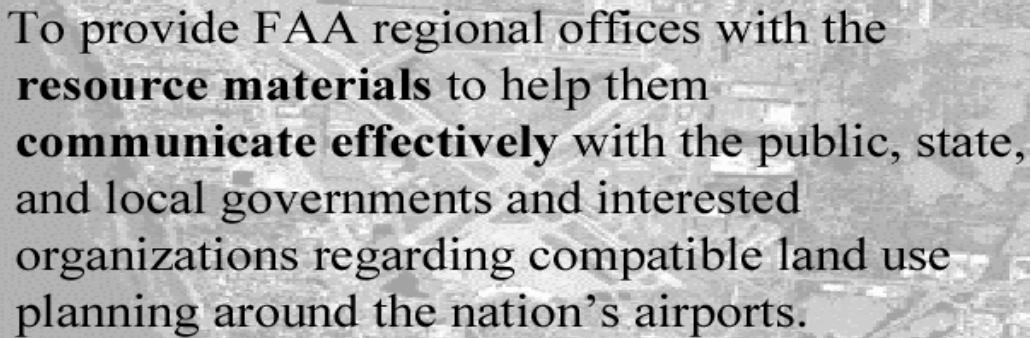
- Office of Environment & Energy
- Office of Airport Planning & Programming
- Air Traffic Airspace Management Program
- Office of Chief Counsel
- Southern Region Airports Division
- NASAO (*National Association of State Aviation Officials*)

**FIGURE 6** Agencies and FAA offices that prepared the toolkit.

Airspace Management Program, the Office of Chief Counsel, the Southern Region Airports Division, and the National Association of State Aviation Officials (NASAQ).

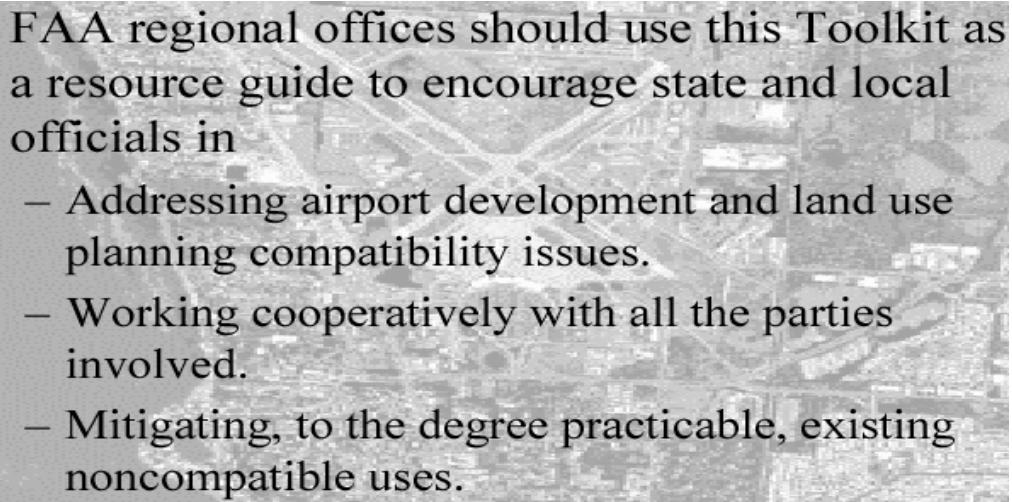
The purpose of the toolkit is to provide FAA regional offices with the resource materials to help them communicate effectively with state and local governments and the general public. The toolkit also helps other interested organizations regarding compatible land use planning around U.S. airports (Figure 7). It is recommended that FAA regional offices use this toolkit as a resource guide to encourage state and local officials in addressing airport development and land use planning compatibility issues. This toolkit also helps state and local officials to work cooperatively with other parties involved and mitigate existing noncompatible uses (Figure 8).

The toolkit contents include (a) FAA policies, regulations, and funding sources; (b) FAA guidance materials; (c) planning tools; (d) state and local noise-compatibility tools; and (e) communication tools (Figure 9).



To provide FAA regional offices with the **resource materials** to help them **communicate effectively** with the public, state, and local governments and interested organizations regarding compatible land use planning around the nation's airports.

FIGURE 7 Toolkit purpose.



FAA regional offices should use this Toolkit as a resource guide to encourage state and local officials in

- Addressing airport development and land use planning compatibility issues.
- Working cooperatively with all the parties involved.
- Mitigating, to the degree practicable, existing noncompatible uses.

FIGURE 8 Toolkit use.

- 
- Overview
  - FAA Policies, Regulations, & Funding Sources
  - FAA Guidance Materials
  - Planning Tools
  - State & Local Noise Compatibility Tools
  - Communication Tools
  - Additional Tools

FIGURE 9 Toolkit contents.

[Click here to see Jan's entire slide presentation.](#)

## APPLICATION OF AIRPORT ENVIRONMENTAL MODELS

# Integrated Analysis of Airport Operations, Airspace Design, and Environmental Impacts

**WILLIAM SWEDISH**

*The MITRE Corporation*

**JAWAD RACHAMI**

*Wyle Laboratories*

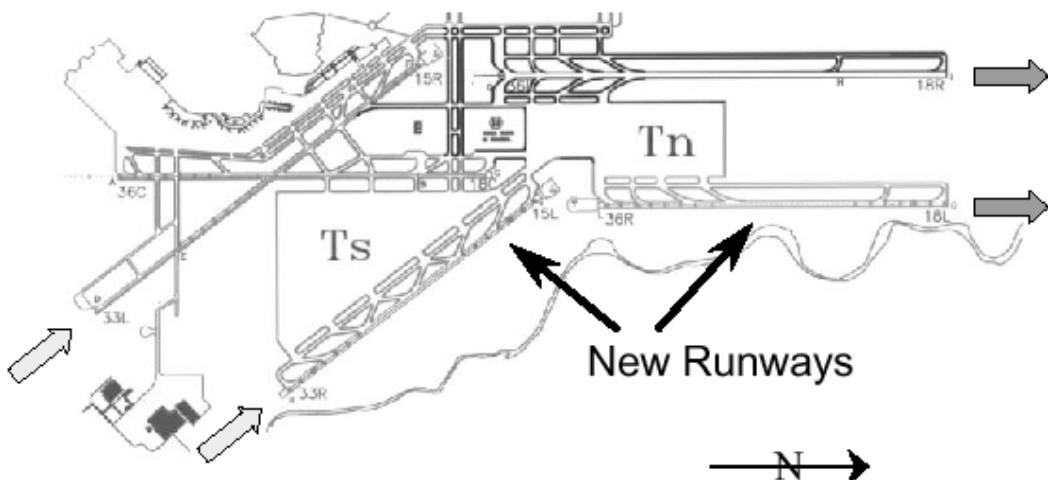
**ASHRAF JAN**

*Community and Environmental Needs, FAA*

## PART 1: POTENTIAL PROCEDURES TO REDUCE DEPARTURE NOISE AT MADRID'S BARAJAS AIRPORT

The first part of this presentation describes several procedural changes to reduce noise impact at Spain's Madrid Barajas Airport (MAD).

