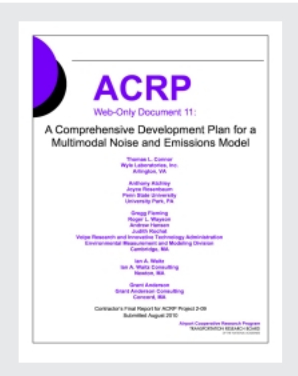
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A Comprehensive Development Plan for a Multimodal Noise and Emissions Model

A Comprehensive Development Plan for a Multimodal Noise and Emissions Model

DETAILS

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SUMMARY

Transportation hubs are essential to commerce and community activity and an integral part of the surrounding environment. Schools, hospitals, residences, and businesses often exist within the vicinity of airports. Highways and passenger and freight railroad lines lead into and around airports. As a result, rarely does one transportation source dominate the environmental impact in and around the airport. Despite this relatively close proximity, the standard course of action is to qualify airport expansion projects and noise and emissions mitigation decisions using single-modal impact.

Availability of a multimodal noise and emissions model would help inform airport and public policymakers charged with evaluating and making decisions on expanding transportation facilities. The purpose of this study is to create a framework for developing a tool that would allow for the assessment of the noise and air quality impacts on the population from each transportation source, assess the total costs and impacts, and assist in the design and implementation of mitigation strategies. This model would enable more efficient use of federal, state, and local funds. In addition to public sector entities, this capability would be made available to airports, airport consultants, and others as a framework for conducting environmental assessments for regulatory, business, and community purposes.

The goal of ACRP Project 02-09 is to produce a comprehensive Model Development Plan (MDP) that will guide future development (by others) of a model to facilitate integrated quantification of multimodal noise and emissions, as well as economic analysis of alternative scenarios. The cornerstone of the approach to the MDP is to set forth the end state. The end state is the ultimate objective for the multimodal noise and emissions modeling capability. The end state defines the requirements (databases, input/output processes, algorithms, etc) for multimodal planning at the local, regional, and national levels.

Based on a detailed literature review, a gap analysis of existing tools and methodologies, and the collective experience of the research team; a multimodal transportation environmental analysis tool based on simulation architecture (most likely time-step based) was selected as the most desirable end state. As envisioned, the end state must:

- Meet the regulatory and policy requirements of every agency involved in an integrated regional planning process.
- Use a highly modular design so that the model can be: (1) updated as the science behind a specific module is advanced; and (2) coupled with a wide range of other transportation planning tools, such as traffic simulation models.

What is the product from the research?

The effort has produced a plan that will effectively jump-start the development of a multimodal noise and emissions model. The plan includes:

- A rigorously assessed model design.
- A multi-phased effort, which each phase resulting in a usable tool, incrementally building towards the desired end state.
- Identification of the technical and policy issues to address during development.
- The findings of an initial market research with a proposal for further work.
- A draft strategic plan for model funding and ownership.

Who is the audience or market for this research?

Market research performed under this effort identified potential user communities and stakeholders along with their needs, and their reactions to the proposed model design and end state. The

research also examined how environmental analysis is currently done with existing models; pointing to potential utility for a future multimodal model.

What are the impediments to successful implementation?

Multimodal environmental analysis and mitigation will require greater collaboration among a variety of federal, state, and regional agencies. Multi-agency acceptance is critical, which requires an understanding of the technical and policy complexities that must be overcome. A technical complexity will involve the ability to incorporate all of the knowledge on the various modes into a single, usable model. Another technical complexity is the extent or lack of investigation of particular empirical factors and the amount of additional expertise required for their resolution. The policy complexity reflects the degree of incompatibility among existing environment assessment requirements promulgated by various agencies. The recommended model design and model build sequence calls for substantive interaction with interested Federal agencies along with periodic feedback from all stakeholders. The objective is to have the parties work together to overcome technical and policy impediments.

What institutions might take leadership in applying the research product?

Sole ownership of the multimodal model does not seem practical; so, the strategic plan accompanying the MDP proposes an interagency forum that could decide federal ownership and identify the technical and policy infrastructures needed to support the model development.

What are necessary activities for successful implementation?

The MDP includes a draft strategic plan on the funding and ownership. The use of strategic planning and tactics should offer flexibility in the model development while also providing contingency (situational) planning.

How to judge the progress and consequences of implementation?

Success will be judged by the actions that U.S. DOT and its modal administrations take with respect to the MDP and the suggested strategic plan. In addition, the evaluation process used in the assessment of alternative model designs should be useful to the future owners and development teams in deciding what direction to take for each model build sequence.

How applicable are the results to practice?

While the scope of this project is not to construct a new operational multimodal noise and emissions model, the MDP offers the fundamental pieces and considerations needed to create such a model. The approach has been to gain a thorough understanding of how the multimodal noise and emissions model would fit into intermodal and multimodal transportation projects involving decision-making that spans across the authority of several federal agencies. The potential user communities and federal agencies have been engaged in the process. The recommended model design has been rigorously assessed against viable alternative design concepts. This rigorous examination of alternatives has produced a design concept that is supported by a thorough, pragmatic MDP.

CHAPTER 1. INTRODUCTION

This document describes the Model Development Plan (MDP) for a multimodal transportation environmental analysis tool. The MDP only addresses transportation sources. Considerations for other sources will only be included as needed for the transportation analysis and these efforts will be considered secondary. The overall goal of the proposed tool is to provide a capability to perform an environmental analysis consisting of noise, air quality, climate and economics of all modes of transport for various geographic scales (microscale, regional, national, and global). The proposed tool will streamline transportation-related environmental analyses by minimizing the redundant input currently required to exercise modal-specific tools, e.g., traffic, performance, etc. It will also facilitate a systems approach to transportation-related environmental analyses for air quality, climate, and noise. Additional modules on fuel burn and economic analysis will allow analysis to be more comprehensive. Inclusion of environmental cost/benefit capabilities will allow transportation planners to make more informed decisions on transportation-related projects. For example, should additional roadway access be provided to a particular airport or are limited resources better spent developing a public transit link?

Details included in this MDP were developed from surveys of stakeholders (Appendix A), comprehensive literature reviews, and the experience of the research team. Several rounds of stakeholder engagement were included in the overall process. While the market research was successful in providing valuable insights for the model design, there was an issue concerning the small response to the questionnaire. Chapter 5 offers suggestion on how to build upon the initial market research. Appendix D suggests an interagency forum to engage federal stakeholders and as a vehicle for federal funding.

The ACRP Panel (Panel) participated in an evaluation of five possible model development approaches put forward by the research team. As summarized in Appendix B, the approaches receiving the highest overall scores by the Panel and project team were the ones that build on the development of the FAA Aviation Environmental Design Tool (AEDT). Although aviation focused, AEDT combines many of the desired components of a multimodal environmental analysis tool (see Figure 1-1). It provides an excellent foundation for the future multimodal noise and emissions model.

For example; the computation core of the AEDT component, shown in Figure 1-1, is based on EPA-approved air quality models and internationally-accepted aircraft noise models. Using the EPA-approved models, AEDT is capable of modeling roadway emissions to a limited degree and includes the architectural foundation and some of the algorithms for modeling roadway noise. The impacts and cost benefits modules of Aviation Portfolio Management Tool (APMT) provide the basis for multimodal environmental cost and economic impact analysis. It is also logical and cost effective to draw upon the extensive Graphical User Interface (GUI) that brings together the various components of the AEDT tool suite. Additionally, the new EPA emission model MOVES that was recently required for motor vehicle emission estimation also has a similar data base to AEDT using SQL and as such will allow for a direct combination of the data during analysis.

Due to the substantial anticipated time and resources needed to develop the proposed end-state model, the research team recommends a multiphase approach as described in detail in Chapter 2 of this document. With this approach, the development process is recommended to be divided into a series of phases, each called a “Build”. An important aspect of this plan is that each Build results in a usable product.

1.1. Purpose

The purpose of the MDP is to define the work needed to develop a multimodal transportation environmental analysis tool. The MDP presents the proposed work as a multi-phased effort, which each phase resulting in a usable tool, incrementally building towards the desired end state as time and resources allow. Each Build is expected to be completed in such a way to allow the next phase or build to be a continuation of the model development rather than starting anew each time. It is difficult to determine the exact timeline for each build due to resource uncertainty. However, based on the assumption that resources will be available, the project Builds have been defined for short-, mid-, and long-term development.

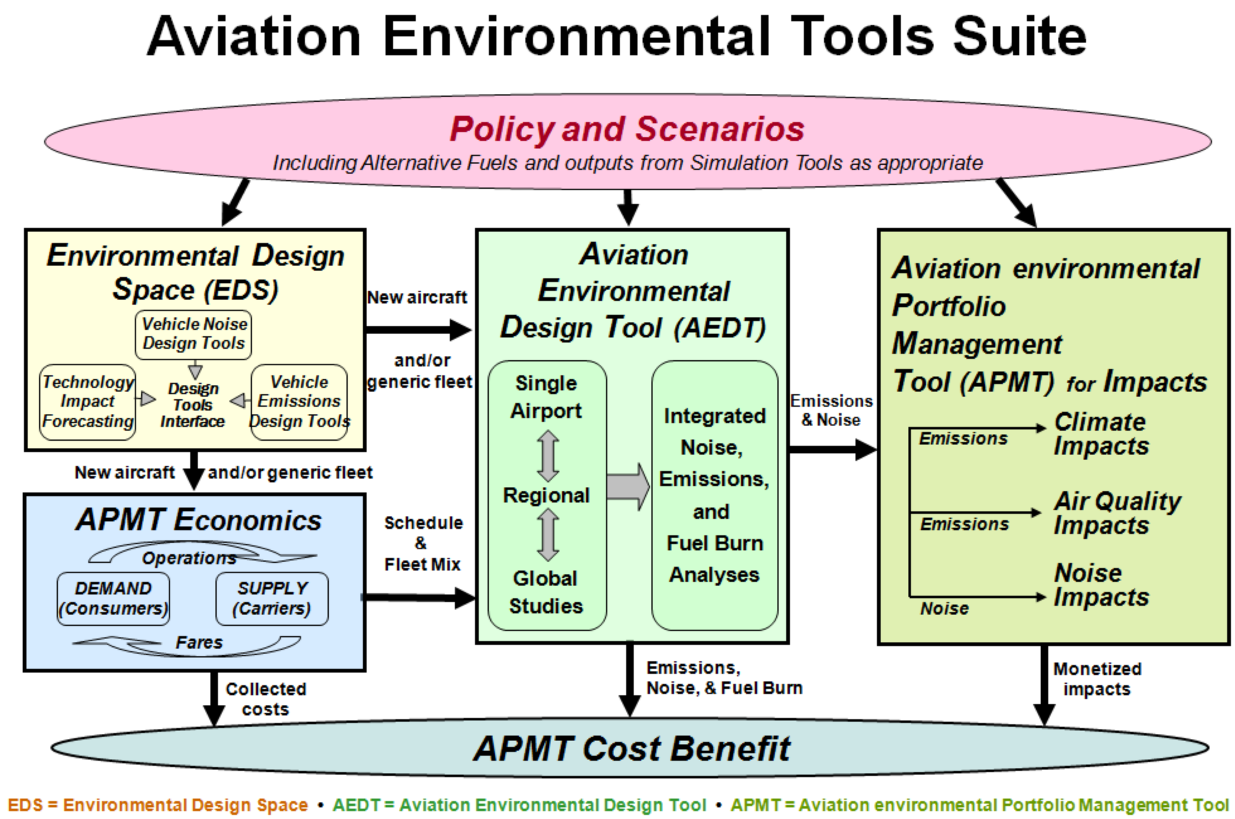

Figure 1-1. AEDT with linkages to other related FAA/AEE tools.
Source: FAA, Office of Environment & Energy

Details of each Build are presented in Section 2.3, Project Deliverables. The series of Builds (1 to 6) are what is currently envisioned. However, depending upon needs, progress, and future unforeseen events, these Builds could be combined, expanded in scope, and/or possibly deleted, as related science and information technology advances.

1.2. Scope and Background

Based on a detailed literature review, and a gap analysis of existing tools and methodologies and the collective experience of the research team, the project team agreed that a multimodal transportation environmental analysis tool based on simulation architecture (most likely time-step based) would be the most desirable end state or final Build. The advantages of a time-simulation approach include:

- Increased flexibility in modeling approaches, e.g., the ability to take into account transportation schedules in a comprehensive way;
- Fewer needs for simplifying assumptions such as line sources or energy averaging;
- More comprehensive analysis of microscale conditions; and,
- The ability to have more detailed and representative emission factors and reference acoustic levels.

It was also recognized by the research team that initiating the Build sequence with a simulation model could have substantial pitfalls. Primary among these were the need to develop new source data, the lack of precise vehicle time-space-position information across the modes, and increased computer run time. To this end it was decided to review possible scenarios to advance the project to an end state while providing for each step of the development as outlined in Section 1.3.

The evaluation and selection process was comprehensive and included two rounds of evaluations. Five designs were considered and included an option based on step by step integration, which was the initial thinking at the start of the project. The five possible model development approaches were:

- **Step by Step Integration**: The end state is a source (airplane, automobile, truck, marine vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs. Rather than initiating a single, large-scale effort to design and develop the end state, the design incorporates a build sequence toward the end state in a series of steps, each step providing an improvement to some facet of the overall model. This is the concept initially put forward by the research team and used in the stakeholder questionnaire (Exhibits E-1 and E-2 of Appendix E).
- **Build on AEDT:** The FAA is developing a tool named the Aviation Environmental Design Tool (AEDT). This tool is part of an integrated suite of tools used to perform comprehensive environmental and economic analyses, which allow policy decisions to be made in a more informed way. This development approach calls for the continued development of AEDT to a multimodal environmental analysis tool. Development is proposed in a phased fashion that would eventually result in a time-simulation-based model.
- **Build on Existing Simulation Models:** This development approach would be based on the expansion of existing single-mode, simulation-based, noise and air quality models used for transportation source analysis. The approach would be based on time-step based simulation of source movements, source emissions, and propagation scenarios resulting in detailed output reports at receptor locations.
- **Federal Adoption of Commercial Software:** This concept promotes a market-based approach for the development of a multimodal environmental analysis tool. Commercially available environmental analysis software would be the basis of this approach. The end state would be a vendor controlled software package including modeling capabilities for all modes of transportation.
- **Build on EC IMAGINE Project:** Drawing on research completed by the European Commission (EC), the fundamental principle of this model development approach would be to continue to build on IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment). The end state, a true simulation model, would be geared toward application on large, regional transportation projects where the environmental outcomes for more than one transportation mode are critical elements of the decision making.

The five model development approaches were presented to the Panel with detailed instruction on evaluation procedures. Appendix B describes in detail the two round evaluation process. Five designs were evaluated in the first round. As a result of the first round scores, a new design was constructed taking the most desirable attributes from the 5 original concepts. The second round evaluated the winner of the first round against the newly constructed sixth design. Thus, the design and build requirements described in Chapter 2 are the products of two rounds of evaluation and incorporate the most desirable attributes of the alternative designs considered. Appendix B discusses how the final design was constructed with justification for the choices made.

1.3. Developmental Goals

Section B.7 of Appendix B describes the winning model design. This section describes the goals of that design in terms of the time required beginning with the short term and looking to the future. Full implementation of the winning design has been divided into “Builds” or individual projects to allow the work to progress in a staged manner. It should be noted that these times are based on the best estimates of work effort. Many factors could extend the time such as collection of needed data, administrative requirements, and unforeseen problem areas.

Short Term (1-3 Years from Initiation): The short term goals include two Builds. Build 1 would include a postprocessor for outputs of existing models, integrating those outputs into a single presentation. Table 1-1 presents a listing of existing candidate models for this process. Determination of specific models for all modes should be made during initial planning; coordination with stakeholder agencies will be required to select from the listing. Additionally, some of the models have already been integrated into AEDT, such as INM, HNM, and AERMOD for airports and AERMOD may also be adapted for other modes. To enable the combination of results from various models, an output combination rule base will be required to sum similar results of each model. This rule base is required due to conflicts in model outputs that might prevent a direct combination of results. For example, the FHWA requires the use of the noise metrics L_{eq} or L_{10}, while most others use L_{dn}. Other conflicts such as time of analysis, assumptions by operating mode and use of weather conditions will also occur. This rule base will utilize approximate procedures in the short term to allow combination of similar outputs. No advancements to input processing are expected in Build 1 and all existing required stakeholder agencies tools selected for integration would continue to be used in their existing fashion. Build 2 would be a series of screening tools that will be integrated and adapted in later Builds to provide mitigation tools for quick planning analysis and comparison between various future project options. All screening tools would be tested for accuracy against existing tools and sensitivity to input variables.

Midterm (3-8 Years from Initiation): The midterm goals include Builds 3 and 4. Build 3 would be a large effort and would include integration of other modal analysis tools with AEDT, but leaving the original tool intact. The model structure and protocol would be maintained throughout the remainder of Builds unless overriding technical requirements demand otherwise. It is envisioned that the methodologies to be integrated would be again selected from and based primarily on the tools shown in Table 1-1. Build 3 would also include a substantial expansion of AEDT’s GUI, assisting the user in model input and output tasks. Build 4 would result in a harmonized set of databases and methods across the various modes to the extent possible. For example, propagation for noise and dispersion analysis for air quality would use the same algorithms for all modes of transportation. Builds 3 and 4 would also incorporate tools to move from emissions inventories and noise contours to a more direct assessment of the health and welfare impacts of transportation activities.

Long-term (8+ Years from Initiation): The long-term goal would be to implement a first generation simulation architecture, which would begin in Build 5 with a hybrid approach. The initiation of this build would be limited based on the availability of high-resolution source data, e.g., noise hemispheres. This development will be sequential in that it will be based on the work in previous Builds, most notably the GUI structure, the use of a framework consistent with AEDT, and the output combination rule base. Build 5, envisioned as a hybrid tool, would include steady-state and simulation-based model processing. Build 6 is seen as the desirable end state, a full simulation-based, multimodal environmental analysis tool, with all supporting algorithms and databases fully harmonized as began in Build 4.

TABLE 1-1 Noise, Air Quality and Related Models in Use or Developed by Federal Stakeholder Agencies

	Transportation Mode			
	Air	**Ground**	**Water**	**Rail**
Noise	AAM (NMSIM + RNM) **AEDT** HNM INM NIRS NOISEMAP	CREATE HICNM Horn Model HSRNOISE RCNM TNM		Spreadsheet: Guidance on Assessing Noise and Vibration Impacts
Emissions	**AEDT** *EDMS*	**AEDT** *EDMS* EMIT MOBILE6 MOVES NONROAD2005	EPA AP-42 Emission Factors	EPA AP-42 Emission Factors
Atmospheric Dispersion	**AEDT** *EDMS (AERMOD)*	CALINE3 CALINE4 CAL3QHC CALPUFF AERMOD	OCD Gaussian Puff-based models (e.g., CALPUFF)	
Impact Assessment and Valuation	APMT			
	CMAQ and BenMAP			

1.4. Guiding Principles

In developing the MDP, the research team followed a number of guiding principles so that the work plan will result in the final model(s) meeting stakeholder needs. The MDP development included input received as part of stakeholder engagement as well as the collective experience of the research team. Comments of the stakeholders were considered and key concerns/observations included:

- The users would be federal and state agencies and those conducting noise and air quality analyses on their behalf to perform project level analysis to meet requirements of regulations, perform research, and/or evaluate future scenarios in general planning. Other uses are possible but would be secondary to the stated uses.
- The MDP should consider how the projected model is likely to affect the cost, duration and risks of the environmental/design process.
- The MDP should estimate potential environmental impacts and evaluate mitigation measures.
- The MDP should allow estimation of the individual and aggregated contributions of the various modes.
- There is significant complexity, bringing the various modes into a single environmental analysis tool. This is especially true for the integration of inputs which are in some cases very different. Combination of outputs was also cited as a concern.

- Current analyses are conducted by teams, with each team member adding specific expertise in one or two technical fields. If preparation and running of the model is significantly more time consuming and expensive than use of current models, the simpler project and less experienced user will be disadvantaged. As such, models should be easy to use, and scalable.
- The expanded use of Geographic Information Systems (GIS) is essential.
- Inclusion of sources beyond transportation such as point sources could be helpful.
- Use of a build sequence would allow the designers to adapt and learn as they go, should help to develop long-term support from stakeholders, and each build should expand upon the previous.
- Existing tools should be used as much as possible.