Two new runways, 33R/15L and 36R/18L (Figure 1), are proposed as a result of increased traffic demand. The proposed runways are parallel to existing Runways 33L/15R and 36R/18L. To minimize noise impact, several departure procedures are explored. The first procedure considers independent parallel operations according to the standard International Civil Aviation Organization (ICAO) and FAA departure procedures. Under these procedures, the departure tracks must diverge by 15° immediately after takeoff (Figure 2).

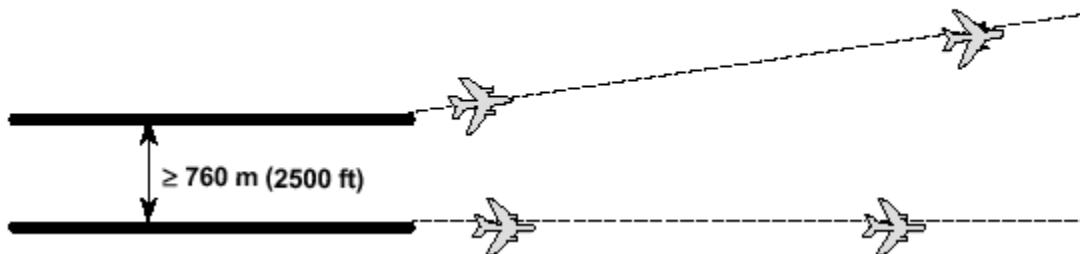


**FIGURE 1** Proposed runway configuration; predominant flow is northbound.

At MAD southbound departures have the greatest noise impact on the surrounding community at night (2300–0700) because of the southbound operations that exceed the permitted nightly noise level of 55 dBA (Figure 3). According to the study findings, only one runway should be used to reduce noise impact of these departures. It is also suggested that a new runway, 33R/15L, be built farther away from sensitive areas.

Several additional alternative procedures were developed for parallel departures as a response to traffic growth because a single runway cannot provide enough departure capacity at night (Figure 4). Compared with the standard procedures, varying departure flight paths may lower noise impact by reducing the divergence angle and avoiding populated areas or turning both aircraft in the same direction. However, the feasibility of such techniques at MAD is not assured.

The next procedure explores the reduction of the divergence angle for independent departures from the standard ICAO 15° divergence to 10° divergence (which is implemented at Toronto International Airport with a 3300-m runway spacing) and 5° divergence (Figure 5). Another considered procedure includes parallel departures for 5 nautical mi (NM; which is implemented at Paris' Charles de Gaulle Airport with a 3000-m runway spacing), but this



**FIGURE 2 Independent parallel departures: standard ICAO/FAA procedures.**

- 0 **Greatest noise impact would be due to southbound departures at night (2300-0700 local time),**
  - “Noise Impact” is population exposed to critical noise levels
    - = 65 dBA in daytime
    - = 55 dBA at night
  
- 0 **Recommendation: To reduce noise impact for these departures, use only one runway**
  - New Runway 15L, *farther away* from sensitive areas
  - Single departure track over open land
  - Less capacity, but demand is light

**FIGURE 3 Southbound departures.**

procedure would be possible only with positive course guidance [e.g., very-high frequency omnidirectional range (VOR) on a runway centerline].

The next procedure considers turning both departures in the same direction, that is, having independent departures with same-direction turns (Figures 6 and 7). This procedure is completely new [not explicitly covered by the ICAO Procedures for Air Navigation Services (PANS)] and requires more analysis and testing. Independent departures with same-direction turns require new procedures with enhanced safety. These departures would need a straight segment before a turn takes the aircraft closer to the noise-sensitive area.

The alternative concept suggests dependent departures with same-direction turns and a 60-s interval between departures on different runways, which would provide longitudinal separation (Figure 8). The advantages of dependent departures with same-direction turns are many. For example, the turns are not simultaneous (side-by-side), and the straight segment is not required. The procedure can also be implemented gradually by starting with a 60-s interrunway separation (for radar). Then it could be gradually reduced as pilots and controllers gain more experience and confidence.

- 0 As traffic grows, single runway may not provide enough departure capacity at night
- 0 Varying the departure flight paths may reduce noise impact compared to standard procedures
  - Reduce divergence angle to avoid populated areas, or
  - Turn both in same direction
- 0 Feasibility of such techniques at Barajas is not assured

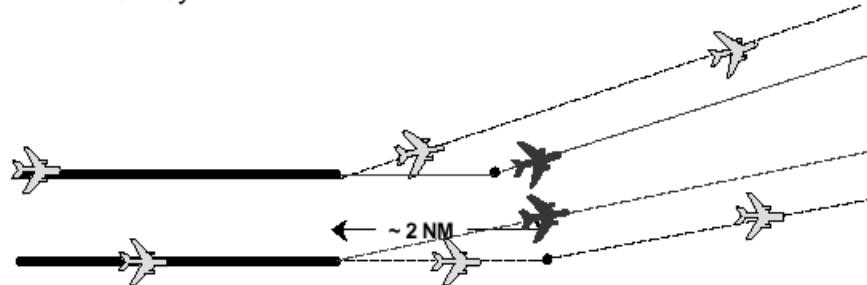
**FIGURE 4 Alternative procedures for parallel departures.**

- 0 ICAO standard procedure: 15° divergence
- 0 10° divergence
  - Implemented at Toronto, Canada (3300 m runway spacing)
  - Investigating 5° divergence
- 0 Parallel departures for 5 NM
  - Implemented at Paris Charles de Gaulle (3000 m runway spacing)
  - Requires positive course guidance (e.g., VOR on runway centerline)

**FIGURE 5 Reduced divergence angles for independent departures.**

**0 Concept: Independent departures with same-direction turns**

- New procedure, not explicitly covered by ICAO PANS
  - = Would require more analysis, much testing
- Need to ensure separation between departures
  - = Minimum straight segment required on "outside" runway
  - = Protects against a slow climb to 400 ft before turn from "inside" runway



**FIGURE 6** Concept for turning both departures in the same direction.

**0 Independent departures with same-direction turns**

- New procedure with safety issues
- Straight segment before turn takes aircraft closer to noise-sensitive area
  - = Will increase noise impact compared to turn at runway end

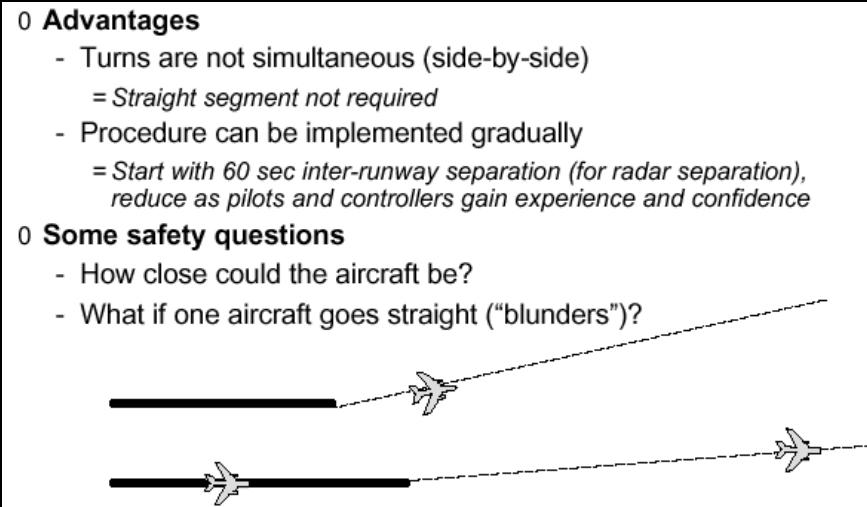
**0 Alternative concept: Dependent departures with same-direction turns**

- Interval (e.g., 60 sec) between departures on different runways
  - = Provides longitudinal separation
- Departure capacity is function of this interval

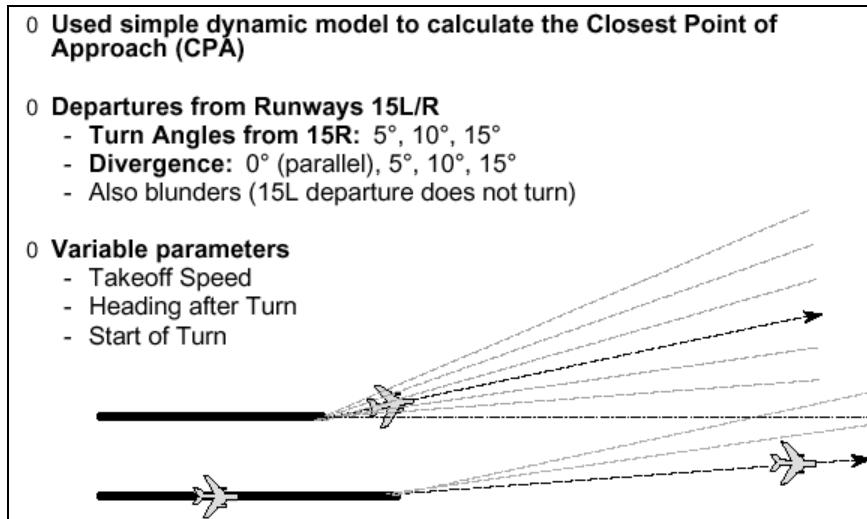
**FIGURE 7** Alternative concept for turning both departures in the same direction.

A preliminary Monte Carlo simulation (Figure 9) was used for simple dynamic modeling to calculate the closest point of approach (CPA). The departures from Runway 15R had turn angles of 5°, 10°, and 15° and divergence angles of 0° (i.e., parallel), 5°, 10°, and 15°. The other input parameters include the takeoff speed, heading after the turn, and start of the turn.

The presentation concludes that the high-noise impact for southbound night departures (which occur about 2% per year) can be greatly reduced by using only a single runway for departures (Figure 10). Reducing the departure divergence at MAD could potentially reduce the noise impact or provide additional departure capacity, or both. It is also found that the dependent-departure-same-direction turn procedure appears promising but needs further analysis.



**FIGURE 8** Dependent departures with same-direction turns.



**FIGURE 9** Preliminary Monte Carlo simulation.

- 0 High noise impact for southbound night departures (2% per year) can be greatly reduced by using only a single runway for departures**
- 0 Reducing departure divergence, if feasible at Barajas, could potentially reduce noise impact and/or provide additional departure capacity**
- 0 Dependent departure / same direction turn procedure appears promising, but further analysis is needed**
  - Especially blunder performance

**FIGURE 10** Conclusions.

## PART 2: WYLE'S ROLE IN THE ANALYSIS OF POTENTIAL PROCEDURES TO REDUCE DEPARTURE NOISE

The second part of this presentation describes the role of Wyle Laboratories in the analysis of new procedures to reduce departure noise at MAD. The presentation discusses the methodology, approach, tools, and procedures used to reduce the departure noise at this airport.

The objectives of the study (Figure 11) are to (a) optimize flight tracks to the north and the south of MAD to minimize noise impact on the population, (b) analyze additional noise abatement alternatives (such as traffic distribution and nighttime restrictions), and (c) determine the operational feasibility of alternative noise-abatement procedures by coordinating with MITRE and FAA.

The proposed methodology includes the noise metric, which is identical to the day–night (average-sound) level (DNL), except that LAeq is averaged over 16 h for the day level and 8 h for the night level (Figure 12). The runway utilization includes a 100% north-flow configuration and a 100% south-flow configuration (Figure 13)—the actual traffic distribution is 93% in the north-flow configuration and 7% the south-flow configuration.