***Defined logic of MDP*:** Following good engineering practice, the logic was based on five key points: 1) development should be phased to allow advancement as resources become available and as science and technology allows, also providing a usable tool at the end of each Build; 2) development should be based on proven principles, using/adapting existing approaches in early Builds and with more comprehensive development occurring in later Builds; 3) the methodology must be responsive to the stakeholder's needs, primarily the stakeholder agencies; 4) combination of model outputs must be an outcome of the first Build and continue to be developed with each Build; and, 5) the overall development should lead to improvements in the modeling process. In addition to the base logic, the models must be user friendly. This would require the use of the AEDT's advanced GIS-based GUI to allow ease of use as well as a rule base to allow various outputs, especially related to different metrics, to be combined. This output combination rule base can be continually improved upon with each build allowing the combination of results to become more robust. Because the model must comply with the requirements of multiple stakeholder agencies, it is imperative that the rule base allow output of various metrics.

Practical limitations: Based on the preceding logic, limitations were considered to allow each build to be completed within a specified schedule and with available resources. This required careful delineation of all tasks.

<u>Time.</u> The Build process was divided into six stages, called Builds, so that each could be completed in a reasonable time frame. It is possible that Builds could be combined or other Build stages added as development progresses. The project team reasoned that no Build should take longer than 3 years or overall project development could be impeded because of a loss of flexibility in the technologies, and potential loss of stakeholder engagement.

<u>Project resources</u>. Using the AEDT development as a basis for estimates, significant resources will be needed to develop the end state. However, since the development of the multimodal model will be based on the work of AEDT, significant leveraging of resources should occur leading to reduced time and lower costs. For example, beginning with Build 1, the architecture and protocol of AEDT will be utilized for GUI development. This will help define programming efforts leading to reduced time requirements when in Build 3 the models are integrated into a single platform. Many of the development issues that were addressed during AEDT development can be recognized and avoided. The large work effort already accomplished for aviation sources will not need to be repeated.

Improvements made to overall modeling process: The starting point for the MDP was to identify gaps in AEDT, as well as candidate models for integration with AEDT, with respect to a multimodal model. Appendix C presents the assessment of gaps identified in existing emissions, dispersion and noise models being considered as a part of MDP development. As each Build occurs, there should be a well-defined plan to eliminate these gaps. It must be recognized that while many of the gaps may be overcome in the Build options depending upon the concurrent advancement of the knowledge base, others will require scientific advancement and basic research. The MDP may identify some scientific gaps, but the scope of this document, including estimated schedule and resources, does not include the research effort required to address these scientific gaps.

Single model concept advancement of a multimodal tool: The advancement of a single model concept of a multimodal tool would require not only inclusion of the existing single-mode models beginning in Build 3, but would require that these models be integrated more completely with each Build. This will require adaptation of the models. In the early stages this will be external to the models as the outputs are the foundation for "integration". With each successive build the inclusion of these models would become more comprehensive and seamless, resulting in a fully integrated tool. This principle will result in an end state in which each mode uses the same fundamental emission, dispersion and acoustic modules. Additionally, as these advancements occur, gaps in the models should be addressed to the extent possible, given that expected resources for the MDP will not permit advancement of fundamental science. It must also be noted that significant changes to any model will require extensive testing to validate and meet federal requirements.

Additionally, inclusion of the regional, national, and global scale modeling will require large databases and models to be included in the overall framework. It is very likely that these options will require multiple platforms (e.g., portable computers and server-based systems) to be used. Additionally, it is recognized that global modeling for some modes may be difficult due to the extensive data requirements. For example, in the case of rail, non-regulatory models, such as the Florida Department of Transportation Rail Model, and European models such as the German Rail Model will need to be reviewed to establish what is available in terms of both method and database. This is also complicated for rail sources since the various types will need additional classification including heavy rail, light rail, high speed rail, etc.

Integration into the Federal system: Federal stakeholder requirements must be observed during development. Any Build that would result in processing, calculations, outputs, or metrics that are not accepted by the federal stakeholders is unacceptable.

Vehicle. Each mode of transportation has different vehicles. This results in different operational parameters, emission (noise and air quality) considerations, and different operating environments. While the early Builds will not change what is now being modeled, later Builds must find ways to define these vehicles using defined, acceptable methods available at the time. Work to derive new methods is not expected to be part of this work unless a specific need occurs.

Model response. Many inputs are similar for various models now being used, e.g., meteorology. While not realistic in the early Builds, later Builds would need to incorporate a methodology to have input in a simple fashion that could be used for all modes when possible.

Metrics. While air pollution computations from multiple models can be combined directly due to the use of similar metrics and the same standards, varying metrics now exist for noise. Since the output must be combined to determine the total noise exposure at any modeled location[1] a rule based structure will be needed, beginning with Build 1, to allow prediction of the various metrics required for federal impact analysis (see Section 1.2). This rule base should be continued and strengthened with each Build.

[1] Note that in AEDT development, due to the differing use of the words "receiver" and "receptor" in legacy models, all modeled locations are now referred to as receptors.

CHAPTER 2. BUILD REQUIREMENTS

In this section, requirements of the six Builds are discussed in detail. These requirements are based on the principles discussed in Section 1.

2.1. Project Objectives and Motivation

The primary objective for each successive Build is to advance the ability to conduct multimodal environmental analyses, as compared with previous Builds. Builds 1 and 2 will concentrate on combining outputs and preparation of screening models to help in advanced transportation planning. Subsequent Builds will focus on harmonizing inputs and computational algorithms. The last two Builds will first focus on implementing needed changes into the AEDT structure and then transitioning the common databases and algorithms to a simulation-based architecture.

The motivation for this work includes the need for increased flexibility of environmental analysis, including the ability to assess interdependencies between both environmental parameters, as well as the various transportation modes. An expected outcome of this effort will be better coordination among federal agencies.

Initial market research of stakeholder requirements was conducted at the start of this ACRP effort. It is recognized that the needs of the stakeholder community will change over time and that it is important to reestablish the baseline for each phase of the Build development. The market research effort may vary by Build but should be part of the formal task of establishing requirements for each Build. Critical to the establishing the Build requirements are the need to include federal requirements and concerns and reassessing technological advances.

This is a complicated topic since differing metrics, modeling approaches and assumptions must be considered. Continued coordination with the stakeholder agencies is essential. Chapter 5 discusses further stakeholder involvement.

2.2. Assumptions and Approximations

As discussed in Appendix C, gaps in the current algorithmic knowledge base have been identified. As stated previously, the scope of the MDP does not include considerations for advancing the environmental sciences. Consequently, each Build will likely require a number of assumptions and approximations, depending upon the degree to which the science has been advanced at the time the Build is initiated. During planning of each Build, these gaps must be reassessed and an in-depth discussion of assumptions and approximations will be needed.

The basis for any assumption must be explained in the Build documentation. New assumptions must be explained in terms of proven theory. Assumptions previously used and carried over from a prior Build must be documented.

The rationale for approximations must be explained. It is recognized that some approximations are because of knowledge gaps while others are driven by requirements such as run-time.

Each Build will have risks during development and upon implementation. These risks vary for each Build but will become more substantial in later Builds due to the increased complexity. It is important that these risks be minimized by first understanding each and then by planning to minimize each to the degree practical.

Because the Builds will be sequential and much work will be spent on each build identifying assumptions, approximations, and gaps in the knowledge comprehensive supporting documentation will be needed, including an annotated bibliography.

2.3. Details of Each Build

As previously stated, each Build will be a usable tool, with an accompanying technical manual and user guide. Administrative requirements will include quarterly reporting, draft final and final reports. Documentation of testing, evaluation, and acceptable performance must also be included with each Build. Environmental impact assessment and cost-benefit economic analysis will be included beginning with Builds 3 and 4.

Six Builds are recommended in the MDP, where each Build is a stepping stone for the next. Figure 2-1 illustrates the overall Builds while detail is provided in the following sections on scope, estimated costs and timelines.

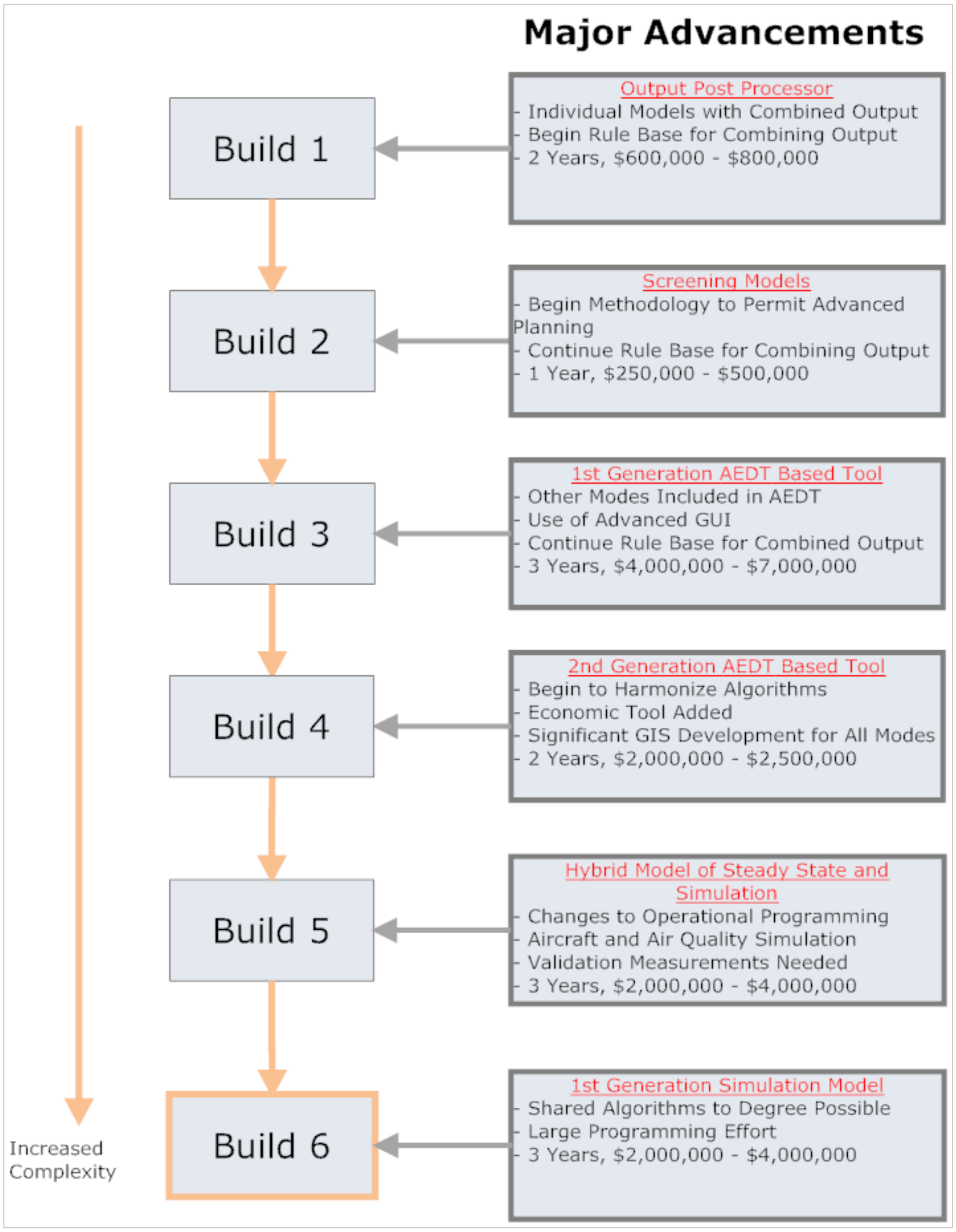

Figure 2-1. Simple flow chart of Build phases.

Build 1. Output post processor. The first build will focus on preparing a post processor that is compatible with existing model outputs. Required or preferred models would continue to be used, but this build would allow for integrated analysis of the various tool's output. The post processor would create an echo file of the output parameters from each model that is included; combine the outputs of each tool into a single set of reports and graphics, thus allowing integrated impact assessment. Build 1 will be the first step in having a greater degree of uniformity in multimodal environmental analysis. Market research, as described in Chapter 5, should be an initial required task.

While a beta version of AEDT (a replacement for INM, NIRS and EDMS) is currently available, the first full public release of AEDT is scheduled for 2011 (AEDT2a) with the next release scheduled for 2013 (AEDT2b). In 2013, INM and EDMS will be withdrawn as required regulatory models. Since it is a postprocessor for existing tools, initiation of Build 1 could be coordinated with the release of AEDT2a, to allow compatibility with the AEDT structure. Coordination of the AEDT development and the Build stages is crucial to maximizing the use of resources. Build 3 should not be started until post AEDT2b. However, beginning with Build 1 and effort should be made to begin using the AEDT protocol.

The postprocessor for Build 1 should be based on the output content of the current required models. The postprocessor will automate the needed work to combine the output results from the models for all modes. This will provide a uniform combination of data and greatly reduce analysis time. The postprocessor should include as a minimum the output from: AEDT, INM, HNM, AERMOD for air, FTA's spreadsheet Guidance on Assessing Noise and Vibration Impacts for rail, TNM, MOVES, and CAL3QHC for motor vehicles; and, input for user specified values for sources that may not have a required or preferred model. Additionally, models in common use by military operations should be addressed, e.g., NOISEMAP. This may also include military non-transportation sources (e.g., BNOISE) if it is determined that a significant effect could change the overall results. Note that some of these legacy models have been included in AEDT such as INM, HNM, and AERMOD. In addition, construction noise models and special source models regularly used for transportation projects should also be included. These would include HICNM for ground and horn noise models for rail. If Build 1 is initiated prior to the release of AEDT Version 2a, INM, EDMS, SAGE and MAGENTA will also need to be included.

Combination of the outputs will require a rule base development. For example, the differences between policy-driven noise descriptors across the agencies (e.g., FAA with L_{dn} and FHWA with peak-hour L_{eq}) must be considered and overcome so that the outputs comply with the stated policy of the lead agency. This will require substantial liaison activities with the stakeholder agencies. It is envisioned that this rule base will be expanded in subsequent Builds as well. The rule base must allow processing from all modes of transportation. Combining output into common metrics may require some simplifying assumptions that could lead to uncertainty specification around modeled results. The use of standard combined reporting mechanisms such as extensible markup language (XML) base, using innovative graphics, color, and output tables will be essential to the success of this build.

Multimodal environmental analysis tools should directly make use of GIS capabilities. GIS is integral to AEDT and TNM Version 3 and should be fully developed in the near future. While GIS architecture will be considered in general, resources are not planned for GIS implementation of the other modes until Build 4. This is because of the resource intensive nature of the work and problems that could occur. For example, one potential challenge in combining the AEDT and TNM structure is that two tools currently use different GIS engines (ESRI for AEDT and Manifold for TNM). There are good technical reasons for this, but further investigation will be needed.

Verification and validation (V&V) are discussed in Section 2.4 (Software Testing), but it should be pointed out that the primary goal of V&V for the first Build would be to ensure descriptors are combined correctly, that the derived combination rule base is performing adequately, and testing against a real world test case with representative data. For Build 1, most of the required testing could be accomplished using a simple spreadsheet template.

The other vital testing is to demonstrate the capabilities of the tool using actual case studies, which applied existing single mode models. This testing would help address ease of use of tool versus multiple runs of single mode models and the value of assessing the combined effects from all modes.

The risks for this Build are considered low since no changes will be made to the underlying models. They will be connected using a post processing capability. Possible pitfalls include misunderstanding of model output and problems establishing the rule base for combination of noise descriptors.

This first Build is estimated to take 2 years with funding of $600,000 – $800,000.

Build 2. Development of screening tools. Build 2 will be the development of environmental screening tools to permit advanced planning to occur quickly. Screening tools are very quick, conservative estimates to determine if more detailed modeling is required. It is desirable to minimize the total number of screening tools but it is envisioned that at least four will be needed (air, rail, highway, ports). The advantage of focusing on screening tools in Build 2 is that it will further advance stakeholder understanding of the pros and cons of having a multimodal analysis capability. Important to this overall understanding of multimodal analysis is a reestablishment of the technological advancements of each mode and desires of the stakeholders during development. This Build is important in the total sequence since it will begin the development of mitigation analysis for multimodal projects that will be based on these screening models. While the screening tools will work with the postprocessor developed in Build 1, they are envisioned to be related to a single mode at this time. Note that in Build 3 the screening tools will be combined to permit a single mode to be reviewed in What-if and mitigation analysis. This will allow changes by mode and the change to the total environmental effect. Outputs should include a base case analysis and then allow for various scenarios deviating from the base case. Ease of use is a primary requirement. This Build will also help the various agency stakeholders to begin to plan for possible future policy changes.

Existing screening tools, such as the TNM lookup tables, the noise Area Equivalent Method (AEM) for airports, the FTA screening method described in Guidance on Assessing Noise and Vibration Impacts, CO concentration screening tools commonly used for highways, and any screening tools released in the interim time period before Build 2 begins must be evaluated to determine if they may be utilized in this Build. Where screening tools are non-existent or if existing screening tools are not found to supply needed detail, they must be developed in this Build.

Continued development of the rule base to combine output from the various in-use models that was began in Build 1 should continue. It is important that this advancement occur in such a way to provide continuity in this Build and subsequent Builds. The screening tools should allow a direct feed into the output processor so that the results of different What-if and mitigation analyses can be easily recognized and quickly determined.

Required testing will include verification of the outputs, testing of the rule base, sensitivity analysis for inputs, and demonstration of the capabilities against a real study.

Risk for this Build is considered low to moderate due to the conservative nature inherent in screening models. Possible problem areas will be reduced by assuming methods that may over-predict so that any analysis will not under estimate probable impacts. Possible problem areas are federal agency acceptance of the screening model methodology and implementation of screening tools in a single package. For example, if a call statement were to be used for external programs such as the FTA spreadsheet approach, there must be a seamless interface sending needed information to the spreadsheet and bringing output back into the overall process.

Build 2 is estimated to take 1 year with a budget of $250,000 - $500,000.

Build 3. 1st generation AEDT-based tool. The development of AEDT is currently in the later stages with the first full public release planned for 2011. Interim versions have been developed and achieved limited distribution outside the development team. At the time of this writing, the beta version has been released so the time schedule is expected to be met. Although AEDT is aviation centric, it has been designed to conduct limited multimodal environmental analysis around airports. Consequently, it is an excellent foundation for a more robust multimodal tool. Likewise, TNM Version 3 is slated for release in 2011. It will be the target version in terms of requirements to be integrated within AEDT. At the start of Build 3, it is estimated that AEDT and TNM Version 3 will have been in use for 3+ years and the various pros/cons and areas of improvement will have been identified. Most of the “bugs” that are inherent to computer programs should have been identified and corrected. In essence, AEDT is expected to be sufficiently mature so as to be the foundation for this Build. Starting with AEDT, Build 3 would include expansions for all modes of transportation, new meteorology input/internal modeling needed for noise analyses, and expansion of the GIS-based GUI to account for the various multimodal requirements. The postprocessor developed in Build 1 was required to utilize AEDT protocol and is expected to be leveraged as part of this Build. Additionally, the screening models of Build 2 would be implemented to allow rapid advanced planning analysis of changes made to each mode. Another round of market research as described in Chapter 5 would be required.

Comprehensive inclusion of the non-aviation modes is expected to build upon and leverage the capabilities of existing models such as TNM. All modules that will be developed to interact between existing models must be fully compatible with the AEDT build framework, e.g., Microsoft .NET, etc. In cases where the state-of-the-art predictive capabilities, including the sciences have been advanced, it would also be desirable to include these changes during model implementation. Non-aviation source levels (noise and emissions related to air quality) would be included in a database similar to that of AEDT. As with AEDT’s airports database, it is envisioned that railway and roadway databases will need to be developed. Since these databases would have to be created, each should be compatible with AEDT and would most likely be facilitated using GIS layers. Other possibilities include movements databases, which are available for maritime, and to lesser degree for rail.

Development of the GUI should be done in such a way to prevent the model from being unwieldy. Not only must the GUI control input and output, but Build 3 may include limited GIS capabilities to support new module development. The GUI should also allow the user to make selections of the desired functions needed for any particular analysis. The screening tools which were developed in Build 2 would become mitigation tools allowing What-if analysis. This would be accomplished by using the single mode tools as a quick analysis of possible changes adding more flexibility if needed. For example, if rail is considered to be a minor part of the overall air quality concentrations, the screening tool module would permit a range of operations to be quickly analyzed. The output of the rail screening module would then be summed into predicted concentrations, and using the GUI, the user could quickly see the progression of impacts. If the summation shows little change it can be quickly determined that the rail component need not be considered in greater detail. If however, there is a significant change, or concentration levels approach the National Ambient Air Quality Standards, then detailed analysis must be conducted. The screening tools then become an effective mitigation analysis tool for quick planning.

While the GUI is anticipated to be the primary input mechanism, other inputs should also be included to assist the user. For example, the model should have the ability to read Extensible Markup Language (XML) files and database files such as the Structured Query Language (SQL). This input should be flexible, related to state-of-the-art at the time of build, and based on available options in the existing agency models.

The output will also be streamlined and tailored to the specific analysis to be undertaken by the user. Current thinking is that the GUI would be customizable based on the specific analysis to be undertaken. The user would be queried regarding elements of their specific analysis, and a tailored GUI would help streamline analysis and make the process more user-friendly. Alternatively, all of the databases would be open to the user and the more advanced users' could write their own tools to write directly to a study specific database and avoid the GUI. In such cases, it is recommended that preapproval of any developed tools by the lead agency during the analysis would be a prerequisite. It should be noted that this follows ongoing development of AEDT and that the primary database will not be changed, only the study specific database.

Flexibility will also be built into the model. For example, if an analysis begins and then an additional mode must be considered, the model will have the capability to add this source, such as using a pull down menu, which will change the input GUI and output content.

In Build 3, combination of the model results will be both easier and more difficult at the same time, requiring the rule base to be adapted. Since the models will all be contained in a single framework, processing of outputs will be an internal function for the software instead of external manipulations. The framework can be directly used for calculations during runs making the combining of information easier to accomplish and transparent to the user. At the same time, a higher degree of fidelity of the output combination rule base will be required of the combined results than in Build 1 and 2. Advancement of the rule base in Build 3 will need to be based more on the science and less on approximations to reduce the uncertainty of the final output of the combined data.

The GIS-based capabilities will be expanded in this Build to allow a limited degree of input and output. It is the foundation for a lot of the capabilities in both AEDT and TNM and should be advanced so that in Build 4 full advantage of this resource may occur. The GUI will essentially serve as a software layer that will invoke the wide range of capabilities of GIS, such as mapping, demographic analysis, standard reporting, 3-D views, etc. in Build 4. In Build 3, the process should begin by allowing some additional modal input into the mapping capabilities and accomplished in such a way to allow other components such as the addition of the demographic analysis to be more easily integrated in Build 4.

Depending upon available resources, other parameters could be brought into the model at this time, e.g., vibration due to noise. However, research to establish additional parameters such as vibration criteria is not a part of this process. Only defined parameters would be included. In the case of vibration analysis, the method will come from the FTA Guidance on Assessing Noise and Vibration Impacts.

This Build will include a major V&V component. Required V&V will include extensive error testing for GUI input, verification of the outputs, testing of the rule base, sensitivity analysis for inputs, and demonstration of the capabilities against real studies. This will be accomplished by anticipating testing needs as part of regular development. For example, standard testing methods such as unit tests will be included as part of software design and development.

The risk for this Build is substantially larger than the first two Builds and thought to be moderate to high. This is because of the increased number and complexity of tasks that need to be completed, the multiple computer languages to be interpreted, and the demands placed on GUI and moderate GIS development. It must also be recognized that all computer algorithms may not be on the same computer, especially in the cases of very large, computational intensive models. In these cases, calls could be made to these computing facilities or servers for the actual processing. This could result in access problems for some users. One possible reduction to this risk would be to divide this Build into different work efforts that could be sequentially completed. However, division of this Build, or any subsequent Build, should be done in such a way that the interim products result in a useable product.

Build 3 is a major effort and is estimated to take 3 years to complete. Of note is that consideration could be given to divide Build 3 into two parts if time requirements are thought to be more than 3 years. This would allow the development phases not to exceed 3 years, the time frame for keeping development current and responsive to the stakeholders needs as previously discussed. Resources will also be critical to allow all work to be accomplished on time and will require interagency funding. It is estimated that the budget will be $4,000,000 – $7,000,000.

Build 4. 2nd generation AEDT- based tool. Build 4 is expected to have the same look to users as Build 3 but significant major internal architectural and software changes will occur. The largest of these changes will be the use of shared (harmonized) algorithms for the different modal sources. In Build 3, existing models were imported into the overall "umbrella" of the program. Beginning in Build 4, these models will be broken down and analyzed. Where possible (e.g., geometric spreading for noise or dispersion modeling for air) the equations will be shared, eliminating the need for multiple models. It is also important to note that specific algorithms may need to be maintained if sharing would in any way reduce the usefulness of the model to a specific federal agency. The sharing of algorithms should not be undertaken if the result is any degradation in accuracy or robustness or if considered to change the needed requirements of a federal agency. Again, market research should be an integral task. Complete documentation of all changes to codes, simplifications, or modifications is critical to acceptance of this approach.

The next large change in terms of effort is the expansion of the environmental impact and economic analysis tools in the APMT assumed to be completed by this time, which work in conjunction with AEDT (see Figure 1). If APMT is not available, additional time and resources would be required to establish an economic analysis tool or this task could be scheduled for a later date. These models would need to be expanded to include all modes of transportation. While this is not a trivial effort, it will allow for direct evaluation of cost and benefits as a part of the overall, multimodal environmental planning process.

Currently APMT uses reduced-order models of air quality and climate (based on more complex simulations) to estimate how changes in aviation emissions inventories may lead to changes in climate and air quality. Changes in physical impacts (e.g. ambient pollution concentrations) are used to estimate changes in health and welfare impacts. Then established methods are used to make economic estimates of these impacts. For noise, contours are overlaid on census data (housing, population, personal income) and estimates are made of the economic impacts. These analyses are conducted within a probabilistic framework as a means of explicitly propagating and communicating the uncertainty in such estimates. With further development, these methods could readily be adapted to be applicable to other transport modes. However, these methods are also the focus of ongoing research (e.g. through the Partnership for AiR Transportation Noise and Emissions Reduction, PARTNER, and the Aviation Climate Change Research Initiative, ACCRI) and it is likely that the methods will be different at the time that Build 3 is complete and consistent multimodal transportation emissions and noise inventories are ready for the assessment of environmental impacts. Therefore, Build 4 will leverage as appropriate the development of APMT and other research to enable environmental cost-benefit analyses of policy and other scenarios for the various transportation modes.

Here we have assumed that the industry and consumer cost impacts of different policies and mitigation scenarios would be exogenous inputs and that the multimodal model would produce only economic assessments of the environmental impacts. There would certainly be scope for more fully integrating economic models, but the appropriate models would be different when applied at the national or local level and thus at this time it is felt that it is most appropriate to not integrate these directly into the model.

The GUI should also be updated and refined as needed, based on the cumulative experience of users. In this Build, GIS implementation will also be much more prominent. Full use of the changes began in Build 3 will be achieved allowing all modules that interact between existing models and AEDT to be fully compatible with the AEDT build framework, e.g., Microsoft .NET, etc. The emphasis of these updates should be increased computer compatibility of the individual modules, ease of use, flexibility of analysis, and federal agency preference.

All architecture and software updates should account for the fact that later Builds will be focused on simulation modeling. Any programming decisions that could directly help the transition to simulation modeling should be considered and implemented if resources permit.

Extensive testing of this Build will be needed. This should include verification and possible validation as compared to "gold standard" measurement data for each source, as resources allow. Extensive error testing for GUI input, verification of the outputs, testing of the rule base, and sensitivity analysis for inputs will be needed. Since the basic environmental modeling of the new tool will deviate from established models, compliance with federal requirements such as 40 CFR Part 51, Appendix W (*1*), and 23 CFR 772 (*2*) will need to be confirmed. This will need to comply with requirement of all federal guidelines.

The level of risk for this Build is moderate to high. Use of shared algorithms, while very important to programming efforts and run time, could result in two major flaws. First is incorrect algorithm implementation. Each of the modes and disciplines has unique functions and nomenclature – extreme care must be taken in harmonizing and rectifying differences in implementations of algorithms. Second is the incorrect inclusion of more obscure physical realities of the various sources, such as emission release temperature, height, directionality, etc., using the shared equations. The economic analysis model expansion could also be a difficult task. The interdependencies of all modes may be difficult to capture for the economic analysis. All modules that will be developed to interact between existing models and AEDT must be fully compatible with the AEDT build framework, e.g., Microsoft .NET, etc., given the varying metrics and analysis techniques/assumptions used across the modes. Additionally, ensuring compliance with federal regulations could be time consuming, contributing significantly to the risk the time, and overall effort required for this Build phase.

The expected work effort is estimated to take 2 years, although federal requirements could extend this effort. The possibility of extending the time frame to 3 years and/or dividing into two efforts also could be applied to this Build. The cost is approximated to be $2,000,000 - $2,500,000.

Build 5. Hybrid Model. This Build begins the formal transition to simulation modeling. The transition is expected to be complete by Build 6. Changes that can be made without significant redevelopment should occur in this Build to allow simulation modeling to be more easily implemented. These changes include: (1) adapting input data and the GUI to accept information that can be directly used in simulation; (2) the inclusion of emission and reference levels for sources in a form suitable for use in simulation; and, (3) the ability to import existing simulation algorithms. The algorithm import is key to this phase - Build 5 is not intended to develop simulation models, but rather to use what is available from current simulation efforts, including the Department of Defense (DoD) aircraft modeling, the IMAGINE project, as well as models that have been developed and tested for other transportation sources. The modeling for other transportation sources is expected to be better defined by the time this Build occurs and should be a part of the market research as described in Section 5. This is true not only of simulation modeling for environmental analysis but the simulation modeling of operations as well. Where simulation models capabilities do not exist at the time of this Build, the models currently in use will be continued. This is especially important in the case of some transportation facilities such as small airports.

The move to a hybrid model will also change the rule base for combining results. Due to the nature of simulation, the output combination rule base will change. For example, simulation modeling would have greater detail on noise levels since values would be available for each step (time or spatial). This would allow multiple noise metrics to be computed since noise levels could be combined using the various time steps. This could eliminate simplifications that may have been required in earlier versions of the rule base.

Similar to Build 3, Build 5 will require extensive testing of the integrated versions of the existing models that are used. Testing should include error testing for the GUI input, verification of the outputs, sensitivity analysis for inputs, and demonstration of the capabilities against a real study. Additionally, a comparison to "gold standard" measurement data should be conducted for any source for which the processing is changed in any way.

The level of risk for this Build is moderate. Only proven methodologies will be used and the staged fashion of the previous development Builds will allow a similar approach to be utilized.

This Build is expected to take 3 years for a cost of $2,000,000 to $4,000,000. The primary driver for the scope is the integration of the new methodologies.

Build 6. 1st generation simulation model. The end state model is what was determined to be the ultimate goal when resource limitations were not considered (see Section 1.2). When resource limitations (time and cost) were considered, the practicality of the approach came into question. Simulation modeling provides flexibility and options that are not available in steady state modeling but at a higher cost. A staged approach was selected by the research team based on the market evaluation of the stakeholders and the research team's expertise. Build 6 is expected to be the culmination of this work. Building upon each phase, multimodal impact modeling for all modes of transportation would be available in a true simulation model. Market research for this Build will be needed to establish that this is indeed the true end state model.

In Build 6 simulation modeling would be used for all sources. This will require development of simulation modeling techniques for those transportation sources for which they do not already exist. This development would be based on previous work and associated literature, and implemented based on the shared algorithm use protocol. Changes to input parameters would need to occur. This in turn would require adaptations to the GUI.

While the emphasis would be on software development in Build 6, technical developments and clarifications relating to simulation modeling would also need to occur throughout the Build phase. However, given that this Build would not likely begin until after eleven years from the start of the first Build, it is expected that simulation modeling will see significant advances in this time frame. This could make implementation easier than is currently expected.

The extent of testing for this Build will depend on the state of simulation modeling when it is begun. The more development required, the more testing that should occur. At a minimum, testing should include verification and possible validation to measurement data depending upon available resources. This is especially needed for any source for which new simulation algorithms need to be developed. Extensive error testing for GUI input, verification of the outputs, testing of the rule base, and sensitivity analysis for inputs should be conducted. The validation for the database prepared in Build 5 may also need to be repeated. Since the development will represent new models, compliance with federal requirements defined by regulations such as 40 CFR Part 51, Appendix W (*1*), and 23 CFR 772 (*2*) may need to be verified.

The level of risk for this Build will also depend on the state-of-the-art in simulation modeling at the time of project inception. It is thought to be moderate to high at this time, but could be reduced if significant algorithmic advancements are made in the area of simulation before Build 6 occurs. Similar problems for shared algorithms could exist as those outlined for Build 5, but to a lesser degree. Additionally, confirmation of compliance with federal regulations could again be time consuming, adding delay to the overall Build phase.

Build 6 is expected to last 3 years with a cost of $2,000,000 to $4,000,000.

Summary of Build strategies. The Build strategy was implemented to allow a desired end state to be reached that was not thought to be practical with resources that would be immediately available for a single Build. The process begins with Build 1 where all modal outputs are combined into a single evaluation package using a controlling GUI. From this first Build, better consistency between individual analyses should be realized. A rule base to combine the outputs will be required because of differences in sources, metrics, and modal regulations.

Build 2 leads to the development of screening tools for advanced planning. This Build allows the initial development of a methodology to create what-if scenarios and mitigation modeling based on all modes of transportation. It also begins the transition to computer implementation consistent with AEDT.

In Build 3, the strong model base made possible by AEDT development is utilized and other modes are included via integration of established models. The concepts of what-if scenario development and mitigation evaluation are brought forward from screening tools from Build 2 and will begin to be implemented as a way to conduct mitigation strategies in advanced planning. Software development must remain consistent with AEDT architecture and associated protocols to be effectively implemented. The rule base for combination of impacts for each source development is also continued.

Build 4 continues the AEDT expansion, but begins to use shared algorithms to better harmonize the methodologies from various transportation modes. The APMT is also expanded for all transportation sources in this Build.

Build 5 begins the transition into simulation modeling using a hybrid of both simulation and existing non-simulation modeling techniques. The rule base for the combination of outputs would need to be reevaluated and it is envisioned that earlier simplifications could be revisited and/or omitted.

Well over eleven years will have passed from the start of Build 1 until the commencement of the Build 6 process of developing a true simulation model for all sources. More than fourteen years from the first Build, the completion of Build 6 would provide true, integrated simulation modeling for all transportation modes. This model would offer flexibility and options not possible without the use of simulation techniques. Programming of chemical reactions in the exhaust plumes, combination of noise levels using multiple descriptors, modeling of any moving transportation source whether at an intersection or moving along a runway would then be possible. The degree of analysis would be far greater for project scale modeling. Times in route for global modeling could be adapted for multiple time related events leading to more accurate environmental estimates. For the schedule outlined in this MDP, the investment cost would range from $800,000 to $1,100,000 per year. Adjusting for any time needed between Builds and for federal compliance, assumed to be 6 additional years, the required investment value is more likely to be an average of $500,000 to $750,000 per year.

Each Build is expected to result in a usable product (model or feature). Each Build is expected to be a complete working methodology with technical manual and user guide. Each build may be separated into individual projects or may be combined depending upon the market research. A reevaluation process is expected to occur after each build to determine next step(s) and should include stakeholder input and a review of state-of-the-art practices, especially advances in technology. Documentation of testing, evaluation, and acceptable performance will be included in each Build. Each Build, will permit mitigation options, although this will not be a formal component of development until Build 3. Economic analysis at the local and regional level is expected to be included starting with Build 4. Flexibility must be maintained to accommodate transportation facilities such as smaller airports.

2.4. Other Build Requirements

Model evaluation. Model evaluation includes testing for both the software implementation and correct implementation of technical methodologies such as dispersion modeling. During each Build description, general testing requirements were described based on the tasks to be performed. In this section, more description of each type of testing is described. This section is not meant to suggest a specific testing procedure (e.g., spiral testing, “V&V” testing, online or offline”). These types of tests are described in multiple texts and would best be selected by the project team for each Build. (*3*) Instead, components of those tests plans are discussed.

Technical methodology testing. Regardless of the test method chosen it must be verified that methodologies have been implemented correctly and provide accurate results. It is assumed that the methodologies, implemented as computer algorithms, will be based on theory and assumptions and/or simplifications completely justified and documented as discussed in Section 2.2. But a complete testing and quality control plan must be determined with each Build and included in a detailed work plan. In addition to making sure the implementation is correct, sensitivity testing based on range of variable and Monte Carlo testing must occur to establish reasonable input parameters such as the range of input. All final results of each Build should be compared to a real world test case with representative data as well.

Software testing. Rigorous assessment, validation, and verification processes are crucial to the success of any software development process. A model similar to that undertaken for the AEDT development process is recommended for this effort. (*4*) Again, multiple test processes are described in the literature. Whichever is selected, during project work plan definition, it must allow for performance testing, correct implementation of variable and equations, uncertainty of results, and proper operation of control functions such as the GUI. Performance criteria and comparison to known results should be conducted.

It is recommended that both individual computational module- and system-level assessments be utilized throughout the development. Assessment should include direct support from domain experts (economic, environmental, and transportation industry) and include the review of any existing bodies of data and results. Formal evaluations such as Global Sensitivity Analyses (GSA) should be undertaken to coordinate and provide input, intermediate, and final data for comparative checks on all releases/analyses versus previous versions.

Formal software acceptance test plans and data sets should be developed and maintained. These should include an established battery of tests to be conducted for release of modules and applications and utilize verification against prior analyses and data sets. For example, in the aviation mode, validation against cockpit flight data recorder (CFDR) data, radar and other sensor data (e.g. ETMS, PDARS), external modeling systems, and measured data, should be conducted as available.

System database maintenance processes should include cyclic updates to core data, addition of new source data, as required, and a QA process on both intermediate and result data.

Comparison to measured data. Quality controlled measurement data is often used as the "gold standard". This testing should be required any time an existing model is not used and development has occurred. Any newly developed model component should be compared to this real world test case with representative data. Additionally, federal regulations should be followed to make sure the testing meets requirements of these agencies. Examples of this type of regulations are 40 CFR Part 51, Appendix W (*1*), and 23 CFR 772 (*2*).

After careful testing, evaluation releases of the model should occur in the typical alpha and beta testing formats. This will help to uncover "bugs" that may be only pesky to serious. The exact methodology to conduct this testing is not specified here since the quality control and experience by the successful bidder is crucial to the final product development and testing methodologies should be decided by the selected development team working with the stakeholders. However, a good example of a successful process is that currently being used for AEDT. This is described in Chapter 6 of this document.

Reformulations/recompile. The model must be refined if test results indicate that the model does not meet preset conditions. This may require only small software "fixes" to avoid rewriting and recompiling of all computer algorithms.

Development Framework and Computer Platform Considerations. At the beginning of each Build, it is possible for the development framework to change. For example, Build 1 and 2 kernel programs are expected to run on a personal computer (PC) with possible calls to a server. By Build 3 this could well change so that the PC is only used as a control point to receive input and return output. Reasons for this change would include program security, the large run times that would be expected on PCs, and the large data bases and model base that would result when the models are combined. All computations and all core models could be server based to alleviate these problems. Additionally, it is the general opinion of the research team that future software development for very extensive modeling systems will move to server based systems because of the run times and storage needs. This is necessary because of the extensive computational ability that will be needed in some scenarios, especially for regional, national, and global analysis. This would have to be an open platform, maintained at a single location, so that all users had access. This would require a user fee to maintain the platform but based on the time savings and equipment costs for individual users would still provide an economic benefit to users. Smaller analysis, without the extensive database requirements, could still be possible on stand alone units.

GIS and/or Computer Aided Design (CAD) are expected to become more prominent and more desired by modelers and analysts. GIS and/or CAD are included in all Builds. The savings in data input time would be very significant if direct read of various media are possible. Due to the possibility of GIS/CAD functions being resource intensive to develop, a proven methodology should be chosen in Build 1 and unless radical changes are needed, the basic programming should be kept and continually developed with each new Build. To properly implement these strategies, strong graphic support will also be needed as well as export capability into mapping packages.

Run times can be reduced in four ways; faster computer speeds, parallel processing, simplification of algorithms and streamlined programming such as the use of shared algorithms leading to fewer call statements. The first two are a function of the platform while the second two are functions of the programming. The program functions have been included in the Build statements. Possible platforms were previously discussed in this section.

Testing has been covered in a previous section. Directly related to testing, but a portion of the development framework, is the source database consideration and validation. With Build 3 and subsequent Builds, this must be consistent with AEDT protocol to avoid errors in calls, increased run times, and possible errors due to implementation.

External Agency Program Development. During development of the model described in this document, it is possible that changes could occur to the base agency models such as AEDT. Depending upon the degree of change to the agency models, a difference in the computed values could occur when the model is compared to the revised agency models. A time table for Builds has been established in short cycles of about 3 years. During these short cycles, it is expected that the number of changes (newer versions) of the individual agency models will be small. Agencies will be aware of this development effort for a full multimodal model and hopefully support it rather than sticking to the stovepipe culture of having individual models. By Build 3, agency models should be incorporated into the single multimodal model which should prevent development of the individual models.