- Optimize flight tracks to North and South of MAD to minimize noise impact on population
- Analyze additional noise abatement alternatives (i.e., traffic distribution, nighttime restrictions)
- Coordinate with MITRE and FAA to determine operational feasibility of alternative noise abatement procedures

**FIGURE 11 Objectives.**

- Noise Metric:  
Identical to Day-Night Average Sound Level (DNL) except that LAeq is averaged over 16 hours for Day and 8 hours for Night.
  - LAeq<sub>DAY</sub>: 0700 to 2300 local time. Threshold = 65 dB.
  - LAeq<sub>Night</sub>: 2300 to 0700 local time. No 10-dB Night Penalty. Threshold = 55 dB.

**FIGURE 12 Futuro Sistema Aeroportuario de Madrid (FSAM) study methodology.**

- Runway Utilization:
  - 100% north-flow configuration
  - 100% south-flow configuration
  - Actual Traffic Distribution: 93% north, 7% south

**FIGURE 13 More on FSAM methodology.**

- Collect and review operational data based on forecast CY2025 operations data
- Convert and integrate data into INM
  - Operations data
  - Population data
  - Terrain data
- Noise impact for Baseline CY2025 conditions
- Flight track optimization

**FIGURE 14 FSAM approach.**

The study approach included a collection and revision of the operational data based on the forecasts for CY2025 (Figure 14). The operations, population, and terrain data were converted and integrated into the integrated noise model (INM). The noise impact for baseline CY2025 conditions was computed. Once the flight tracks are optimized, they are also validated.

The additional analyses (Figure 15) included examining other noise-abatement alternatives and comparing the baseline and alternative noise impacts. To support such studies, the following tools were used (Figure 16): INM 5.2a, Wyle's aircraft noise community impact model (ACNIM), advanced Wyle aircraft equivalency algorithms, several Wyle conversion utilities for terrain and population data, and a geographic information system (GIS).

After the analysis of the flight tracks was completed, it was concluded that the most amount of noise comes from the south-flow departures—approximately 7% of total annual operations (Figure 17). In addition, the arrivals from the south are the principal source of noise in the north-flow configuration. It was also concluded that the nonstandard procedures with decreased divergence could result in noise benefits. The last conclusion was derived from the analysis of nighttime traffic. On the basis of this analysis, it was concluded that runway restrictions show a tremendous noise benefit (approximately 90% impact reduction) during nighttime (2300–0700) operations in the south-flow configuration.

- Validation of optimized flight tracks
- Analysis of other noise abatement alternatives
- Comparison of baseline and alternative noise impacts

**FIGURE 15** More on the FSAM approach.

- Integrated Noise Model 5.2a
- Wyle's Aircraft Noise Community Impact Model (ACNIM)
- Advanced Wyle aircraft equivalency algorithms
- Several Wyle conversion utilities for terrain and population data
- GIS

**FIGURE 16** Tools used.

- Flight Track Analysis
  - Biggest noise impact contributor being south-flow departures (~7% of total annual operations)
  - In the north-flow configuration, biggest noise impact contributor being arrivals from the south
  - Non-standard procedures with decreased divergence can result in noise benefits

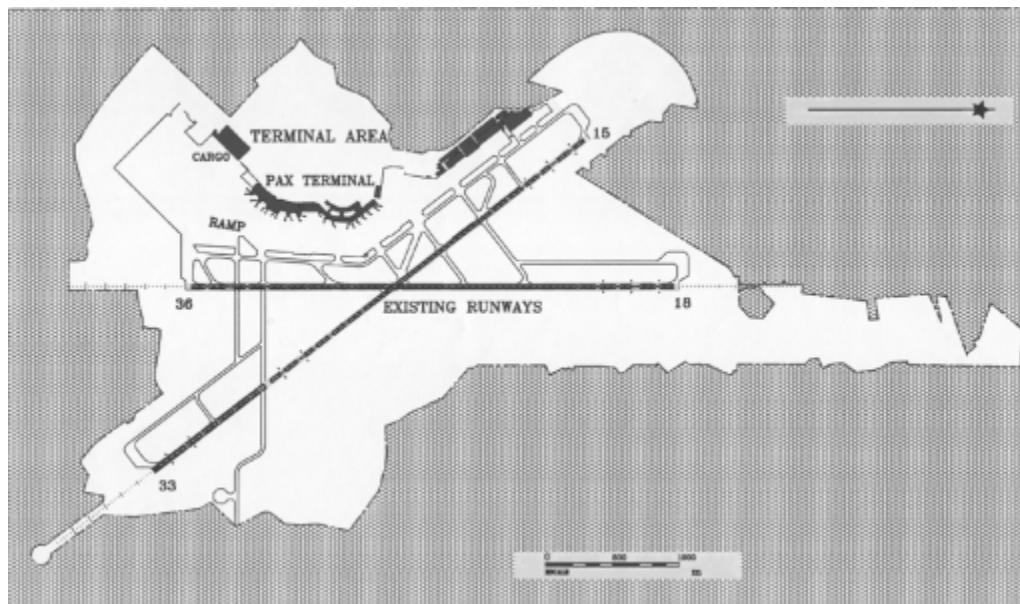
**FIGURE 17** Conclusions.

## PART 3: INTERACTIONS OF AIRPORT, AIRSPACE, AND ENVIRONMENT ANALYSIS

This session discusses the interactions of airport development, capacity, airspace operations, and environment for MAD. It provides a brief background of the Plan Barajas, a proposed long-range development plan for this airport.

In 1990 the FAA's Civil Aviation Assistance Group (CAAG) stationed in Madrid began assisting Spain's Director General of Civil Aviation (DGAC) with a long-range development plan for MAD, Plan Barajas. The development of MAD was (and is) the DGAC's top priority. MAD is important not only from the domestic but also from the international travel perspective. In 1993 this airport generated more than one-fifth of Spain's total air traffic and served 17.34 million passengers. The passenger volume had grown 4.1 million since 1988, indicating a 31% increase in 5 years. However, the airport faces severe capacity problems both in the air and on the ground. The constraining factors included the inadequacy of the air traffic system, airfield facilities and layout, and terminal and gate complex.