Chapter 5 discusses the importance of stakeholder input to the MDP and Appendix D suggests an interagency forum to oversee the development. Early involvement of the federal stakeholders should minimize any coordination problems between the development of this model and the individual base agency models, but it is an issue that the development team should monitor, especially during Builds 1 and 2. Build 1 uses the outputs of the individual models and the output file structure of the agency models should only change if there is a major modification or replacement of the model. It does not matter if values change since data would be read by the Build module. As such, a problem with the multimodal Build 1 would only be required if a major modification in the output file structure of an individual agency models occurred. In this case there would be two options: 1) redo the processing model (Build1) to account for the changes, or 2) use the user defined input option for the short term. The first option would require additional resources to reprogram Build 1 to read then new output file. This would be much less work and effort than originally required for model development. The second option would not require any changes to Build 1 or additional resources. Because of the relatively short time frame, the second option would seem to be the most preferable. The second option would require the user to manually enter the results for the individual model that was changed resulting in additional work during input but no changes to Build 1.

Build 2 is the development of screening models. No real changes would be required since it works with Build 1 based on the existing screening models. The screening models are to be based on a review of the science when developed and if changes to agency models are underway or planned; this could be considered during development.

Legal issues. This document has not recommended changes to Federal or State policy. This however, is a reality that could occur as the project Builds occur. Not only could this add considerable time and resources to estimates but could change the way the work is performed. During the stakeholder input recommended for each Build, these issues should be addressed and the work effort scaled and/or changed as appropriate.

CHAPTER 3. PROJECT SCHEDULE

General time frames for each Build have been outlined in this document based on expected work tasks and are provided both in Figure 2-1 and the text. Changes in technology, a desire to change Build work tasks, and unforeseen issues could significantly change this schedule. Individual tasks and work schedules must be defined with each Build phase during project planning to properly determine the needed tasks to obtain desired results. Required information would include: definition of tasks and sub-tasks, time required per task, interdependencies of tasks, administration/coordination time, and Gantt Charts for each Build. Quality control should be a required task for all Builds, given the complexity of the proposed system. Market research of the stakeholders should also be required in Builds 3 and 5.

CHAPTER 4. PROJECT ORGANIZATION

While some Builds are similar, each Build will be organized differently because of the emphasis on different work task and the level of effort that will be required in each Build. Builds 2, 3, 4, and 5 will require significant technical investigations, whereas Builds 1 and 6 will be more heavily weighted toward software and database development. In addition, the exact staffing and organization will also vary depending on the internal structure of the organization with the successful proposal.

For these reasons, it would be premature to set an exact organizational chart for the various Builds, but some information should be in any organizational chart for this work. Each project proposal should include a detailed organizational chart, depicting at a minimum the project manager, project investigators, programmers, and staff support – including responsibilities – that fits the project and the team. Exact function and professional expertise of each position, and resource loading for each position must be identified. To provide a basis, or starting point, for these organizational charts, Figure 4.1 has been developed for the overall project flow that will be needed in each Build.

The box in the right hand portion of the figure represents the project team while the other inputs will come from stakeholders, selected evaluators, and the final users of the model. The project team management is crucial for various scopes for each Build defined in the MDP. Project tasking, overall direction of the work, budget monitoring and control must be the responsibility of the project manager and/or Principal Investigator (PI) to ensure success of the project. Accordingly, this management function must be included in all phases of the work as shown by the folders in Figure 4.1.

Technical decisions, practical decisions (approximations or simplifications) during implementation, and technical evaluations should be done by the domain experts and these individuals would be heavily involved in three phases of the work. The domain experts would also interact heavily with the program group in software implementation and the entire team in document preparation.

The stakeholder process must be included. The needs and desires of the stakeholders are necessary at the top level of the project direction and the final model. As such, stakeholders should have direct interaction with the project manager and/or PI and be among the external evaluators. Policy decisions should also be guided by the federal segment of the stakeholder group.

Evaluators will be both external and internal to the research team. The external evaluators should be from the stakeholders, especially the potential heavy users of the model.

Important to note once again is that Figure 4.1 is only the starting point for the organizational chart development showing how the work flow should occur.

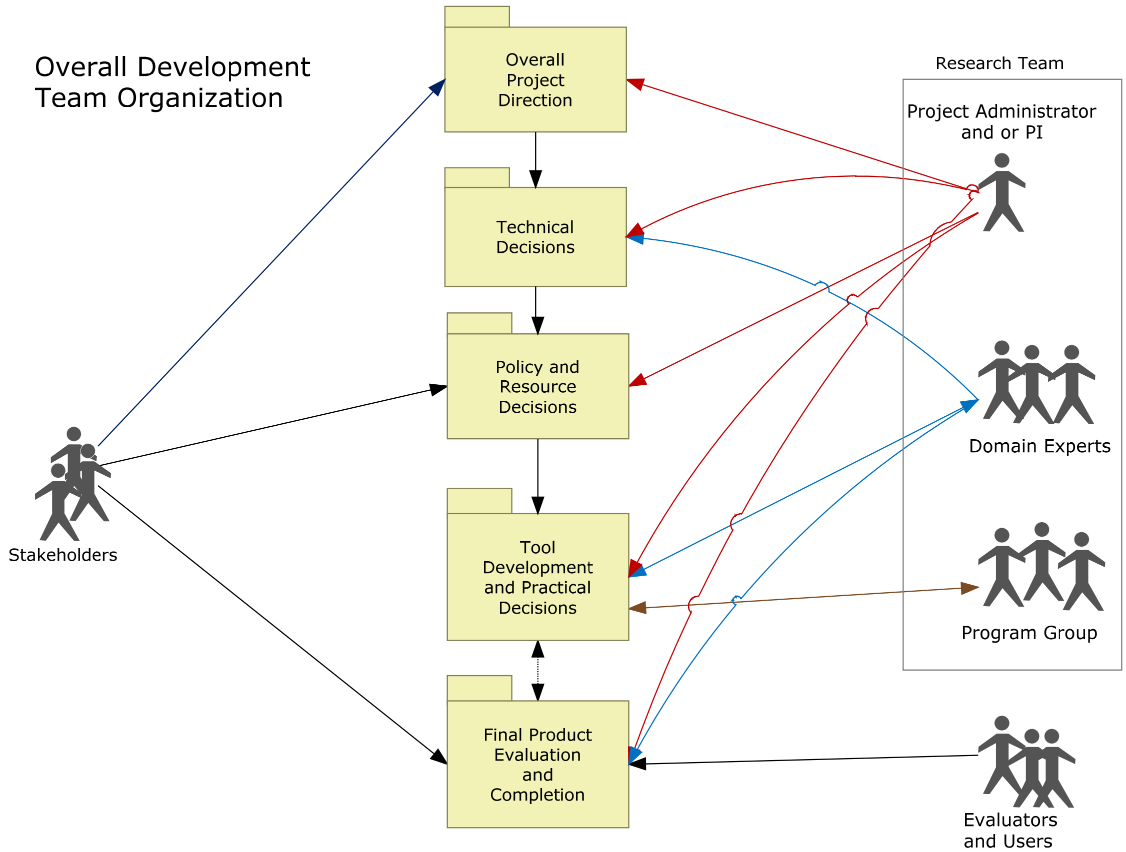

Figure 4.1. Overall work flow as it relates to project organization.

CHAPTER 5. STAKEHOLDER INPUT

As described in Chapters 1 and 2, market research was conducted as a part of the development of MDP. This was a rudimentary market research effort through the use of a questionnaire to solicit responses from broad cross-section of stakeholders and experts on the need and utility of a multimodal noise and emissions model. While it is felt by research team that the MDP captures the needs and desires of the stakeholders, an expanded solicitation would add substantial value to the initial Builds and serve as a device to gain the cooperation of the pertinent federal agencies.

This plan is intended to increase stakeholder input beyond just a questionnaire by including workshops and webinars to solicit answers to the following:

- Who would use a multimodal noise and emissions model?
- At what stage of the environmental/design process would it be used?
- What are the requirements of a multimodal noise and emissions model?
- How would it be used?
- What output is desired?
- What value would the model bring to a transportation project?
- What do you think of the proposed model?
- What technological advancements are available for the development?

The sequence of events would be as follows:

1. 1-day kickoff workshop for stakeholders to gather initial answers.
2. Webinar at mid-point of Task 2 to share details of the design.
3. Additional webinars to liaise with the federal agencies on output requirements.
4. Direct face-to-face technical interaction and communication with agency policy makers.
5. Feedback webinars with stakeholders after completion of Task 3 to demonstrate the model and discuss test results.

The needs and desires of the stakeholders could certainly change with time. Accordingly, market research of the stakeholders, especially federal agencies and existing users of the Build, should be updated as the Builds progress. Market research should be an integral part of each Build and updated at the beginning of each Builds. This update should not only contain the feedback of the stakeholders, but also assessments of the changes in technology and the possible stakeholder requirements that will be included in each Build. For example, if changes are made to the models, stakeholder requirements exist to establish the validity of the changes and/or new models as previously described. Additionally, an evaluation process for each Build should be included to allow changes to occur to better fit the needs of the stakeholders.

Each Build may not require the same degree of market research. The project that produced this report included a rudimentary market effort. If things go as planned, Build 1 should begin near the completion of this report. Part of the Build 1 activity is the expanded market research described in the previous paragraphs. In Build 2, which is 2 years later, more effort may be required to reassess the baseline and establish what should be done in the screening tools. As Build 3 begins, AEDT will have been promulgated for sufficient time that user responses and FAA experiences will be available and this should become part of the market research. Build 4 will begin 3 years or more after Build 3 and again significant changes could have occurred. By Build 5, as the transition to simulation modeling begins, technology will need to be reassessed especially relating to simulation modeling and including simulation models that address operational aspects. Build 6, the end state, will require a go or no go decision from the federal stakeholders. The stakeholders will assess any technological advances and confirm that this is indeed the desired end state. Each of these steps is critical in the development path; reestablishment of stakeholders needs, desires and concerns is therefore of the utmost importance. The total effort for the market analysis in each Build may vary, and the involvement could occur in a variety of ways including telecoms, webinars, workshops, panel meetings, surveys, and working and/or design review group meetings. In addition, stakeholder involvement could also be continued with each Build by having model demonstrations, training courses at the end of each build process, and informative literature available on the internet and in hardcopy.

It is important that funding mechanisms be explored to continue the Build phases. Funding through federal entities would provide a control function on overall development for the agencies. However, the funding and the ownership structure must be determined. Funding through legislative initiative, research organizations such as ACRP, and/or establishment of commercial options, are all viable options. Appendix D offers a concept for funding and ownership through an interagency forum.

CHAPTER 6. REPORTING

Reporting for all Builds should consist of quarterly reports, a draft final report, and a final report. Quarterly reports are expected to provide a complete administrative review of the project (budget, timelines, etc) as well as all key technical details of development. Draft and final reports should include all technical detail as well the use of appendices or other formats as needed. Key appendices should include user manuals and technical manuals. Depending upon the desires of the funding agency or agencies, the source code may also be required. Validation of the model versus gold standard data, as well as verification versus legacy tools and/or previous Builds, will be important to ensure system robustness and continued stakeholder engagement and confidence. All Builds should report these results and uncertainty evaluations.

A crucial part of any software development is the careful documentation of all modules and databases. In addition to the source code, description of the general model architecture should be included. There are multiple formats that this could occur, but a consistent reporting format throughout the Build stages would result in the ultimate usefulness. Since AEDT is projected to become the base upon which to build, following the reporting format established for AEDT would seem to be beneficial. The AEDT developers have adopted a set of three primary documents for doing this: Algorithm Description Document (ADD); Interface Control Document (ICD); and Database Description Document (DDD). All modules and/or applications must have both an ADD and an ICD. The ADD defines all science and computations contained within the module. It does this explicitly and/or by reference, as appropriate. The ICD explicitly defines all input and output requirements for the module. Given the ICD for a module a 3rd party software developer should be able to call a "black box" module, handing it the required input data and receiving back the resultant output data. DDDs describe every data field within a database, including formatting and units, as well as any assumptions associated with the use of the data, and data sources as appropriate.

The level of effort required in reporting for each Build will vary. Build 1 programming consists of post processing outputs from existing models and as such is not as substantial of an effort as in later Builds. Additionally, the methodology used in these models will have been previously described in the literature. As such, actual software documentation is expected to be secondary to the description of the rules used to combine the various output. How problems are overcome, both on a technical and regulatory basis in this rule formulation will be the more important and extensive documentation.

Build 2, requiring the development of screening models, will also require substantial documentation on the rules and reasoning behind the models, with the model documentation being more substantial than Build 1, but still less than required in the later Builds. The principles used to construct the screening tools could be the major effort during reporting.

Builds 3 and 4, based on AEDT, will be able to utilize documentation created for AEDT but will need to be updated for the changes that occur. Changes will include revision and creating of new algorithms, changes to the database, and changes in input/output of the model. Complete documentation of this will be a substantial effort. Consequently, Builds 3 and 4 will require much more documentation of the computer model development than the first two Builds. Implementation and methodology description will also be extensive.

Build 5, the beginning of simulation modeling, will require substantial documentation on both the methodology and the programming. If as expected, simulation models are continued to be advanced, then much of the methodology may already be in the literature and could be incorporated by reference which could reduce reporting efforts. Even so, the model implementation documentation is still expected to be substantial. Documentation for Build 5 is expected to require substantially more documentation than previous Builds.

Build 6, the first generation simulation model, will also require a substantial amount of documentation for both the methodology and programming. It is expected that continued research will have continued on simulation modeling allowing references to be heavily used. But documentation on the implementation of all sources is still expected to be a very substantial effort.

In addition to the technical model reporting all Builds will require regulatory discussions to various levels. Since these projects will be multi-modal, differences in regulatory requirement from various agencies is inevitable. This will require very careful documentation of the stakeholder process in the reports and could also require statements of policy with the approval of the various Federal agencies.

GLOSSARY AND ACRONYM LIST

Airside--the part of an airport directly involved in the arrival and departure of aircraft.

Black box--any device or process whose workings are not understood by or accessible to its user.

CAD (computer aided design) -- software used to create precision architectural and engineering drawings or technical illustrations including geographic data management.

Call statement--a line of software that calls another set of code, such as, function, procedure, or subroutine.

Decision Analysis--a branch of science focused of problem solving by processes that break complicated decisions down into small pieces that can be dealt with individually and then recombine logically.

Emissions--releases of gases to the atmosphere (e.g., the release of carbon dioxide during fuel combustion). Emissions can be either intended or unintended releases.

Emission factor--the rate at which pollutants are emitted into the atmosphere by one source or a combination of sources.

Emission inventory--a list of air pollutants emitted into a community's, state's, nation's, or the Earth's atmosphere in amounts per some unit time (e.g. day or year) by type of source. An emission inventory has both political and scientific applications.

End state--the ultimate conditions resulting from a course of events.

Exogenous-- an action or object coming from outside a system

Geometric spreading -- refers to the spreading of sound energy as a result of the expansion of the sound waves.

GIS (geographic information systems)--a computer software program used to analyze spatial data that can be especially useful in examining noise distribution over a geographic area.

Gold standard--a method, procedure, or measurement that is widely accepted as being the best available.

Greenhouse gas--any gas that absorbs infrared radiation in the atmosphere. GHGs include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Ground absorption--as sound propagates near the ground, ground absorption is the interaction of the sound wave with the ground that results in attenuation of the sound. Hard ground, such as water, has less attenuation than soft ground (most other surfaces). Also known as lateral attenuation.

Interquartile Range (IRQ)-- a measure of statistical dispersion, being equal to the difference between the third and first quartiles.

Isopleth--a continuous line on a map that represents some equal value.

Isopollutant line-- A continuous line on a map that represents equal levels of a pollutant.

Median--the middle value of an ordered set of values.

Microscale--a scale of physical consideration or of bounds having a characteristic dimension typically under 1 mm.

Microsoft .NET--is a software component of the Microsoft Windows operating system that provides a large body of pre-coded solutions to common program requirements, and manages the execution of programs written specifically for the framework.

Mobile Source--a moving vehicle that emits pollutants. Such sources include airplanes, cars, trucks and ground support equipment.

Module-- A self-contained software program that carries out a clearly defined task and is intended to operate within a larger program suite.

Monte Carlo test--a technique which obtains a probabilistic approximation to the solution of a problem by using statistical sampling techniques.

Multiple Attribute Decision Models (MADM)--a discipline aimed at supporting decision makers who are faced with making numerous and conflicting evaluations with incomplete information; thus relying on indicators of the strength of various preferences.

Noise contours--a continuous line on a map that represents equal levels of noise exposure.

Noise hemispheres--noise data represented as the overall sound pressure levels on hemisphere of fixed radius around a source.

Nonparametric statistics--the branch of statistics dealing with variables without making assumptions about the form or the parameters of their distribution

Post processor--additional software to organize the output from a computer model or models such that it is easily understandable.

Reduced-order modeling--a function that approximates another function, but requiring mush less data.

Rule based system--a way to store and manipulate knowledge to interpret information in a useful way. The system is composed of a list of rules and the actions to be taken for each.

Run-time--time that it takes to run a software program.

Screening tool--in environmental modeling, refers to an easier to use version of a computer model to perform quick and conservative estimates of exposure and impact.

Server-based--refers to running applications on the computer network server while forwarding the output to the users on the network.

Simulation-based--is more general than time-step based in that other parameters than time can be used in the calculation process.

Six Sigma Method--is a highly disciplined approach to decision making that helps people focus on improving processes to make them as near perfect as possible. The term six sigma describes a statistical measure of variation equal to 99.9997% accuracy.

Sound pressure level (SPL)--is 10 times the base-10 logarithm of the ratio of the time-mean-square pressure of a sound, in a stated frequency band, to the square of the reference sound pressure in gases of 20 micropascals.

Stakeholder--a person or entity that has an interest in the project and related outcomes and decisions. Transportation project stakeholders include the general public, manufacturers, contractors, operators, consultants, local authorities, state agencies, and Federal agencies, which are also referred as **agency stakeholder** or **stakeholder agency**.

Steady-state--in environmental modeling, refers to calculations done in which several known variables are held constant. For example, aircraft modeling in FAA's INM assumes that speed, thrust, and angle of flight are held constant along straight flight segments.

Time-step based simulation--a modeling practice where simulation is accomplished by performing calculations for a defined time period, then advancing by a predefined time step and recalculating. This process is repeated to estimate the changes with time.

Webinar--an interactive seminar conducted via the world-wide web.

ACRONYMS

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

REFERENCES

(*1*) EPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, 40 CFR Part 51, Federal Register, Vol. 70, No. 216, Wednesday, November 9, 2005.

(*2*) FHWA, Procedures for Abatement of Highway, Traffic Noise and Construction Noise, 23 CFR 772, http://ecfr.gpoaccess.gov/cgi/t/text/text 76cd7d6d616f6b&rgn=div8&view=text-&node=23:1.0.1.8.44.0.1.9&idno=23, last accessed February 8, 2010.

(*3*) Utting, M. and B. Legeard Practical Model-Based Testing: A Tools Approach, ISBN 978-0-12-372501-1, Morgan-Kaufmann 2007.

(*4*) FAA, Excerpt from AEDT Testing Framework, Doc #AEDT-TPF-11-01, Version 1.0, February 8, 2008.

APPENDIX A. MARKET RESEARCH

Through widely distributed questionnaire, literature review, and personal interviews; the market research attempted to gather information about customers and the market. Customers are the future user communities for the multimodal noise and emissions model, including consultants involved in transportation planning, state and federal agencies that provide the oversight for these modes, and office staff of regional transportation administrations that organize/fund specific projects. Section A.1 summarizes what was learned from the customer base. The market consists of the current and future multimodal and intermodal projects that would benefit from the use of this model. Section A.2 describes what was learned about recent and ongoing multimodal projects. Section A.3 discusses what the market research finding implies for the MDP.

It was vital to seek input from a broad cross-section of the transportation and environmental communities. Questionnaire was chosen as the device to obtain the needed input. Because of the subject matter, the questionnaire contained open-ended questions that required substantive effort of the respondents. A sample questionnaire is presented in Appendix E. The questionnaire also included two fairly detailed exhibits on the initial thoughts concerning the end state and build sequence for the model. The questionnaire elicited some excellent responses including ideas for the desired model end state. The problem is that there were very few responses. The complexity of the questionnaire contributed to the lack of response. The problem is described in Section A.1 and the implication is addressed in Section A.3.