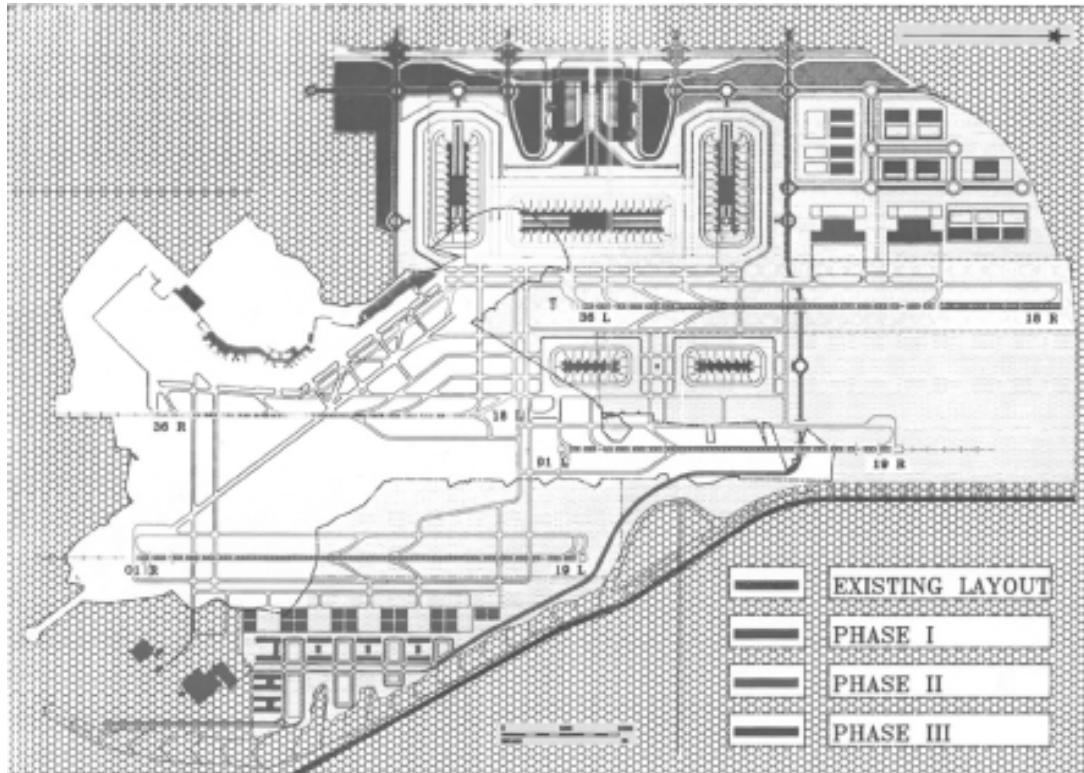
At the time the airfield system included two crossing runways (Figure 18), Runway 15/33 (4100 m) and Runway 18/36 (3700 m). The Runway 15/33 threshold was displaced 1050 m in 1992 to reduce the distance and travel time to the runways crossing point. It was a part of the short-term recommendations for improving the airport capacity. The recent growth in traffic volumes and future forecasts clearly underscore the need for increasing MAD's capacity. To address the capacity delay problems at the airport, the DGAC (with the assistance of FAA-CAAG) developed the Plan Barajas (Figure 19). The original concept plan was approved in 1992 and included a new terminal, new airport traffic control tower, and system of four parallel north-south runways (two for arrivals and two for departures). Their separation was based on the FAA's design standard for simultaneous independent precision instrument landing and takeoffs



**FIGURE 18 Existing layout of MAD.**

(4,300 ft or 1300 m). One of the runways in the parallel system was the existing Runway 18/36. According to the preliminary plan, the existing crosswind Runway 15/33 was going to be abandoned.

During the follow-up reviews, strong concerns were expressed regarding the aircraft operations over the neighborhoods to the south of the parallel north–south runways. It was feared that with the increased traffic, the community to the south would be exposed to noise impacts from the operations on the north–south parallel runways (existing Runway 36R/18L and proposed Runway 01R/19L). Runway 36L/18R, included in the first phase of the Plan Barajas, was implemented in January 1999. It was decided that Runway 15/33 would be retained for noise abatement because there was no extensive residential community development to the south of Runway 15/33's approach. In addition, it was decided by Spain's civil aviation authorities to undertake the feasibility analysis of a 15/33 parallel runway system instead of the 18/36 parallel runway proposed earlier.



**FIGURE 19 Development phases of MAD.**

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[Click here to see Rachami's entire slide presentation.](#)

## APPLICATION OF AIRPORT ENVIRONMENTAL MODELS

### Aircraft Noise Analysis to Support Growth in Air Travel

PETER KOSTIUK

*Logistics Management Institute*

This presentation reviews the noise impact model (NIM) capabilities and applies the NIM to examine the impact of quieter aircraft at Orlando International Airport in Year 2015.

Aircraft noise is one of the primary constraints to growth in air travel (Figure 1). Airport and aircraft noise analyses are needed to help researchers and operators assess potential impacts of changes in aircraft performance and noise on a community. To conduct such analyses, NASA developed the NIM (Figure 2). This model enables users to examine the potential impact of quieter aircraft technologies and operations on air carrier operating efficiencies at any one of 16 selected U.S. airports and 1 European airport. The model also considers the impact on a community in terms of the size of the noise footprint and the numbers of homes and people within various contour intervals. The NIM provides flexible departure flight tracks and changes in aircraft noise characteristics and number of operations. It is an Internet-accessible model that runs on the Logistic Management Institute (LMI) and NASA aviation system analysis capability (ASAC) website. The model was developed through an industry and government partnership and was funded by Pratt and Whitney (P&W) and NASA (Figure 3).

The NIM outputs (Figure 4) include (a) a geographic information system (GIS) analysis of populations, homes, and lands affected; (b) estimated airline distance and time savings (at the flight track level of detail); and (c) impacts under different technology scenarios. NASA and the airline industry have also used this model to evaluate noise reduction technologies in several noise studies.

- Aircraft noise is one of the primary constraints to the growth in air travel
- Benefits from expanding beyond the regulatory perspective to defining the policy objective more clearly
- Provides focus for evaluating policy options

**FIGURE 1 Objectives.**

- ASAC Noise Impact Model (NIM)
  - Enable users to examine the impact that quieter aircraft technologies and/or operations might have on air carrier operating efficiencies at any one of 16 selected U.S. airports and 1 European airport
  - Also considers the impact on the community in terms of size of the noise footprint, and numbers of homes and people within various contour intervals
- NIM provides for flexible departure flight tracks, changes in aircraft noise characteristics, and number of operations
- Internet-accessible model that runs on the LMI/NASA Aviation System Analysis Capability (ASAC) website

**FIGURE 2** Airport and aircraft noise analysis.

- Developed through an industry/government partnership
- Funded by NASA from 1996 to 1998 as part of the Aviation System Analysis Capability (ASAC)
  - Model designed to help researchers and operators assess potential impacts of changes in aircraft performance on community noise
- In 1999, P&W agreed to fund a NIM enhancement project to add functionality and more airports
- In FY00, additional funding from the NASA QAT program

**FIGURE 3** History of NIM (QAT = quiet aircraft technology).

- GIS analysis of population, homes, and acres of land impacted
- Estimated airline distance and time savings (at the flight track level of detail)
- Impacts under different technology scenarios
- Model has been used by NASA and industry in several noise studies evaluating noise reduction technologies

**FIGURE 4 Outputs.**

- Updating baseline schedules and fleet mix forecasts
- Adding five domestic airports
  - Baltimore-Washington International
  - Cleveland Hopkins
  - Reagan National
  - Norfolk
  - Newport News

**FIGURE 5 Current model development.**

This presentation ends with a discussion about development efforts with the current model (Figure 5). Current efforts include updating baseline schedules and fleet mix forecasts and adding five domestic airports (Baltimore–Washington International, Cleveland Hopkins, Reagan National, Norfolk, and Newport News) into the airport database.

[\*\*Click here to see Kostiuk's entire slide presentation.\*\*](#)

## CASE STUDIES OF ENVIRONMENTAL ANALYSIS

# Use of Airside Simulation to Support the Environmental Impact Statement Process

**BERTA FERNANDEZ**

*Landrum & Brown*

This presentation reviews the use of the airside module of SIMMOD in support of the environmental impact statement (EIS) process and investigates the major steps in the EIS process (Figure 1).

The EIS process typically follows the master planning process that requires capacity and delay modeling, which can be a key element in supporting the EIS (Figure 2). Because delays cannot increase infinitely, the “do-nothing” alternative (Figures 3 and 4) may require some redefinition of future airport activity. In addition, the air-quality impact assessment requires an understanding of

- Purpose and Need
- Alternatives
- Affected Environment
- Environmental Consequences
  
- *At LAX and ATL airside simulation modeling played a critical role supporting all major steps in the EIS*

**FIGURE 1 Major steps in the EIS process.**

- Capacity enhancement/delay reduction projects require quantitative assessment of project benefits
- There are alternatives for quantifying capacity and delay benefits - simulation modeling is a commonly used tool
- Simulation can also be used to define the demand/activity component of the Do-Nothing Alternative (operations levels, fleet mix, time of day)
- *At LAX and ATL simulation modeling was used to quantify project benefits and to define the demand/activity component of each alternative*

**FIGURE 2 Purpose, need, and alternatives.**

- Imposing a limit on delay triggers a more detailed look at the shape of the Do-Nothing delay curve and capacity of the Do-Nothing Alternative
- If Do-Nothing capacity is understated, operation levels with the project are significantly higher while benefits are reduced by limiting delay
- Goal is to develop a "reasonable" scenario in which the maximum number of passengers are served

**FIGURE 3 Definition of the do-nothing alternative.**

- "Scheduled" activity level is driven by VFR (good weather) capacity
- Excess peak hour demand in VFR results in delay
- If VFR delay is excessive, demand/activity can be adjusted by de-peaking
- If in VFR the airlines cannot schedule to meet all demand (after de-peaking), alternative air service and fleet mix strategies must be considered
- In IFR, activity can be further reduced through flight cancellations
- IFR cancellations are operational tactics used by the airlines in poor weather - Fleet mix cannot be changed in IFR only
- Excessive flight cancellations may require further adjustment to the "schedule"

**FIGURE 4 More of the definition of the do-nothing alternative  
(VFR = visual flight rules; IFR = instrument flight rules).**

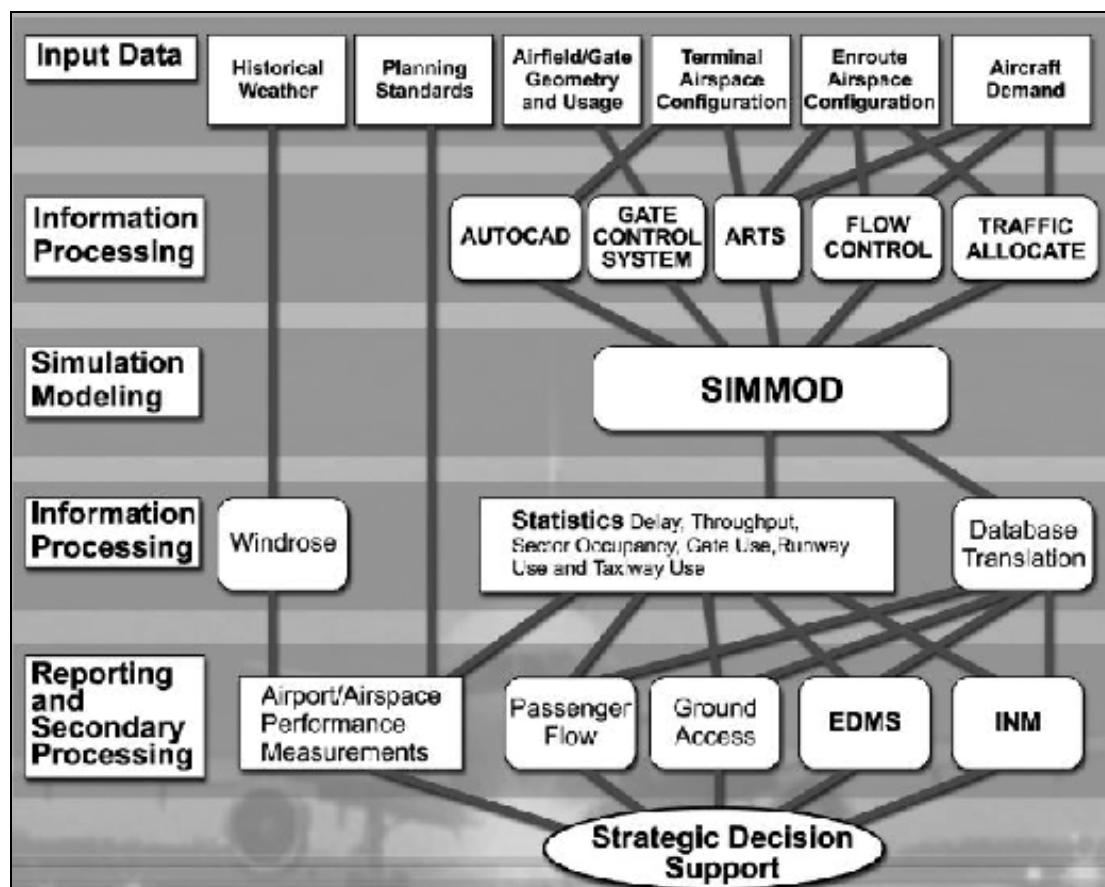
demand–capacity and delay relationships early in the process. Various models [such as SIMMOD, integrated noise model (INM), and emission and dispersion modeling system (EDMS)] are used for conducting analyses that support the EIS process. Because these models have much data in common, the cross-utilization of modeling data can benefit the EIS process. The major steps in the EIS process require well-defined purpose and need, alternatives, affected environments, and environmental consequences.