A.1. Potential Utility of a Multimodal Noise and Emissions Model

Appendix E contains a copy of the questionnaire that was used to solicit responses from broad cross-section of stakeholders and experts on the need and utility of a multimodal noise and emissions model. Viewpoints were sought using questions, such as:

- Who would use a multimodal noise and emissions model?
- At what stage of the environmental/design process would it be used?
- What are the requirements of a multimodal noise and emissions model?
- How would it be used?
- What output is desired?
- What value would the model bring to a transportation project?

The questionnaire also sought reactions to the initial concepts for the end state and model build sequence that had been developed by the project team.

The questionnaire was distributed to various transportation technical committees, Federal agency environmental program offices, Federal interagency groups, and model design review groups involved in transportation-related environmental assessments. The distribution list included:

- Analytical Tools Initiative Standing Committee of the Environmental Working Group under the Joint Planning and Development Office (JPDO);
- FAA Aviation Environmental Design Tool (AEDT) Design Review Group (DRG);
- Federal Interagency Committee on Aviation Noise (FICAN);
- TRB ADC20 Committee, Transportation and Air Quality;
- TRB ADC40 Committee, Transportation-Related Noise and Vibrations; and
- TRB AV030 Committee, Environmental Impacts on Aviation.

The questionnaire was distributed to subscribers of the Wyle Email Web Forums and its availability was announced in two newsletters, *Airport Noise Report* (Vol. 20, No. 29) and *Aviation Emissions Report* (Vol. 1, No. 6).

After receiving few responses, a second solicitation went to the groups identified above and to subscribers of the Wyle Email Web Forums in the hopes of promoting more responses. The solicitation was expanded to specific airports. The airports targeted in this solicitation were those contained in the Metropolitan Areas Solution Set of the FAA Implementation Plan for the Next Generation Air Transportation System (NextGen). This solution set is predicated on meeting the demand for air transportation in these areas through continued emphasis on airport expansion along with innovative approaches to regional planning and multimodal systems. The NextGen Metropolitan Areas Solution Set covers 15 metropolitan areas and 82 civil airports. The questionnaire was sent to the 45 airports on the list with environmental points of contacts. Information on the FAA NextGen Solution Set can be found at:

http://www.faa.gov/about/office_org/headquarters_offices/ato/publications/nextgenplan/.

Less than twenty responses were received from the two solicitations, which is less than a 1% response rate. The respondents came from federal and state agencies, airport authorities, consultants, an aviation association, and an aviation manufacturer. The complexity of the questionnaire contributed to the lack of response, but lack of interest might be an issue. The use of open-ended questions with two fairly detailed exhibits required more effort than individuals might have time to devote. More than one respondent indicated not having the time to look over all the material. Because the sample size is statistically insignificant as a result of the low response rate, this section will not report any quantitative findings or draw general conclusions for the transportation community. The questionnaire was successful in eliciting “gems” of information from the few respondents, which are discussed in the succeeding sections. Section A.3 addresses the implications for the MDP along with ideas for a more in-depth market research effort.

A.1.1. Utility

The respondents identified a variety of users for a multimodal noise and emissions model. To the extent that use of the model is required by Federal and state regulations, the primary users of the model would be Federal and state agencies and those conducting noise and air quality analyses on their behalf. The users would likely include consulting corporations and regulatory agency personnel working to prepare analyses required under the National Environmental Policy Act (NEPA) and air quality conformity analyses. There is a sense that the model must be approved by the appropriate regulatory authorities because it us unlikely that anyone would use a new, complex model and risk unforeseen time delays and expense if they can avoid it. This requirement is much like the current situation in which rail projects use the FRA guidance manual, highway projects use the Traffic Noise Model (TNM), airport projects use Integrated Noise Model (INM) and Emissions and Dispersion Modeling System (EDMS), and military aviation projects use NOISEMAP. Because the model covers all the transportation modes, it would require teams with the various members each having one of the necessary areas of expertise. In order to competently prepare input, and run and assess outputs, several areas of expertise will be necessary.

Projects where this model could be most useful are ones that are truly multimodal. That is, projects involving trade-offs among transportation mode interactions, such as, a port project (like cargo handling at Long Beach) that involves alternative docking, truck and rail interaction alternatives. Another example would be projects that assess choices in different transportation modes, such as, the examination of city-pair transportation capacity looking at the alternatives choices within the aviation, rail, and road system services. Regional transportation planning was mentioned as an example of a project where the multimodal model would be of use. It was emphasized that the success of regional transportation projects requires good coordination and cooperation among the various federal and state modal agencies.

One respondent suggested that the model would also be useful for projects that are not necessarily multimodal, but where other modes are present, such as a county airport near a highway. In that, the airport is ancillary to the project, but may have an effect on abatement efforts for the highway project. Multimodal environmental analysis could ensure that a project involving any single mode (highway construction) is not unfairly punished when another existing mode (the airport) may be the gross offender.

Some of the suggestions for airport planning are applications that are already addressed by existing suite of models, such as, how to grow the capacity at an airport hub and yet minimize the noise and emissions impact. Thus, it was recommended that agencies should provide clear guidelines for which projects require use of a multimodal model. For example, the majority of road projects do not involve rail or aviation considerations, and many aviation projects do not involve rail or road, etc. It is not clear that these projects would benefit from the extra expense of using the more complex multimodal model over the current single mode tools.

The MDP should consider how the projected model is likely to affect the cost and duration of the environmental/design process. Respondents indicated that project sponsors will be concerned if a new model means significantly increased study costs. Again, agency approval is important and specific guidance on when the model is to be used in the environmental process is needed. One respondent suggested that if the model was cheap and easy to use, it would be used in the initial stages of the environmental assessment process. If expensive and difficult than in a later stage, but before a significant sum of money had been spent. Other respondents suggested that the model would be used early in the process, such as for air transport capacity projects or infrastructure planning projects.

Suggestions for how the model would be used reflected the individual perspective of the respondent and the stakeholder that the person represents. Some suggested uses include:

- Identify trends, as information and education for the noise and emissions-impacted communities, to address speculation;
- Estimate potential environmental impacts and evaluate “designed-in” mitigation measurers;
- Verify the correct emission factors being used, power settings, and time-in-modes in the model for Navy aircraft;
- Estimate the individual contributions of the various modes and construction activities as well as the sum of all of them;
- Evaluate projects alternatives that may consider mode changes as an alternative to a proposed project;
- Understand how improvements in product design to reduce source noise or emissions would contribute to reduction in noise or emissions at an airport hub;
- Determine ambient noise levels in and around the airport for existing and build scenarios;
- Determine emissions for existing and build conditions in and around the airport at major intersections;
- Public information and environmental reporting;
- Monitor and measure the aggregate impacts of each component part;
- Review Environmental Actions for State Block Grant and Federal approvals;
- Scenario-based planning studies, on a limited basis;
- Analyze highway projects with other modes present in the project area; and
- Use it for regular (quarterly) noise modeling and in a Part 150 program.

Again, the respondents are looking for agencies' approvals for specific uses of the model.

Some respondents tempered their suggestions on uses of the model with expressions of concern about the complexity and practicality of bringing the various modes into a single environmental model. For example, aviation noise and air quality analysis use different inputs. Similarly, aviation, road, rail and marine all have additional different inputs as well. Rail and road analysis look at the noise source-terrain-receiver geometry on the order of ten's of feet and usually use localized, high detail elevation/terrain data that may change as a result of the proposed action. The more detailed data are provided by the planning team as opposed to public accessible database, like the U.S. Geological Survey (USGS). A respondent identified the need to accommodate independent input and testing of these separate areas. This independence probably means inputs should be modular where necessary (aviation operations, highway traffic, rail and marine traffic all separate for starters) but setting up and running would naturally have identical geographic and topographic input that would be at different levels of detail throughout the study area.

In addition to the kinds of output available from current single mode models, the respondents desired the following noise and air emissions output from the multimodal model:

- Gridded (geo-located) emissions and noise levels; available on a time of day basis.
- Hot spots, lines of (islands) pollutant concentrations – isopollutant lines; isopleths.
- Greenhouse gas (GHG) emissions and the flexibility to evaluate alternate fuels or sustainability elements.
- Emissions concentrations should be evaluated for less than 1-hour, along with 1-hour, 3-hour, 8-hour, 24-hour, and annual periods.
- Hazardous air pollutants (HAPs) from mobile sources; Mobile Source Air Toxins (MSAT).
- Appropriate local regions PPM (parts per million) concentration levels for receptors with an option to convert the predictions to an 8-hour averaging time.
- Worse case conditions for carbon monoxide (CO) dispersion near project corridor.
- Signal screening information based on LOS (Level of Service) and emission factors.
- Audibility on projects near noise sensitive remote areas.
- Airport noise contributions against a background of ambient levels.
- Noise level at specific points including barrier effects.

The respondents want the capability to identify source contributions to a total concentration. On an individual mode basis, it could be used to determine the impacts of an airport action, the impacts of a separate rail project or highway project. It could also combine all modes associated with a single project. Another respondent emphasized the need for a simple, easy to understand breakdown of the data for all those involved; especially the general public, press, politicians, etc. It would also be critical to include the ability to evaluate noise abatement in the same model for both traffic noise and construction noise.

One respondent suggested that the model visually display noise and air emissions output individually and together. It would be especially useful, if aerial photos were able to be incorporated and modeling results were presented as both contours and levels at discrete receptors. A respondent emphasized the value of graphical representation of results to better educate and use for public communication of results. There are very powerful and accurate modeling tools now in use, however, they only provide the first step of analyzing the data, and do not excel at presenting the results of the analysis.

Some respondents identified the need to assess the effects of alternative fuel types for various mobile sources. One respondent suggested extending the model output to include impacts, such as, number of sleep awakenings and number of people highly annoyed. However, this respondent also cautioned that the latest scientific studies suggest that communities do not react equally to noise from all sources, so that including effects may make combining impacts across modes better amenable to the different reactions. For example, once there are reliable dose-response relationships for annoyance by the various modes, then total numbers of people annoyed will be additive, whereas number of people living within a given total DNL is likely to be incorrect in estimating number annoyed.

The respondents' viewpoints are generally favorable on how the multimodal model could improve decision-making. Projects are almost always focused on a single mode, with the goal of improving the performance and minimizing, reducing, or limiting the impacts of that mode according to reviewing agency with authority over that mode. The multimodal model could be used to identify major trade-offs among modes; not available capability in current single mode models. If the model could identify significant reductions in impacts (noise, emissions, CO2, energy use) that result, for example, from raising road tolls so that travelers use rail or air between NYC and DC (or from high cost of air travel so that travelers use rail between these two cities) then the model could significantly improve urban planning, transportation infrastructure design decisions. As a respondent observed, projects are hindered by comments or criticisms that alternative transportation modes were not considered. In some cases, the criticism is justified as there does not currently exist practical way to conduct these analyses that involve trade-offs between modes. Other positive aspects identified by the respondents are as follows:

- Allow airport planners, airport environmental managers, or policy makers to better understand the various source contributions to total noise and emissions at an airport hub and how to determine the most cost-effective policies to reduce the environmental impact.
- Improve the understanding of trade-offs between noise and emissions for a potential policy solution not only for a given transport mode, but between modes of transports.
- Develop a better understanding between "air-side" and "terminal access-side" contributions to noise and emissions within the "airport bubble". Improved modeling of these noise and emissions contributions could lead to improved policy decisions on mitigation strategies.
- Serve as an early indicator of any problems that may arise and be able to correct or reduce project cost with abatement measures for either of the two environs (noise and air quality). The decision making process would definitely benefit.
- Provide consistent and comprehensive outputs across the modes.
- Screener in the scoping phase to determine the appropriate level of air quality and noise documentation.
- Facilitate the improvement in decision making by allowing those involved in the process to evaluate different scenarios.
- Could be useful in the Alternatives Discussion, prior to the creation of the Sponsor's Proposed Action.
- Improve decision making by ensuring "fairness" across all transportation modes.
- Identify locations where other modes may interfere with highway noise abatement designs. It would also improve understanding of the contribution to the overall noise environment from other noise sources. If used in early planning stages, it may also help guide land use planning recommendations and decision-making.

- Represents the first step in developing a comprehensive community noise model. In the case of a Master Plan project, it could model all sources from a single program to calculate total impacts.

One respondent suggested that synergistic benefits or additive impacts across modes are usually either rare or minimal, and probably can be identified without use of a special model, like the proposed multimodal model. This respondent reasoned that: (1) impact metrics, criteria regulations/guidance and lead agencies are different and (2) currently the results from the existing suite of models can be very efficiently combined post process. Further, the patterns of noise exposure from the modes are so different that they should generally be considered independently. For example, aviation noise is made of a series of relatively loud events, while highway noise tends to be continuous with occasional louder levels from loud trucks or motorcycles. Thus, highway noise should not be thought of as masking aircraft noise events, and vice versa. This respondent also offered that the reaction of people to combined noise sources is not well developed and in need of more research so that the combined results can be properly assessed.

A.1.2. Thoughts on Model Design

The respondents generally like the all encompassing design of the proposed end state from the aviation perspective. It indicates the potential for a comprehensive evaluation of both noise and air quality parameters, looking at the individual contribution of different modes to a location as well as the total contributions they make. A respondent pointed out that the use of a simulation approach would be an enormous improvement for realistic modeling and analysis of time varying impacts. It would permit development of detailed analyses tailored to specific situations. Specific times of day could be identified as “hot spots” and the end state model would permit design of mitigation measures that address the specific activities responsible. It would also permit, and perhaps encourage examination of real modal trade-offs – changing the total modal balance to reduce impacts.

Other respondents want more technical detail to be able to offer their thoughts. Some respondents thought the end state would be difficult to achieve. One believes the end state is wishful thinking unless the development of the end state is envisioned in terms of short time lines, i.e. not more than ten years. One concern is that databases age rapidly and become of limited use in projecting the future. Algorithms also change with time and technology, and demographics. This respondent suggested looking backward at historical information and present day results may serve to validate and identify past mistakes or information deficiencies. Another offered the examples of two complex model development projects. FHWA has had horrendous problems in the development of TRANSIMS and EPA has had similar difficulties with their MOVES model (which covers only emissions). EPA found that available data were not sufficient to support their model structure. Early applications required multiple, powerful computers; otherwise, the runs simply required too much time. The economic cost of air quality pollution is incredibly complex, controversial, and uncertain. This respondent views the described end state as an admirable goal, but not practically achievable.

There are also concerns about the size and complexity suggested by the description of the proposed end state. How easy will this be to use? How data hungry is it? This multimodal model will likely require considerable user expertise in some or all of the environmental areas to take advantage of the model’s capabilities. Current studies are done by teams, with each team member adding specific expertise in one or two fields. If preparation and running of the model is significantly more time consuming and expensive than use of current models, the simpler project and less experienced user will be disadvantaged. This possibility suggests that use of the model on the less complex projects needs to be relatively easy and quick – in fact, a design goal should probably be to make use of the model as easy as possible – and if it could be easier to use than current models, so much the better.

Another concern is how the model would measure the environmental costs in terms of dollars, current state versus modeled future state? How does the benefits evaluator work? In addition, will the end state lead to a penalty of one mode over another based on an ultimate do not transgress line? This suggests a potential for conflicts across metrics, methods, and fidelity level. Since no one tool addresses all transportation modes, there could be inconsistencies in the results. The effort would require a very diverse team to generate accurate results. Then there is the hurdle of gaining acceptance and approval from all government agencies.

The respondents proposed the following additional components for the end state:

- Ability to automatically grab, via the internet project, required available databases – census data, current fleet mix and operations by airport, state highway traffic data, radar data for identified time period, etc. Current methods require considerable user time and effort to collect the necessary available input data that are not project specific.
- Consideration of potential unintended consequences of planned actions. For example, airport expansion produces more traffic but also includes increased demand on sewer, water, waste disposal, electric demand, etc.
- GIS-based approach starting with the receptor location identification and then computation of noise/air at these locations based on distance to each source. A GIS that includes buildings and walls would then account for barrier effects. A regular grid could be used to generate contours (by source and/or combined sources).
- Flexibility in the model to tweak the model inputs such as vehicle speeds, fleet mix, fuel types, fuel economy for each vehicle type.
- Include sources beyond transportation including point sources.
- Assessment of impacts on the population including environmental justice.

The respondents also offered thoughts on the model development design process. The complexity of the end state is a clear concern. One suggested the following design goal:

> "Assembly of input data and development of reports will require fewer person hours than required by current models."

This goal could be tracked by developing a test case that is carried throughout the entire series of builds and run each time by test staff to identify difficulties, simplifying methods. The design needs to more completely address the regulatory process with a goal like the following:

> "Regulatory requirements for use will be clearly enunciated, responsive to model capabilities, and updated as experience with the model accumulates."

One respondent suggested that the design needs to be scaled back, such as, do not combine noise and air quality in the same model and do not link to models that may not be widely deployed such as TRANSIMS. Another respondent emphasized the need to explain all this to the public and decision-makers, especially those who would decide funding.

A.1.3. Thoughts on Build Sequence

The respondents agree that the incremental build sequence makes sense. Reasons cited include:

- Allows the designers to adapt and learn as they go.
- Garners long-term support from stakeholders, plus provides a limited, early operational capability.
- Leverage what is already out there and what is coming next.
- Builds upon previous successful stages.

One respondent suggested an earlier step that studies existing models and notes similarities and differences in inputs and outputs. Another suggested starting with a GIS database and adding source noise and emissions to it.

One viewpoint was that it is premature to put together a detailed build process before getting a better understanding on the “real world’ applications for the multimodal model. The working premise that all potential stakeholders would agree on the first build might not be true. Several questions need to be addressed. Are the data available to support the desired level of modeling? Many of the described emissions and air quality models are still evolving. How do these updates get incorporated? What are the agencies really doing with ongoing development of their current models? Do good emissions models exist for the full range of air side ground support vehicles?

The proposed build sequence assumes each preceding build worked successfully. There is no clear roadmap for full testing of each build. Testing will be time consuming and costly. How is this testing to be done? Will the user community be expected to test each build on projects? If so, there should be recognition that the types of projects that would benefit from such a model take several years from the point of model selection to public release of the results, and hence, several years to identify a specific build’s strengths and weaknesses.

Other respondents recommended using existing tools as much as possible. One suggested streamlining all the existing models, accepted and in use; into one all encompassing model for the benefit of all kinds of users. Another expressed it as leveraging existing noise and emission predictions tools as much as possible and make sure the capability is modular to allow easy substitution of individual elements.

One respondent suggested examining some ongoing or recent airport projects that included more than aircraft – likely road or rail traffic. Investigate with the various participants how they are or have conducted the separate analyses and how those analyses address the regulatory criteria of the one or more reviewing agencies. What methods did they use to combine or compare impacts from the different modes? What tools or guidance would have helped in the analysis and decision-making? Did having more than aircraft in the analysis affect any of the decisions, or were decisions made independently by mode?

A.1.4. Other Issues and Concerns

The “stovepipe culture” is a concern shared by respondents. The RFP describes this stovepipe culture as “The social, environmental, and economic effects of noise, emissions, congestion, and delays from aircraft, highways, and rail are typically evaluated and mitigated separately.” The stovepipe metaphor extends far beyond the technical models and into the regulatory approaches of the various agencies. Apart from the obvious incongruities (e.g., DNL - aviation and some rail issues - vs. loudest-hour Leq - highway and other rail issues), there are other important differences, e.g.: treatment of indoor vs. outdoor use areas, annoyance vs. activity interference, mitigation requirements, and cost reasonableness criteria. It would appear that a multi-agency noise policy would need to accompany the multimodal model. In general, getting acceptance from governmental agencies to adopt the new model over existing ones and to accept outputs from the model seems a major hurdle.

The proposed build sequence depends on having active supportive user communities and agencies sponsors to continually test new versions. Is it realistic to expect such support as successive versions of the model become more complicated; leading to more opportunities for inconsistencies from user to user and more time and effort required to wring out the bugs and problems with each build? Maintaining consistency of results from version to version is an issue. Then there is the practical matter that major multimodal projects might extend across the release of more than one of the intermediate versions of the model. Who makes the decision on the official version to use and what is the rationale?

Cost and time are widely shared concerns. Several respondents recognize that this is a very expensive effort. For example, it takes a lot of money and time to develop models that will validate EPA baseline metric for emissions. Then there is the cost to the end user. The complexity of this model renders it expensive to use and thus prohibitive to all but the largest of airport operators. Making it cost effective to use for all facets of airport development should be a priority.

One respondent observed that the most challenging task will be to harmonize all the noise models (airplanes, autos, buses, trains, etc) and to end up with a "composite" model that can reasonably project the overall impact on airport community noise by introducing changes or new technology to reduce the noise of one or more sources of noise. Adding to the challenge is to ensure that the model and all the data can reside on a desktop computer offering reasonable runtimes.

Another respondent is concerned about lack of underlying data. For air quality, different experts are required for different pollutants, as well as for emissions and air quality modeling. Atmospheric concentration models are large, complex, and still evolving. There may be more that is not known about air toxics and fine particulate matter than is known.

The issues and hurdles that the respondents identified also led some to express doubt about the outcome. One respondent suspects that the effort will produce a big, data hungry, complicated, expensive model that no one either can or will use because of its complexity. Another is concerned that the model would be used without using topographic and barrier information to adequately propagate rail and road noise into the community. One indicated that he might not be able to use the CO emissions component of the model if it does not incorporate streamlining software developed by his agency. Another respondent worries about effect of too frequent updates on the end user. Upgrades are costly and time consuming. It is further complicated when the upgrade causes a significant change in model output that could affect project decisions. Another respondent questioned whether it's desirable or advantageous to combine these into a single modeling system since the noise and air quality are very different disciplines. One respondent worries that use of the model will foster discrimination of one transportation mode (arbitrary reduce the capability) over another mode.

One respondent indicated that it might help to allay some concerns if there is clearer identification of what types of projects can use such a model, what value it would be to such projects and how the various reviewing/regulatory agencies that oversee each individual mode would interpret and use the results of the multimodal analysis. This respondent would like to see more effort to identify the types of projects that would really benefit from the massive effort entailed in developing all the builds. Several airports are near or bordered by highways – JFK, EWR, LGA, PHL, FLL, SAN to list a few – assessment of these situations, perhaps through interviews, and some modeling exercises could reveal the value of a multimodal model. Several recent airport Environmental Assessments (EAs) and Environmental Impact Statements (EISs) have involved changes to roadways and rail lines; these studies could serve as examples to understand how the modeling was performed and the results were interpreted relative to agency criteria. A fundamental issue is that impacts for highway and road occur in relatively narrow corridors, while airport impacts cover generally larger areas, many of which may not be affected directly by the corridor impacts. In partial response to the issues raised by this respondent, Section A.2 describes what was learned so far about recent and ongoing multimodal projects.

A.2. Multimodal Case Studies

As part of this research project, the major modal administrations within DOT, plus others, were contacted for information about their past multimodal studies. Of particular interest were noise and air quality procedures for transportation modes outside that administration's direct jurisdiction—for example, highway and rail computation/assessment within FAA-sponsored studies. Answers were sought to the following questions:

- What models were used? Who used them? How were they used?

- What data was used and the data sources?
- What were the decisions? Who made the decisions? What were the environmental criteria?

A.2.1. Recent and Ongoing Studies

The FAA, in cooperation with the Department of the Interior, recently prepared an Environmental Impact Statement (EIS) for the proposed Southern Nevada Supplement Airport (SNSA)—otherwise known as the Ivanpah Valley Airport. Travel between this airport and Las Vegas, some thirty miles north, would involve a new transit line and/or increased traffic on Interstate 15—depending upon the chosen project alternative. This induced surface traffic between the airport and Las Vegas requires assessment of non-aviation noise and air quality as part of this FAA-sponsored study (details can be found at www.snvairporteis.com). Other recent and ongoing multimodal projects sponsored by FAA include:

- Environmental Assessment (EA) for the Erie International Airport, Tom Ridge Field, including roadway closing and bridge replacement (http://www.erieairport improvement.org);
- Draft EIS for the Philadelphia International Airport (PHL) Capacity Enhancement Program, which explicitly considers other modes of transportation (www.phl-cep-eis.com); and
- Final EIS for the O'Hare Modernization Program (www.agl.faa.gov/omp/FEIS.htm).

The FTA, along with the FHWA, recently completed a Draft EIS for the Columbia River Crossing between Portland, Oregon, and Vancouver, Washington—along a five-mile segment of the Interstate 5 corridor. This project proposes to replace or rehabilitate the existing river crossing, provide highway improvements, and either extend light rail or provide bus rapid transit with several transit alignment and length options. This complex study required computation and assessment of non-rail noise and air quality as part of this joint FTA- and FHWA-sponsored project (http://drafteis.columbiarivercrossing.org).

The FRA has completed its Final EIR/EIS for the California High-Speed Rail Project, proposed to run between Sacramento and San Diego. This immensely complex study included airport-only and highway-only project alternatives, which required computation and assessment of non-rail noise and air quality as part of this FRA-sponsored project (www.cahighspeedrail.ca.gov).

The FHWA, along with the Ohio Department of Transportation, has sponsored two recent multimodal projects in Ohio. The Eastern Corridor Major Investment Study in Hamilton and Claremont Counties involved a roadway/rail multimodal project (*Eastern Corridor Multimodal Projects, Hamilton and Clarement Counties, Ohio: Tier-1 Draft Environmental Impact Statement* (portions). Ohio Department of Transportation, Office of Environmental Services, Columbus OH. Provided by Noel Alcala, Noise and Air Quality Coordinator). The West Avenue Grade Separation Project in Ashtabula included a new Northfolk Southern overpass or underpass, depending upon the chosen project alternative (*West Avenue Grade Separation Project* (portions). Ohio Department of Transportation, Office of Environmental Services, Columbus OH. Provided by Noel Alcala, Noise and Air Quality Coordinator.). Both these studies required assessment of non-highway noise and air quality as part of the FHWA-sponsored project.

A.2.2. Noise Assessment Procedures

Noise procedures differ significantly by modal administration. Each administration has its own computation methods (computer programs or spreadsheets), noise metrics, and assessment criteria, which focus almost exclusively on the single transportation mode that it regulates and sponsors. These existing computation/assessment methods are discussed below.

Essentially without exception when a particular project involves additional transportation modes, the sponsoring administration defers to the noise procedures of the administration with jurisdiction over those additional modes. For such multimodal projects, sometimes deferral is by regulation and sometimes it is through "guidance" documents. The following paragraphs summarize how various federal agencies address modal noise assessments.

A.2.2.1. FAA. FAA regulations do not stipulate methods for assessment of highway and rail noise. Instead, FAA guidance on those matters appears in Chapter 17 of its Environmental Desk Reference (Environmental Desk Reference for Airport Actions. Federal Aviation Administration, Office of Airports, Office of Airport Planning and Programming, Airports Planning and Environmental Division, APP-400, October 2007. Available at http://www.faa.gov/airports__airtraffic/airports/environmental). This chapter specifies the use of the Integrated Noise Model (INM) for airport development actions requiring a detailed aircraft noise analysis. INM is an average-value-model designed to estimate long-term average effects using average annual input conditions. This guidance document also explicitly requires use of FHWA noise procedures whenever highway-noise impacts potentially exist on FAA-sponsored projects. Although rail is not mentioned explicitly, the implication is clear that FTA and FRA procedures should be followed, as well, to determine rail-noise impacts.

To satisfy this FAA guidance, the Ivanpah Valley Airport project assesses impact from the induced highway and rail traffic with FHWA and FTA procedures, respectively—the latter as further regulated by the Nevada Department of Transportation. The Erie Airport Improvement Project, which concluded with a Finding of No Significant Impact (FONSI) by FAA, used FAA's Integrated Noise Model (INM) to assess aircraft noise exposure. The Erie project also involved the relocation of a street and the EA qualitatively addressed the temporary noise increase due to both the road and runway construction. The PHL Capacity Enhancement Project used INM to assess aircraft noise.

A.2.2.2. FTA. FTA policy on multimodal projects is explicitly defined in its guidance manual, *Transit Noise and Vibration Impact Assessment* (Report FTA-VA-90-1003-06, Federal Transit Administration, Office of Planning and Environment, Washington, DC, May 2006). In particular, where an FTA-sponsored project involves highway noise sources—most often transit buses—then this guidance manual explicitly requires computation and assessment per FHWA procedures.

The Columbia River Crossing DEIS employed several noise assessment methods and impact criteria. Long-term operational impacts were evaluated through a three-dimensional modeling analysis using the FHWA Traffic Noise Model (TNM), Version 2.5. The predicted noise levels for each alternative were compared to the Oregon Department of Transportation (ODOT) and Washington State Department of Transportation (WSDOT) absolute noise impact criteria. The transit noise analysis for the project alternatives followed the FTA's Detailed Noise Analysis methodology. This methodology provides a comprehensive assessment of project noise impacts commensurate with the level of design detail available. For bus transit and highway transit projects, the FTA guidance recommends following the FHWA methodology and, therefore, TNM was used for this analysis. Bus transit centers or other bus transit/highway transit stationary sources were analyzed following the FTA's Detailed Assessment methodology. The transit vibration analysis for this analysis follows the FTA's General Vibration Assessment methodology.

A.2.2.3. FRA. In practice, FTA and FRA share resources and expertise for federal actions involving rail noise. FRA relies upon the FTA noise and vibration impact assessment procedures for assessing improvements to conventional passenger rail lines and stationary rail facilities. A supplemental freight rail analysis spreadsheet tool was developed for the Chicago Rail Efficiency and Transportation Efficiency (CREATE) program using FTA procedures (www.fra.dot.gov/us/content/253).

FRA issued its record of decision (ROD) on the California high speed rail project on November 18, 2005. The environmental review compared the environmental consequences of building a high speed train system to other modal alternatives—building more lanes, bridges and ramps along highways versus new terminals, gates and runways at airports. The noise assessment of the components comprising the No Project and Modal Alternatives are based on relevant criteria adopted by the FHWA, FAA, and FTA. Each agency's criteria were used to define a screening distance for assessing the potential for noise impact from relevant sources. The assessment also used FRA and FTA vibration impact criteria related to rail transportation. The screening assessments can be summarized as follows:

- FRA and FTA noise and vibration impact criteria were used for the High Speed Train (HST) and conventional rail alternatives.
- For modal alternatives that involve highway improvements (additional lanes), FHWA TNM was used to determine the distance at which the road noise contour of 65 A-weighted decibels (dBA) LEQ is reached.
- For modal alternatives that involve airport improvements (additional gates and runways), the 65-dBA DNL noise contour was redrawn and reassessed and overlaid with census data to assess the potential for aircraft noise impact.

A.2.2.4. FHWA. The FHWA has no procedures concerning assessment of non-highway transportation noise. It does, however, delegate part of its regulatory authority to the various state highway administrations, requiring each state to adopt a noise policy that is consistent with FHWA national policy. Those state policies can, if the state desires, contain additional regulatory detail. And therefore, for lack of any national policy about non-highway modes, multimodal methods are decided state by state.

Only one state's noise policy mentions other transportation modes—that of WSDOT. That state policy explicitly requires use of FTA procedures for multimodal projects involving rail transit. In general, other states also follow this same deference to the policies of non-sponsoring administrations. This is the case, for example, in the two multimodal projects of the Ohio Department of Transportation, mentioned above.

For the Ohio Eastern Corridor Multimodal Project, FHWA Look-up Table in TNM was used as a screening assessment of highway segments that might approach the FHWA Noise Abatement Criteria (NAC). FTA noise impact assessment guidance was used to identify rail noise sensitive locations. FTA vibration screening method was used to determine if the proposed rail transit alternatives might affect certain vibration-sensitive land uses. For the Ohio West Avenue Grade Separation Project, FHWA TNM was used both for highway noise prediction and barrier effects on rail noise. FTA screening procedure was used for rail noise. The EA also combined the models outputs to produce transportation (rail and highway) hourly LEQ predictions.

A.2.3. Air Quality Assessment Procedures

The Environmental Protection Agency has overarching jurisdiction for computing and assessing air quality of federally funded projects. As a result, air quality procedures of the DOT modal administrations are essentially equivalent. In essence, they involve a consistent set of computation methods for air quality emissions and dispersion, independent of the sponsoring administration.

Of particular interest to this research project is FAA guidance material about these EPA requirements. That material is contained in Chapter 1 of the FAA Environmental Desk Reference, supplemented by the FAA Air Quality Handbook. This chapter discusses requirements to conduct air quality analyses for airport development projects under the NEPA and Clean Air Act (CAA). Generally, detailed analysis is needed for a project that, due to its size, scope, or location has the potential to affect the attainment and maintenance of established air quality standards. Those standards are known as "National Ambient Air Quality Standards" (NAAQS) and are present for six criteria pollutants. Although the requirements under NEPA and the CAA differ in certain respects, generally the same analysis fulfills requirements under both. NEPA is more rigorous in that it may require detailed analysis where it is not needed under the CAA general conformity provisions. FAA requires the use of its own Emissions and Dispersion Modeling System (EDMS) for assessing aviation-related air quality impacts except hazardous air pollutants. The EDMS contains emission factors for aircraft engines, ground service equipment (GSE), motor vehicles, and other sources of emissions common to airports. To comply with FAA requirements, analysts must use the most current version of the model when preparing airport emission inventories and performing a dispersion analysis.

The Erie Airport project used EDMS to compute: (1) emissions inventory for transportation and general conformity with CAA and (2) dispersion concentrations for NAAQS assessment. The Columbia River Crossing project used EPA's MOBILE6.2 model for the transportation and general conformity determination. MOBILE6.2 and CAL3QHC models were used to predict local Carbon Monoxide (CO) concentrations. The air quality technical report for this project discussed shortcomings in current air quality models when it comes to predicting Mobile Source Air Toxins (MSAT). The air quality analysis for the California High Speed Rail Program EIS focused on the potential statewide, regional, and localized impacts on air quality. The regional pollutant burdens were estimated based on: (1) changes in vehicles miles traveled (VMT) for on-road mobile sources (vehicles), (2) off-road mobile sources (number of plane operations and train movements), and (3) changes in emissions of stationary sources (electrical power generators). For example, On-road pollutant burdens were calculated as a ratio of baseline VMT to estimated VMT changes under each alternative and FAA's EDMS was used to estimate airplane emissions. The Ohio Eastern Corridor Multimodal project did not include any air quality modeling because it was determined that the project was consistent with air quality goals of the one-hour ozone maintenance plans of Ohio, Kentucky, and Indiana.

A.3. Implications for the Model Design Plan

The market research was to identify future user communities for the multimodal noise and emissions model and to receive their reactions to some of the initial design concepts. The market research findings were also intended to describe the current and future multimodal and intermodal projects that would benefit from the use of this model. The effort as reported here was partially successful on each of its objectives.

One of the major issues, as already discussed, was the lack of response from the potential user communities. The people who did respond provided valuable gems of information. This appendix contains good ideas that will be addressed in the MDP on things such as the kinds of output they want. The respondents also raised very valid concerns about the complexity and cost associated with the new model that need be addressed in the build sequence section of the MDP. However, it is not practical to draw conclusions on behalf of the overall user community when the response rate is less than 1%.

Market research remains an important instrument for gauging interest in the model. Therefore, the MDP includes ideas for more effective survey instruments to use with the potential user communities. For example, the FAA Aviation Environmental Design Tool (AEDT) and Aviation Portfolio Management Tool (APMT) development projects began with a series of workshops conducted by the TRB. The intent was to assist FAA in defining the attributes and requirements for the new models by gathering input from the aviation user, operations, manufacturing, and research communities through a series of sequential workshops. Other ideas for the MDP include the employ of professional market survey firm and survey devices like focus groups of pertinent stakeholders to uncover a customer base for the multimodal model. Bringing in a market survey organization would also help to address questions about the utility of the model.

Section A.2 just scratches the surface on how federal agencies conduct multimodal projects. The case studies discussed in this section seem to have been successful in adequately addressing noise and emissions impacts from more than one transportation modes. Almost all of the studies relied on approved models and procedures that addressed noise and emissions impacts according to the individual criteria established by the relevant modal agencies. These case studies did not provide enough material to be able to answer how a multimodal noise and emissions model would have helped.

As one of the questionnaire respondents pointed out, there is a need for clearer identification of what types of projects can use such a model. Therefore, to justify the future investment of federal research funds, the MDP proposes a systematic process to gauge the utility of the multimodal model through the use of a market survey firm. The products of this effort are the identification of the kinds of airport projects that would benefit from the model and answers on what value the model would be to such projects and on how the various reviewing/regulatory agencies that oversee each individual mode would interpret and use the results of the multimodal analysis.

APPENDIX B. MODEL DESIGN EVALUATION

As dictated by the RFP, the recommendation for the multimodal model design should consider "costs associated with development and application of the resulting model versus expected benefits, as well as technical feasibility; capability to support demographic, transportation, and economic analysis of alternative scenarios and mitigation strategies; acceptability to regulatory agencies; and flexibility to meet changing needs." This was accomplished through a structured evaluation process to support the choices on how to proceed from the current models and development projects to the end state of multimodal model design.

Section B.1 explains the evaluation process. Section B.2 describes the alternative model design concepts that were constructed for the evaluation. Section B.3 identifies the benefits and drawbacks and each alternative. Section B.4 presents the results of the first round of evaluation. Section B.5 summarizes the round 2 evaluation process. Section B.6 presents the results of the second round. Section B.7 describes and justifies the model design that won the second round.

B.1. Evaluation Process

A critical step of the project is to decide on the multimodal noise and emission model design concept on which to then construct the MDP. The field of Decision Analysis (DA) offers various techniques and processes that could form the basis of a formal, quantitative evaluation process to justify that design against reasonable alternative designs. The project team explored 3 processes, or what are sometimes called multiple attribute decision models (MADM). They were:

- Pugh Matrix *(B-1)*
- Analytic Hierarchy Process (AHP) *(B-2)*
- Simple Multi-Attribute Rating Technique (SMART) *(B-3)*

These three processes were chosen because they are some of the most commonly used decision tools when dealing with incomplete information. The team chose a version of the Pugh Matrix for the MDP evaluation. Section B.1.1 summarizes the Pugh Matrix. Section B.1.2 discusses the criteria selected for the MDP evaluation. Section B.1.3 provides the details on the application of the Pugh Matrix for the selection of the multimodal noise and emissions model design.

B.1.1. Pugh Matrix

The Pugh Matrix is a method for concept selection using a scoring matrix in which alternatives are scored relative to weighted criteria. It is widely used in the Six Sigma Method as it provides a straightforward means to choose the best alternative with limited information. It uses simple scoring of the relative merits of the alternatives based upon criteria that attempt to take into consideration the needs of the user. It is named after Stuart Pugh who described the method. *(B-1)* The Pugh Matrix is also referred to as the "Pugh Concept Selection", "Pugh Method", and "Criteria Based Matrix", and "Datum Design Concept". The Pugh Matrix compares a concept to a reference concept, usually referred to as the Datum. Researchers from Stanford University suggested an attractive modification to the Pugh Matrix which separates performance evaluation from the cost evaluation to provide a summary value score. *(B-4)* The modified Pugh Matrix was selected for this evaluation and an example is presented in Table B-1.

TABLE B-1 The Modified Pugh Matrix

Evaluation Criteria		Concepts				
	Weight	**Datum**	A_1	A_2	A_3	A_4
R_1	W_1		S_{11}	S_{12}	S_{13}	S_{14}
R_2	W_2		S_{21}	S_{22}	S_{23}	S_{24}
R_3	W_3		S_{31}	S_{32}	S_{33}	S_{34}
R_4	W_4		S_{41}	S_{42}	S_{43}	S_{44}
R_5	W_5		S_{51}	S_{52}	S_{53}	S_{54}
Performance Score (P)			P_1	P_2	P_3	P_4
Evaluation Criteria						
	Weight					
C	**1**		S_1	S_2	S_3	S_4
Cost Score (C)			C_1	C_2	C_3	C_4
Value Score (V)			$\frac{P_1}{C_1}$	$\frac{P_2}{C_2}$	$\frac{P_3}{C_3}$	$\frac{P_4}{C_4}$

The MDP evaluation criteria (R) The weight applied to each evaluation criterion (W) is derived from the relative importance of that factor. Section B.1.3 defines the criteria weighted for this project. The sum of the weights must equal 1. The rating scheme assigns a criteria score (S) for each alternative (A). Each score is based on a comparative judgment against the datum or reference concept. The relative cost is represented by the evaluation criterion, C. The literature provided several examples of the rating schemes for the criteria score, S, which are used for rating both performance and costs. Table B-2 presents the rating scheme selected for this evaluation.

TABLE B-2 Rating Scheme

Relative Performance	Rating (S)
Much worse than reference concept	1
Worse than reference concept	2
Same as reference concept	3
Better than reference concept	4
Much better than reference concept	5

In Table B-1, the performance score (P) for each alternative is simply the summation of the individual rating multiplied by the criterion weight as shown in Equation B-1.

$$P_{ij} = \sum_{i=1}^{6} \left(W_i \cdot S_{ij} \right) \qquad \textbf{Equation B-1}$$

The most preferred concept is the one that achieves the highest relative value score (V), which is the ratio of the relative performance score (P) over the cost score (C).