Capacity enhancement–delay reduction projects require quantitative assessment of project

benefits. Simulation modeling is a commonly used tool for quantifying capacity and delay benefits. Simulation can also be used to define the demand and activity component of the do-nothing alternative (operations levels, fleet mix, time of day). For example, at Los Angeles (LAX) and Atlanta (ATL) International Airports, simulation modeling was used to quantify project benefits and to define the demand and activity components of each alternative. However, if the do-nothing capacity is understated, operation levels with the project are significantly higher and benefits are reduced as a result of the limiting delay. Hence, the goal is to develop a reasonable scenario to serve the maximum number of passengers.

Modeling with SIMMOD, INM, and EDMS often requires large sets of data, which could be shared (Figure 5). The cross-utilization of modeling data (Figure 6) has many advantages; because of the data consistency, there is less risk of inconsistencies across analyses that require similar input but are performed by different teams of specialists. It is common for such analyses and results to be more robust. Simulation modeling is an iterative process, and direct input data into the EDMS (from a file) would ease the modeling process.

The last part of the presentation discusses the inbound delay benefits that are not a factor in EDMS (Figure 7). Inbound delays include the delay caused by airborne holding and ground delay at the origin airport (which has only national interest, not local).



**FIGURE 5** Cross-utilization of modeling data: SIMMOD, INM, and EDMS.

- Approach definition up front - forces thinking through the implications of how each scenario is defined on the environmental impact assessment
- Data consistency - less risk of inconsistencies across analyses that require similar input and are often performed by different teams of specialists
- Analysis and results are more robust
- May not be applicable to all airports
- Less practical if simulation needs to be created from 'scratch'
- Application is easier if previous modeling has been performed as part of the planning process

**FIGURE 6 Advantages and disadvantages of data cross-utilization.**

- Inbound delay benefits that are not a factor in EDMS:
  - Airborne holding
  - Ground delays at origin airports – not of local interest but important at national level
- Different level of detail available in SIMMOD vs. EDMS requirements
- Simulation modeling is an iterative process – direct input data feed to EDMS from a file would ease the process

**FIGURE 7 Final observations.**

[\*\*Click here to see Fernandez's entire slide presentation.\*\*](#)

## CASE STUDIES OF ENVIRONMENTAL ANALYSIS

### Hartsfield Atlanta International Airport *The New Fifth Parallel Runway*

**TOM NISSALKE**

*Department of Aviation, City of Atlanta, Georgia*

This presentation describes planning efforts in the development of a new fifth parallel runway at Hartsfield Atlanta International Airport (ATL).

Because planning and development of airport facilities is increasingly affected by environmental and community concerns, more emphasis must be placed on environmental considerations as part of the planning process (Figure 1). Traditionally, the noise–land use has been a significant environmental–community factor. In addition, air quality is becoming an increasingly important consideration that drives an airport’s ability to expand and develop new facilities. The planning and development of airports includes two components (Figure 2): airside (runways and airspace, taxiways, aprons and gates) and landside (terminal buildings and curbside, auto parking, on- and off-airport roads).

Several modeling tools are available for the analysis of the various airport components and environmental categories (Figure 3). These tools can estimate measures of performance, such as airfield and airspace capacity and delay, terminal passenger flow, curbside flow, roadway traffic flow, economic impact, noise, and emissions (air quality).

An airport planner faces the typical modeling challenges, which include some of the following questions: What needs to be modeled? Which models should be used? What data is available for the modeling? Are the data and assumptions consistent across models? Do the models produce realistic results? Does the modeling lengthen the project schedule? What are the costs and benefits of these modeling analyses?

- **Planning and development of airport facilities is increasingly affected by environmental and community concerns**
- **More emphasis must be placed on environmental considerations as part of the planning process**
- **Traditionally noise/land use has been a significant environmental/community factor**
- **Air quality and others are becoming increasingly important considerations driving the airport’s ability to expand and develop new facilities**



**FIGURE 1** Airport planning and environmental context.



**FIGURE 2** Components included in the planning and development of airports.



**FIGURE 3** Modeling tools available.

ATL is home to the world's largest hubbing operation (Figure 4). Delta Air Lines alone has 665 aircraft departures per day from 80 domestic gates and Concourse E. In addition, Atlantic Southeast Airline launches 244 departures, and AirTran Airline offers 135 operations per day. The latest statistics indicate that ATL will be the most delay-impacted U.S. airport for the fourth consecutive year (Figure 5). According to the consolidated operations and delay analysis systems (CODAS) data, the average arrival delay is 7.85 min and the average departure delay is 8.52 min. The peak departure queue length can reach up to 23–25 aircraft for each runway.