The modified Pugh Matrix scoring system seems a good fit for decision making on the choice of model design for the MDP. The next decision was on the evaluation criteria (R).

B.1.2. Evaluation Criteria

The evaluation criteria (R) are based on the project requirements that have been turned into the following attributes:

- Cost effectiveness;

- Technical feasibility (practicality of the design and access to needed resources and expertise);
- Acceptability to the regulating agencies;
- International credibility (i.e., compliance with international technical standards and recommended practices);
- Scalability (i.e., flexible architecture and modular design to support airport-centric up to regional applications);
- Analytical proficiency (capability to support alternatives and mitigation analyses); and
- Responsiveness (flexible to changing demands).

Since the 7 evaluation criteria are qualitative, Table B-3 provides more clarity on each to help guide the evaluators.

TABLE B-3 Meaning of the 7 Evaluation Criteria

Evaluation Criteria	What does it entail?
Agency Acceptance	• Meets or exceeds agency technical requirements for: o Metrics o Data sources o Fidelity (accuracy) o Scope of analysis o Reliability o Verification & Validation • Meets agency need in terms of readiness, accessibility, and availability for use in NEPA and other requisite environmental impact assessments.
Technical Feasibility	• "Constructability" -- What is the availability of the resources (data, scientific, financial, expertise, etc) and how are they used to build the model? • Practicality -- How easy it to maintain and use? • Robustness – How well does it handle errors (human and otherwise) and failures (hardware and software)
Analytical Proficiency	• How capable is the model to support alternatives and mitigation analyses? • How well does the model perform the required applications? • What are the extent of the model limitations and how well are they managed? • What are the degrees of uncertainty in model outputs and how well are they understood?
Scalability	How flexible is system architecture and design to support the wide range of anticipated applications (airport-centric to system-wide)?
Responsiveness	How adaptable is the design to changing requirements from regulators, users, and stakeholders (source characterizations, new algorithms, input/output formats, etc.)?
International Credibility	• To what extent does the model meet all appropriate international standards and recommended practices? • Transparency – To what extent is information on the model and design available to any interested party?

TABLE B-3 Meaning of the 7 Evaluation Criteria (*concluded*)

Evaluation Criteria	What does it entail?
Cost Implications	• Development costs - To what extent does the design require research and development funding beyond levels of current projects? • Operating costs - How complex is the model to use (input requirements, special expertise, etc.)? • Life cycle costs – How much effort is required to maintain the model (training, tech support, updates, etc.)?

These evaluation criteria form the basis of the justification for the preferred design and associated build sequence from current state of the art to the desired end state. As part of the modified Pugh Matrix, the project team and Panel performed a rigorous assessment of design alternatives to define an optimal roadmap (build sequence and end state), which becomes the blueprint for the development of the MDP.

B.1.3. Pugh Matrix Scoring System for ACRP Project 02-09

The performance criteria (R) are taken from the seven desired attributes as described in the previous section. Using the modified Pugh Matrix, the cost effectiveness attribute is represented by the relative value score (V=P/C) and “Cost Implications” has been added as a criterion. The Datum or reference is the preferred design that Wyle described in its proposal. This Datum is described in Section B.2 along with the alternative design concepts.

The weighting for each criterion, from the previous section, was derived from the market research that was discussed in Appendix A. The market research assessed the viability and utility of a multimodal environmental model. Through widely distributed questionnaire, literature review, and personal interviews; the market research attempted to gather information about customers and the market.

Some of the key positive responses elicited by the questionnaire were:

- “Combining these two functions speak to airport community’s dual concerns of aircraft noise and aircraft-related pollutants as a primary irritant to their quality of life.”
- “Such a model would allow for improved understanding of tradeoffs between noise and emissions for a potential policy solution not only for a given transport mode, but between modes of transports.”
- “The use of a simulation approach would be an enormous improvement for realistic modeling and analysis of time varying impacts.”
- “Incremental build makes sense.”

Some of the respondents’ key concerns are:

- “Cost.”
- “Stovepipe culture.”
- “Getting acceptance from governmental agencies to adopt the new model over existing ones, and to accept outputs from the model.”
- “Maintaining stakeholder support over a long period of time may be difficult.’
- “We will end up with a big, data hungry, complicated, expensive model that no one either can or will use because of its complexity.”

The respondents were not asked to rank the attributes (criteria), but it is possible to glean from their responses enough information to make an initial judgment on how to weight each attribute. This initial judgment on weighting also draws upon comments received when this project was presented to the TRB ADC40 Committee on Transportation-Related Noise and Vibration (July 23, 2008 in Key West, FL) and to the Federal Interagency Committee on Aviation Noise (FICAN, on November 6, 2008). The criteria weightings are shown in Table B-4 along with a short rationale for the weight. The criteria in Table B-4 are listed in order of importance. Cost is an obvious important consideration and “Cost Implications” is handled separately in the modified Pugh Matrix.

TABLE B-4 Proposed Multimodal Noise and Emissions Model Design Criteria Weighting

Performance Evaluation Criteria	Weight	Rationale
Agency Acceptance	0.30	*This issue was the one most frequently mentioned by the respondents and during the presentations to TRB ADC40 and FICAN.*
Technical Feasibility	0.20	*These items are weighted equally just below Agency Acceptance to reflect desires of future users to be able to study tradeoffs and concern about creating a tool that is overly complicated.*
Analytical Proficiency	0.20	
Scalability	0.15	*The ability to do airport-level and regional analyses was mentioned by some respondents but less than the above.*
Responsiveness	0.10	*This item was mentioned in respondents’ comments but is felt to be less important that the attributes above.*
International Credibility	0.05	*This issue has never come up either in responses to the questionnaire or during presentations, but was identified by the ACRP 02-09 Panel.*

The performance scoring scheme is adopted from current practice as shown in Table B-5. The cost implications scoring scheme requires reversal of the performance rating system, such that, ‘1’ is the best cost score and ‘5’ is the worst cost score as shown in Table B-6. Thus, the perfect value score is ‘5’ (V=P/C=5/1).

TABLE B-5 Proposed Multimodal Noise and Emissions Model Design Performance Scoring Scheme

Relative Performance	Rating
Much worse than reference concept (Datum)	1
Worse than reference concept (Datum)	2
Same as reference concept (Datum)	3
Better than reference concept (Datum)	4
Much better than reference concept (Datum)	5

TABLE B-6 Proposed Multimodal Noise and Emissions Model Design Cost Scoring Scheme

Relative Cost Implications	Rating
Much higher than reference concept (Datum)	5
Higher than reference concept (Datum)	4
Same as reference concept (Datum)	3
Lower than reference concept (Datum)	2
Much lower than reference concept (Datum)	1

Putting together the evaluation criteria with the performance and cost scoring schemes, the modified Pugh Matrix for multimodal model design evaluation is shown in Table B-7.

TABLE B-7 Modified Pugh Matrix for Multimodal Noise and Emissions Model Design Evaluation

		Concepts				
Performance E valuation Criteria (R)	**Weight (w)**	**Datum**	**A_1**	**A_2**	**A_3**	**A_4**
Technical Feasibility	**0.20**	**3**				
Agency Acceptance	**0.30**	**3**				
International Credibility	**0.05**	**3**				
Scalability	**0.15**	**3**				
Analytical Proficiency	**0.20**	**3**				
Responsiveness	**0.10**	**3**				
Performance Score (P)		**3**				
Cost Evaluation Criteria						
	Weight					
Cost Implications	**1.00**	**3**				
Cost Score (C)		**3**				
Value Score (V = P/C)		**1.00**				

The Performance Score (P) is the weighted sum of the evaluation scores as shown earlier in Equation B-1. The most preferred design is the one that achieves the highest relative value score (V=P/C) greater than or equal to 1.00.

It was important to have the broadest perspective practical for the evaluation of model design alternatives. Therefore each member of the ACRP 02-09 Panel (14 members) and the project team (13 members) were asked to evaluate the alternatives by filling out Table B-7. The value scores were compiled into something like Table B-8.

TABLE B-8 Compiled Value Score Sheet for Multimodal Noise and Emissions Model Designs

Panel/Team Member	Value Scores				
	Datum	A_1	A_2	A_3	A_4
Evaluator1	1.00				
Evaluator2	1.00				
Evaluator3	1.00				
…	1.00				
Evaluator*XX*	1.00				
Median					
Interquartile Range (IQR)					

Nonparametric statistics, median and IQR, were used because there was insufficient information to conclude that the members' scores conform to a known probability distribution, such as normal distribution. The median is a surrogate for the average value score of all evaluators. The IQR can be used to gauge statistical difference between median values.

The design evaluation consisted of two rounds. Members of the project team and the Panel evaluated 5 designs in the first round. The project team used the results of the first round as an opportunity to construct a better alternative design based on the compiled scores and comments. For example, one could take some of the positive attributes of design A_1 and combine them with the positive attributes of design A_3 and devise a new design A_x that was not considered in the first round. The construction of a new design alternative and the evaluation process for the second round are discussed in Section B.5.

B.2. Model Design Candidates for Round 1

There were five multimodal model design concepts in the first round. The first concept, which was referred to as the Datum in the first round evaluation, is the design that was in the Wyle proposal; the initial preferred design concept. The remaining 4 are distinct alternatives for the multimodal noise and emissions model design.

Task 2 of the project was to "formulate potential model designs to be considered in the comprehensive Model Development Plan (MDP)." Alternative design concept papers were prepared based on examination of ongoing model development projects and feedback from potential user communities; both of which came out of Task 1. The complete design concept papers for the first round can be found in Appendix F.

The 5 design concepts are summarized in the following paragraphs.

B.2.1. Current Preferred Design (Datum)

The end state is a source (airplane, automobile, truck, marine vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs. The model will simulate the sound propagation and air pollutant emissions for the moving sources. Rather than initiating a single, large-scale effort to design and develop the end state, the design incorporates a build sequence toward the end state in a series of steps, each step providing an improvement to some facet of the overall model. The build sequence is predicated on giving the users and agencies the tool that they need within expandable system architecture. The model will draw up ongoing model development projects sponsored by the federal government, such as, FAA's Aviation Environmental Design Tool (AEDT) suite and DoD's Advanced Acoustic Model (AAM).

B.2.2. Build on AEDT (Alternative #1)

The FAA has developed a design tool named the Aviation Environmental Design Tool (AEDT). This tool is actually a suite of programs working together to perform not only environmental impact estimations, but also to allow policy decisions to be made in an informed way. This alternative explores continued development of the AEDT into a true multimodal noise and emissions model for all modes of transportation. This alternative would also include the construction of an environmental study clearinghouse where federal agencies could make available inputs and outputs of past modal studies for assistance in multimodal environmental assessments.

B.2.3. Build on Existing Simulation Models (Alternative #2)

This alternative design proposal outlines an approach to the development of a multimodal noise and emissions model centered on time-based simulation of source movements, source emissions, and propagation scenarios resulting in detailed output reports at receptor locations. The end-state of the model will functionally be the same as other design alternatives resulting in time-based simulation, such as the Datum.

This proposal suggests a multimodal model development plan should be founded on existing single transportation mode simulation model implementations. Research and validation reports of outdoor noise and emissions algorithms are abundant both domestically and internationally. Fostering these efforts – which include studies of both heuristic and simulation approaches – will result in a model more scalable, accurate, and usable than one tethered to legacy approaches and limitations.

B.2.4. Federal Adoption of Commercial Software (Alternative #3)

The concept promotes a market-based option for the development of the multimodal noise and emissions model. Commercially designed software has been leveraged by engineers and designers of all disciplines to provide an efficient and documentable path to solutions of problems ranging from the simple to the complex. Commercial software is already available to noise and air quality engineers. This document focuses on two such software packages. One is maintained by the German company Braunstein + Berndt GmbH and is named *SoundPLAN*. The second is *CadnaA*, the product of another German company – DataKustik.

This document does not determine which of CadnaA and SoundPLAN is the best commercially available software package. Rather, the purpose is to introduce elements of the idea that models sold commercially to the public domain could be adopted, regulated, validated, and provided with developmental assistance by the federal government.

B.2.5. Build on EC IMAGINE Project

Drawing on research completed by the European Commission (EC), the fundamental principle of the model design is the separation of description of the transportation source in terms of sound energy and exhaust emissions from the description of transmission to the receiver in terms of sound propagation and emissions dispersion. In May 2007, the EC completed its major noise modeling project, IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment), which proved that it is technically feasible to build a noise model that can compute noise levels from a variety of sources. The results of the IMAGINE project fit in perfectly with the simulation modeling concepts, such as, DoD Advanced Acoustic Model (AAM). The end state is the same as the current preferred design (Datum). However, this end state is geared toward application on large, regional transportation projects where the environmental outcomes for more than one transportation mode are critical elements of the decision making.

B.3. Benefits and Drawbacks

To assist the evaluators in the first round, preliminary assessments of each of the design alternatives were prepared. These assessments have been accumulated in the matrix contained in Table B-9. The cells contain short, qualitative statements on the pros and cons relative to the criteria. Pro statements are in green and begin with a plus sign ("+"). Con statements are in red and begin with a minus sign ("-").

B.4. Results of Round 1 Evaluations

Twenty members from the Panel and the project team submitted scorebooks in which they evaluated 5 alternatives using the modified Pugh Matrix. The winner from Round 1 was the alternative that received the highest median value score (V). The winner was Alternative#1 – Build on AEDT. Table B-10 provides the median ratings and scores for all alternatives. The full set of evaluation results, statistics, and charts can be found in Appendix G.

The evaluators had the option to provide comments along with their ratings and many did. Appendix H contains a compilation of the comments organized by design comparison (.e.g., Datum vs. Alternative #1, etc) and criteria (e.g., Agency Acceptance, Technical Feasibility, etc.). These comments along with the median scores were valuable in the construction of a new design alternative for the second round.

TABLE B-9 Preliminary Assessment of the Model Design Alternatives

Evaluation Criteria	**Datum** *Building to Simulation*	**Alternative #1** *Build on AEDT*	**Alternative #2** *Build on Existing Simulation Models*	**Alternative #3** *Federal Adoption of Commercial Software*	**Alternative #4** *Build on EC IMAGINE Project*
Agency Acceptance	+ FICAN supports simulation + Agency acceptance test for each build + Multimodal capability available with first build (1 year)	+ Expansion on FAA's AEDT. - DoD moving away from integration to simulation modeling. - No multimodal capability for some years	+ FICAN supports simulation + Agencies will continue to use existing tools + Development from beginning permits desirable options to be included + Open source code (understanding) - Only DOD is currently funding simulation - No multimodal capability for some years - Dramatic change in modeling techniques when completed -Publicly available source code (uncontrolled changes)	+ Agencies will continue to use existing tools in near-term + Agencies determine modules to use in the commercial product. + Multimodal product already exists - Agencies do not have complete control over source code - Known commercial models do not include US source databases - Eventual abandonment of current agency software development projects, like AEDT	+ FICAN supports simulation + Agencies agree on multimodal assessment requirements + Continue to use existing tools until agencies decide to change - Only DOD is currently funding simulation - No true multimodal capability for some years - Use of foreign methodologies - Air quality models would need to be added and databases harmonized.
Technical Feasibility	+ DoD has simulation noise model + Prudent (technically & financially) build sequence - Current lack of source data	+ Based on proven noise and emissions models + EPA preferred AERMOD basis for a single air dispersion model. +Air quality, noise and cost analysis already integrated.	+ Success by others; DoD and FDOT have simulation noise models + Concepts proved by EC IMAGINE/Harmonoise projects + Much greater flexibility in applications + More detail available during model runs + Development from beginning permits desirable options to be included + All sources can be simulated - Current lack of source data - Simulation impossible for some scenarios (i.e., intersections) - Lack of development by most U.S. agencies	+ Multimodal products already exist and in use + Professionally developed and maintained software + Highly modular structures able to accept US approved code - Current lack of US source data -Criticality of detailed benchmarking for software approval	+ Concepts proved by EC IMAGINE/Harmonoise projects + DoD AAM provides framework + Flexibility in noise estimation - EC projects were noise only - Current lack of source data - Very different sound reference levels for many sources, requiring new database development - More validation is needed

TABLE B-9 Preliminary Assessment of the Model Design Alternatives (*continued*)

Evaluation Criteria	**Datum** *Building to Simulation*	**Alternative #1** *Build on AEDT*	**Alternative #2** *Build on Existing Simulation Models*	**Alternative #3** *Federal Adoption of Commercial Software*	**Alternative #4** *Build on EC IMAGINE Project*
Analytical Proficiency	+FICAN: simulation is better + Screening tools for secondary sources + End state can calculate any metric - Computationally complex	+Air quality, noise and cost analysis already integrated. - Accuracy and usability remain static. - Integration model cannot accurately model many noise metrics, such as TA. - AEDT has a simplistic approach to motor vehicles.	+ FICAN: simulation is better + Calculate any metric + Sophisticated algorithms for accurate predictions + Selective use of computation complexion tied to fidelity + More detail available during model runs -Computationally complex - Substantially higher runtimes - Tedious input requirements	+Air quality and noise analysis already integrated. +Access to various calculation methods + Built-in features for mapping and report making +Customizable propagation and transmissions calculations.	+FICAN: simulation is better + Calculate any metric + Draws on EC IMAGINE guidance on accuracy tied to application - Computationally complex - Existing tools and all their faults retained for smaller single mode projects. - Very different sound reference levels for many sources, requiring new database development
Scalability	+ Lessons learned from MAGENTA and SAGE to follow scalable roadmap - Too complicated for smaller projects	+ Global modeling from FAA's SAGE and MAGENTA basis for regional modeling.	+Simulation modeling based on first principals can be scalable to multiple sources and scenarios. + More detail available during model runs + Development from beginning permits desirable options to be included	+Already in use on a variety of projects from EC noise mapping to taxiway noise analysis	+ End state designed for large, regional multimodal projects. + Existing tools retained for smaller single mode projects. + Flexibility in noise estimation - Air quality models would need to be added and databases harmonized.
Responsiveness	+ Each build gives users what they need	+ AEDT modular design easily adapted to further enhancements.	+ Circumvents developmental constraints of legacy approaches. + All sources can be simulated + Open source code (understanding)	+ Highly modular structures; independent updates + Integration with other commercial software - Updates determined by commercial entities - Risk to projects if software developer goes out of business	+ Separation of source from propagation allows for flexibility and adaptability. - Very different sound reference levels for many sources, requiring new database development
International Credibility	+ Learn from some foreign projects + Knowledgeable on international standards - No international coordination	+Noise computation core accepted worldwide. - No international coordination	+ Success by others; Concepts proved by EC IMAGINE/Harmonoise projects + Source code non-proprietary so scientists/engineers can understand implementation - No international coordination	+ Commercial products already widely used worldwide + Similar to EC approach on noise mapping	+ Incorporation of EC IMAGINE results + Collaboration with IMAGINE team members + Proceeding toward a more global model development

TABLE B-9 Preliminary Assessment of the Model Design Alternatives (*concluded*)

Evaluation Criteria	**Datum** *Building to Simulation*	**Alternative #1** *Build on AEDT*	**Alternative #2** *Build on Existing Simulation Models*	**Alternative #3** *Federal Adoption of Commercial Software*	**Alternative #4** *Build on EC IMAGINE Project*
Cost Implications	+ Draws from ongoing model development projects Incremental, increased funding tied to priority needs - Large, complex, and data intensive end state - Requires specialized expertise to use	+ Small additional costs on top of AEDT funding	+ Draws from ongoing simulation projects + Development efficiencies through use of professional software developers - Substantial new funding - Development time and cost - Lack of development by most U.S. agencies - No leverage with FAA's AEDT development - New paradigm has user implications (training and operation) - Large, complex, and data intensive	+ Substantially reduced federal R&D funding focused on source data generation and benchmarking - Prohibitively high license fees for many users - New paradigm has user implications (training and operation) - No leverage with FAA's AEDT development	+ Draws from ongoing simulation projects + Application only required for complex, critical, multimodal projects + Existing tools retained for single mode projects - Substantial new funding on top of current levels - Large, complex, and data intensive end state - Requires specialized expertise to use - Air quality models would need to be added and databases harmonized

TABLE B-10 Median Values from Round 1 Evaluation

Performance Evaluation Criteria (R)	Weight (w)	Concepts				
			Alternative			
		Datum	#1	#2	#3	#4
Agency Acceptance	0.30	3.00	2.50	2.00	2.00	2.00
Technical Feasibility	0.20	3.00	3.50	2.50	3.00	3.00
Analytical Proficiency	0.20	3.00	2.00	3.00	3.00	3.00
Scalability	0.15	3.00	3.00	4.00	3.50	3.50
Responsiveness	0.10	3.00	2.50	3.00	2.00	3.00
International Credibility	0.05	3.00	3.00	3.00	3.00	4.00
Performance Score (P)		3.00	2.78	2.73	2.55	2.63
Cost Score (C)		3.00	2.00	3.50	4.00	4.00
Value Score (V = P/C)		1.00	1.31	0.77	0.63	0.71

Note: Each cell in the Alternatives #1 to #4 columns of Table B-10 contains the median value from the applicable compilation tables on criteria, performance, cost, and value scores (Tables G-1 to G-10). For example, the Alternative #1 value score (V) of 1.31 is not the ratio of the P and C values above it (2.78/2.00), but is taken from the Value Score compilation table (Table G-10).