The airport's primary environmental concerns are aircraft noise and air quality (Figures 6 and 7). ATL has spent approximately \$340 million on acquisition and acoustical treatment, has acquired over 2,500 homes, and has treated approximately 9,500 structures. The 65 day–night level (DNL) contour has shrunk from approximately 55 mi<sup>2</sup> in 1980 to 38 mi<sup>2</sup> in 1998.

- Home to world's largest hubbing operation
- Delta Air Lines departs 665 aircraft per day from 80 domestic gates and Concourse E
- Additionally, Atlantic Southeast launches 244 departures and AirTran 135 per day

FIGURE 4 Airport users.

- For fourth consecutive year, ATL will be most delay impacted U.S. Airport
- CODAS average arrival delay is 7.85 minutes and average departure delay is 8.52 minutes
- Peak departure queue length can reach 23-25 aircraft for each runway

FIGURE 5 Existing airfield delay conditions.

- One noise abatement departure track from each runway (implemented in early 1970s)
- ATL has spent approximately \$340 million on acquisition and acoustical treatment
- Acquired over 2,500 homes and treated approximately 9,500 structures
- 65 DNL contour has shrunk from approximately 55 mi<sup>2</sup> in 1980 to 38 mi<sup>2</sup> in 1998

FIGURE 6 Primary environmental concerns: noise.

- Atlanta area is serious nonattainment for ozone
- When PM2.5 standard is implemented, will be nonattainment for PM2.5
- If ATL were considered a point source, it would be the 8th largest NOx source in the nonattainment area
- Haze forces us to run SILS approaches during the summer

FIGURE 7 Primary environmental concerns: air quality (PM = particulate matter; SILS = shipboard impact locator system).

Air traffic continues to grow. The need for a commuter runway was identified in 1986 to increase capacity and reduce aircraft delays (Figure 8). Thus, two comprehensive environmental analysis (EA) studies were conducted, and the results were compared. The first study examined the feasibility of a 6,000-ft runway north of I-285. To support such an analysis, SIMMOD and the integrated noise model (INM) were used; aircraft, vehicular, and construction emission inventories were performed. The results indicate that a project would be cost beneficial, but the new runway use would be restricted to arrivals of Stage 3 aircraft weighing less than 100,000 lb (Figure 9).

The second study examined the feasibility of a longer runway. The proposed runway would be shifted from the previously approved commuter runway approximately 1,900 ft to the east and would be extended for another 3,000 ft, resulting in a 9,000-ft unrestricted runway (Figure 10). The key models used in conducting the environmental impact statement (EIS) included SIMMOD, INM, corridor microscopic simulation (CORSIM), transportation planning model (TRANPLAN), emissions and dispersion modeling system (EDMS)/CAL3QHC (model for predicting pollutant concentrations near roadway intersections), and several other models (Figure 11). For example, the GeoHMS model was used to preprocess the terrain around the airport for hydraulic modeling, and FHWA's STAMINA (highway traffic noise prediction model) and traffic noise model (TNM) were used for roadway noise modeling (Figure 12). During the course of this study, the analysts faced many modeling challenges because a different model was used for each specialty area (Figure 13). Although much data was common across models, it was expressed differently for inputs and outputs. Close coordination of modeling was required to ensure consistency because the output data from one model was converted to serve as input for another model. The cross-utilization required a basic understanding of all models so that data was properly used.

- **Need for a commuter runway was identified in 1986 to increase capacity and reduce aircraft delays**
- **DOA started EA for runway in 1991**
- **1993 construction cost estimate for West Alternative was \$167 million**
- **EA finding of no significant impact issued in February 1994**
- **In early 1995, cost estimate updated to \$300 million**
- **MII ballot issued January 16, 1996, to fund runway at \$418.8 million (airlines rejected)**
- **MII ballot reissued December 23, 1996 (Delta approves January 24, 1997)**
- **\$75 million LOI granted in 1997**
- **Ground breaking in February 1997**
- **\$184 million of land acquisition started in July 1997**

**FIGURE 8 Commuter runway project.**

- Project would be cost beneficial
- Runway approved at 6,000 feet north of I-285
- Runway use was restricted to arrivals of stage 3 aircraft weighing less than 100,000 pounds
- Agreeing to restriction was only way to obtain Clayton County approval

FIGURE 9 Conclusions from commuter runway EA.

- Shift previously approved commuter runway approximately 1,900 feet east and extend 3,000 feet, resulting in 9,000-foot unrestricted runway
- Runway still located 4,200 feet south of runway 9R-27L
- Bridge I-285 with two structures, roughly 1,800 feet and 500 feet long
- Land acquisition of approximately \$390 million
- Relocate two state highways and two other major streets
- Bring in 27 million yd<sup>3</sup> of fill material
- Current cost estimate of 9,000-foot runway is \$869 million

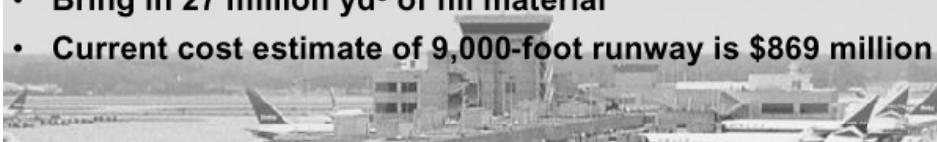


FIGURE 10 Description of proposed project.

- SIMMOD
- INM
- Roadways
- EDMS/CAL3QHC
- Other Modeling

FIGURE 11 Key modeling conducted for EIS.

- HEC's GeoHMS was used to preprocess the terrain around the airport for hydraulic modeling
- FHWA's STAMINA and TNM were used for roadway noise modeling at four receptor sites

FIGURE 12 Other modeling.

- A different model is used for each "specialty" area
- Much data is common across models yet expressed differently for input and output
- Close coordination of modeling is required to assure consistency
- Output data from one model is converted to serve as input for another model
- Cross-utilization requires some basic understanding of all models so that data is properly used

FIGURE 13 Modeling challenges.

[Click here to see Nissalke's entire slide presentation.](#)

## APPENDIX

### Workshop Participants

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