B.5. Round 2 Process

In Round 1, the winner was Alternative#1 – Build on AEDT. However, Alternative#1 was not considered the clear-cut winner as it did not outperform the Datum in performance, and its value score is primarily a product of its relatively low cost score.

Therefore, in the second round, the project team evaluated the winning design from Round 1, based on the highest value score, against a new design alternative. Section B.6 discusses the process in which the compiled Round 1 scores and comments were used to construct a better alternative design. Section B.7 provides the basis for the design recommendation from the results of the second round evaluation.

Table B-10 shows that Alternative#1 received the highest median rating in only a single performance category, Technical Feasibility. Alternative#1 came in second to Datum on the performance score, but achieved the highest value score by virtue of having the best (lowest) cost score. Note that certain cells in Table B-10 are shaded to identify the highest value for each criterion and score; except in the case of cost score, which is the lowest rating. The new design and Alternative#1 underwent a second round of evaluation. The new design concept became the Datum for the second round. The steps of Round 2 are described below.

STEP 1. Identify Most and Least Desirable Design Attributes

Evaluators' scores are useful to identify the most desirable attributes (based on highest median values) and least desirable attributes (based on lowest median value) for each criterion as shown in Figure B-1. In the figure, the green ellipses identify the alternative(s) that received the highest median rating for each of the performance and cost criterion; same as shown in Table B-10. For example, Datum received the highest median rating for 'Agency Acceptance'. The red rectangles identify the alternative(s) that received the lowest median rating, below 3, for each of the performance and cost criterion. For example, Alternatives # 3 and 4 received the worst cost implications rating. We then associate the flagged alternatives with their positive and negative attributes as shown in Tables B-11 and B-12.

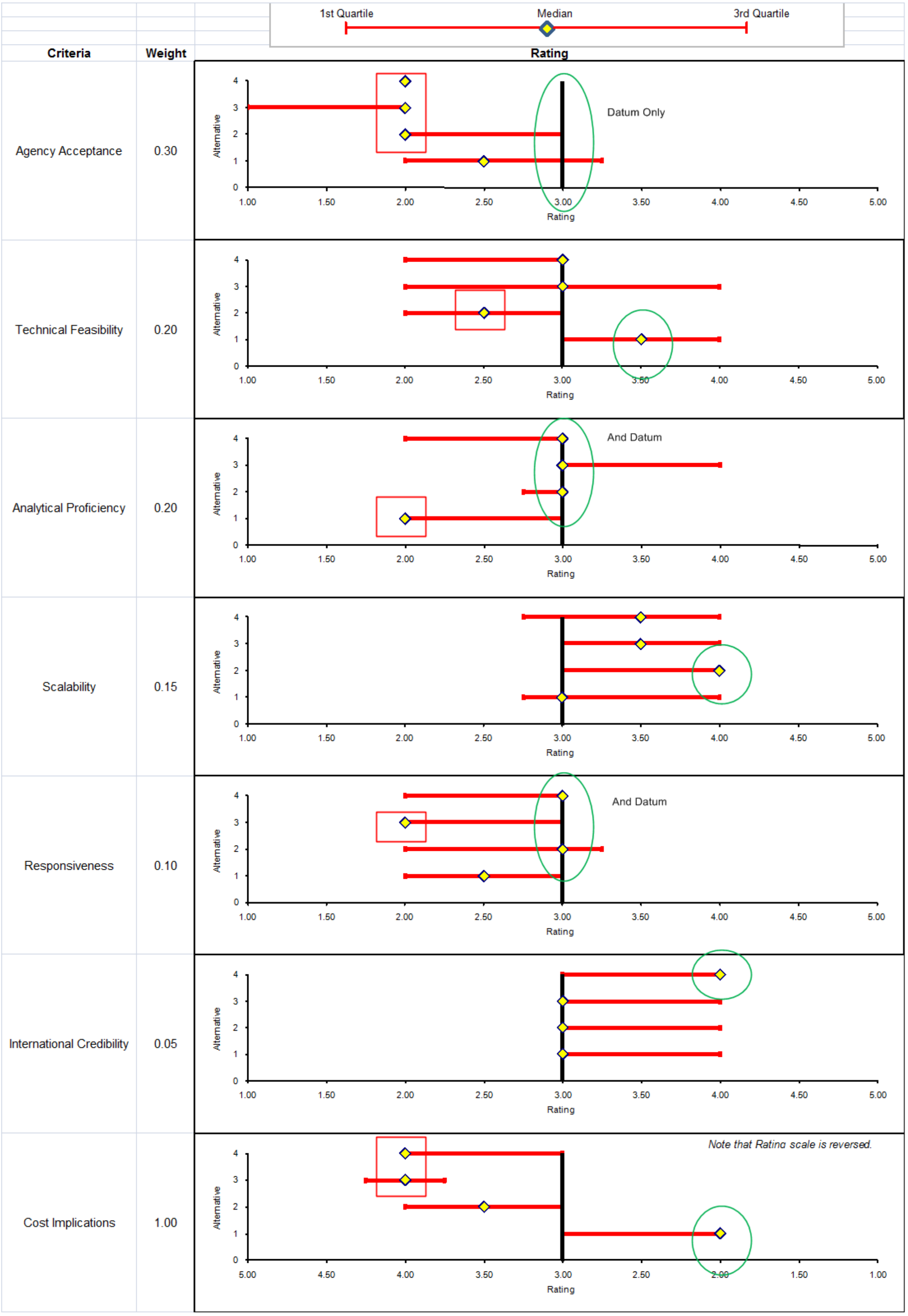

Figure B-1. Round 1 performance and cost rating statistics.

TABLE B-11 Pro Statements from the Preliminary Assessments
(Shaded cells identify alternatives that received the highest median rating in Round 1)

Evaluation Criteria	Datum *Building to Simulation*	Alternative #1 *Build on AEDT*	Alternative #2 *Build on Existing Simulation Models*	Alternative #3 *Federal Adoption of Commercial Software*	Alternative #4 *Build on EC IMAGINE Project*
Agency Acceptance	+ FICAN supports simulation + Agency acceptance test for each build + Multimodal capability available with first build (1 year)	+ Expansion on FAA's AEDT.	+ FICAN supports simulation + Agencies will continue to use existing tools + Development from beginning permits desirable options to be included + Open source code (understanding)	+ Agencies will continue to use existing tools in near-term + Agencies determine modules to use in the commercial product. + Multimodal product already exists	+ FICAN supports simulation + Agencies agree on multimodal assessment requirements + Continue to use existing tools until agencies decide to change
Technical Feasibility	+ DoD has simulation noise model + Prudent (technically & financially) build sequence	+ Based on proven noise and emissions models + EPA preferred AERMOD basis for a single air dispersion model. +Air quality, noise and cost analysis already integrated.	+ Success by others; DoD and FDOT have simulation noise models + Concepts proved by EC IMAGINE/Harmonoise projects + Much greater flexibility in applications + More detail available during model runs + Development from beginning permits desirable options to be included + All sources can be simulated	+ Multimodal products already exist and in use + Professionally developed and maintained software + Highly modular structures able to accept US approved code	+ Concepts proved by EC IMAGINE/Harmonoise projects + DoD AAM provides framework + Flexibility in noise estimation
Analytical Proficiency	+FICAN: simulation is better + Screening tools for secondary sources + End state can calculate any metric	+Air quality, noise and cost analysis already integrated.	+ FICAN: simulation is better + Calculate any metric + Sophisticated algorithms for accurate predictions + Selective use of computation complexion tied to fidelity + More detail available during model runs	+Air quality and noise analysis already integrated. +Access to various calculation methods + Built-in features for mapping and report making +Customizable propagation and transmissions calculations.	+FICAN: simulation is better + Calculate any metric + Draws on EC IMAGINE guidance on accuracy tied to application
Scalability	+ Lessons learned from MAGENTA and SAGE to follow scalable roadmap	+ Global modeling from FAA's SAGE and MAGENTA basis for regional modeling.	+Simulation modeling based on first principals can be scalable to multiple sources and scenarios. + More detail available during model runs + Development from beginning permits desirable options to be included	+Already in use on a variety of projects from EC noise mapping to taxiway noise analysis	+ End state designed for large, regional multimodal projects. + Existing tools retained for smaller single mode projects. + Flexibility in noise estimation

TABLE B-11 Pro Statements from the Preliminary Assessments (Shaded cells identify alternatives that received the highest median rating in Round 1) (*concluded*)

Evaluation Criteria	Datum *Building to Simulation*	Alternative #1 *Build on AEDT*	Alternative #2 *Build on Existing Simulation Models*	Alternative #3 *Federal Adoption of Commercial Software*	Alternative #4 *Build on EC IMAGINE Project*
Responsiveness	+ Each build gives users what they need	+ AEDT modular design easily adapted to further enhancements.	+ Circumvents developmental constraints of legacy approaches. + All sources can be simulated + Open source code (understanding)	+ Highly modular structures; independent updates + Integration with other commercial software	+ Separation of source from propagation allows for flexibility and adaptability.
International Credibility	+ Learn from some foreign projects + Knowledgeable on international standards	+Noise computation core accepted worldwide.	+ Success by others; Concepts proved by EC IMAGINE/Harmonoise projects + Source code non-proprietary so scientists/engineers can understand implementation	+ Commercial products already widely used worldwide + Similar to EC approach on noise mapping	+ Incorporation of EC IMAGINE results + Collaboration with IMAGINE team members + Proceeding toward a more global model development
Cost Implications	+ Draws from ongoing model development projects + Incremental, increased funding tied to priority needs	+ Small additional costs on top of AEDT funding	+ Draws from ongoing simulation projects + Development efficiencies through use of professional software developers	+ Substantially reduced federal R&D funding focused on source data generation and benchmarking	+ Draws from ongoing simulation projects + Application only required for complex, critical, multimodal projects + Existing tools retained for single mode projects

TABLE B-12 Con Statements from the Preliminary Assessments
(Shaded cells identify alternatives that received the lowest median rating, less than 3, in Round 1)

Evaluation Criteria	Datum *Building to Simulation*	Alternative #1 *Build on AEDT*	Alternative #2 *Build on Existing Simulation Models*	Alternative #3 *Federal Adoption of Commercial Software*	Alternative #4 *Build on EC IMAGINE Project*
Agency Acceptance		- DoD moving away from integration to simulation modeling. - No multimodal capability for some years	- Only DOD is currently funding simulation - No multimodal capability for some years - Dramatic change in modeling techniques when completed -Publicly available source code (uncontrolled changes)	- Agencies do not have complete control over source code - Known commercial models do not include US source databases - Eventual abandonment of current agency software development projects, like AEDT.	- Only DOD is currently funding simulation - No true multimodal capability for some years - Use of foreign methodologies - Air quality models would need to be added and databases harmonized.
Technical Feasibility	- Current lack of source data		- Current lack of source data - Simulation impossible for some scenarios (i.e., intersections) - Lack of development by most U.S. agencies	- Current lack of US source data -Criticality of detailed benchmarking for software approval	- EC projects were noise only - Current lack of source data - Very different sound reference levels for many sources, requiring new database development - More validation is needed
Analytical Proficiency	- Computationally complex	- Accuracy and usability remain static. - Integration model cannot accurately model many noise metrics, such as TA. - AEDT has a simplistic approach to motor vehicles.	-Computationally complex - Substantially higher runtimes - Tedious input requirements		- Computationally complex - Existing tools and all their faults retained for smaller single mode projects. - Very different sound reference levels for many sources, requiring new database development
Scalability	- Too complicated for smaller projects				- Air quality models would need to be added and databases harmonized.

TABLE B-12 Con Statements from the Preliminary Assessments
(Shaded cells identify alternatives that received the lowest median rating, less than 3, in Round 1) (*concluded*)

Responsiveness				- Updates determined by commercial entities - Risk to projects if software developer goes out of business	- Very different sound reference levels for many sources, requiring new database development
International Credibility	- No international coordination	- No international coordination	- No international coordination		
Cost Implications	- Large, complex, and data intensive end state - Requires specialized expertise to use		- Substantial new funding - Development time and cost - Lack of development by most U.S. agencies - No leverage with FAA's AEDT development - New paradigm has user implications (training and operation) - Large, complex, and data intensive	- Prohibitively high license fees for many users - New paradigm has user implications (training and operation) - No leverage with FAA's AEDT development	- Substantial new funding on top of current levels - Large, complex, and data intensive end state - Requires specialized expertise to use - Air quality models would need to be added and databases harmonized.

Table B-11 compiles all the pro statements concerning the various designs. These statements have been taken from the preliminary assessments of designs for the Round 1 evaluations. The boxes shaded in green identify alternative(s) that received the highest median rating for that criterion; for example, the shading of the Datum-Agency Acceptance cell. Similarly, Table B-12 compiles all the con statements concerning the various designs; again from the pre-Round 1preliminary assessments of designs. The boxes shaded in red identify those alternative(s) that received the lowest median rating for that criterion; for example, the shading of both the Alternative#3-Cost Implications and Alternative#4-Cost Implications cells.

STEP 2. Examine Evaluators' Comments

The Round 1 evaluators' comments were examined for insights that might signal positive and negative aspects of the designs. Appendix H contains a compilation of the comments organized by design comparison (.e.g., Datum vs. Alternative #1, etc) and criteria (e.g., Agency Acceptance, Technical Feasibility, etc.).

STEP 3. Find Better Design Elements

Table B-13 constructs a rationale for better design elements on the basis of the ratings done in Step 1 and drawing upon both the pro and con statements in the preliminary assessments (Tables B-11 and B-12, respectively) and related evaluators' comments (Appendix H).

The column labeled "Most Desirable Attributes" identifies the alternative(s) that received the highest median rating for each criterion and assembles both the pro statements (from the green shaded cells of Table B-11) and comments that suggest the reasons for the rating. Comments that describe positive aspects were selected because they are linked to the high rating; while negative comments were not selected because they do not.

The column labeled "Least Desirable Attributes" identifies the alternative(s) that received the lowest median rating for each criterion and assembles both the con statements (from the red shaded cells of Table B-12) and comments that suggest the reasons for the rating. Comments that describe negative aspects were selected because they are linked to the low rating; while positive comments were not selected because they do not.

The far right column of Table B-13 lists the design elements and characteristics that would maximize the most desired attributes and minimize the least desirable attributes. Note that this selection of elements is done by collective consideration of the 6 performance and single cost criterion rather than individually. The latter, piecemeal approach would have produced a design of incongruent parts.

The design alternatives, from which the design element was taken, are identified in brackets where possible.

STEP 4. Draft New Alternative Design Concept Paper

A new alternative design concept paper was drafted drawing from the Round 1 papers associated with the best design elements identified in Table B-10.

STEP 5. Evaluate New Design vs. Round 1 Winner

In the second round, members of the project team were asked to evaluate the new design concept drafted under Step 4 against Alternative #1 from Round 1. Just like Round 1, the evaluation was based on the modified Pugh Matrix. The results of Round 2 are discussed in the Section B.6 as part of the justification for the recommendation of a final design that is described in Section B.7.

TABLE B-13 Design Elements that Maximize the Most Desirable Attributes and Minimize the Least Desirable Attributes

Evaluation Criteria	Most Desirable Attributes	Least Desirable Attributes	Design Elements
Agency Acceptance	Datum received the highest rating. The preliminary assessment suggests these positive factors: • Agency acceptance test for each build • Multimodal capability available with first build (1 year) The evaluators' comments related to this rating would suggest that: • Agencies would prefer a step-by-step build sequence to re-evaluate progress versus needs. • Multimodal capability in the near term is more important than the simulation capability in the near term since many of the advantages of simulation modeling cannot be realized until adequate source data are available. • Agencies will be hesitant to scrap ongoing projects, but should recognize the superiority of simulation modeling.	Alternatives #2, 3, and 4 received the same lowest rating. The preliminary assessment suggests these negative factors: • No true multimodal capability for some years • Use of foreign methodologies • Lack of control over software The evaluators' comments related to this rating would suggest that: • Agencies will be hesitant to scrap ongoing projects, but should recognize the superiority of simulation modeling. • Cannot imagine regulatory agencies agreeing to depend upon a commercial entity. • Coming from a Federal agency, this option provides a loss of control. This is not a turf issue, but rather a regulatory compliance issue. • The risk is far too great here should the vendor go out of business, unless licensing could be arranged to include the source code. • Agencies would be unlikely to rely on the market to dictate performance and costs - particularly costs to the users • Agencies would be reluctant to accept a European approach	Taking into consideration the most and least desirable attributes across the 6 performance criteria along with the cost implications, the design elements and characteristics for a better design concept are: • Progressive build sequence [Datum & Alt#1] • Screening tools [Datum] • Multimodal capability right away [Datum] • Calculate all required metrics [Datum & Alt#1] • Leverage AEDT development [Datum & Alt#1] • Simulation end state [Datum, Alt#2, & Alt#4] • Official guidance from federal agencies on how to do multimodal environmental analysis [Alt#4] • Learn from EC IMAGINE [Alt#4] • Minimize user costs [not Alt#3] • Scalable from regional to single-site projects • Periodic agency acceptance test [Datum]
Technical Feasibility	Alternative #1 received the highest rating. The preliminary assessment suggests these positive factors: • Based on proven noise and emissions models • Air quality, noise and cost analysis already integrated. The evaluators' comments related to this rating would suggest that: • While the ability to run individual analyses is probably easier in the datum alternative, the [Alternative #1] configuration management of the software, databases, and results as well as the information management of the input and output data is significantly improved making larger and more complex analyses more feasible. • Seemingly easier to implement and build upon existing methodologies or those already in development.	Alternative #2 received the lowest rating. The preliminary assessment suggests these negative factors: • Current lack of source data • Simulation impossible for some scenarios (i.e., intersections) • Lack of development by most U.S. agencies The evaluators' comments related to this rating would suggest that: • I am severely concerned about the impossibility of modeling intersections - FHWA project very often involve intersections. If this is not a possibility, then this option is much worse then datum. • … the question comes down to sequencing, and due to data availability and other reasons, having the multimodal capability before the simulation capability makes more sense.	

TABLE B-13 Design Elements that Maximize the Most Desirable Attributes and Minimize the Least Desirable Attributes (*continued*)

Evaluation Criteria	Most Desirable Attributes	Least Desirable Attributes	Design Elements
Responsiveness	The 3 simulation-based concepts (Datum, Alternative #2, and Alternative#4) received the same highest rating. The preliminary assessments do not provide a clear indication of other positive factors in common. The evaluators' comments related to this rating would suggest that: • With a multimodal capability being the focus, the Datum gets us there more rapidly [than Alternative #1]. • By virtue of the build sequence, the Datum could be considered the most responsive. Also, AEDT may not allow for new noise metrics • Datum approach facilitates responsiveness due to its 'loosely-coupled', highly modular approach. • The [Datum and Alternative#2] end state in terms of scalability is very similar if not identical. • With modularity and first principles approaches being roughly equivalent between Datum and Alt#4 there do not seem to be any differentiator in Responsiveness.	Alternative #3 received the lowest rating. The preliminary assessment suggests these negative factors: • Updates determined by commercial entities • Risk to projects if software developer goes out of business. The evaluators' comments related to this rating would suggest that: • Mainly because so much is out of the control of US agencies. • Commercial developers could give up any time they wished. … • While the alternative appears to more responsive technically, there is substantial risks that certain regulatory requirements would not be fulfilled if left to the determination of a commercial entity. • The risk is far too great here should the vendor go out of business, unless licensing could be arranged to include the source code.	
International Credibility	Alternative #4 received the highest rating. The preliminary assessment suggests these positive factors: • Incorporation of EC IMAGINE results • Collaboration with IMAGINE team members • Proceeding toward a more global model development The evaluators' comments related to this rating uniformly emphasized collaboration with EC IMAGINE as a major plus. However, one of these evaluators suggested that there will always be the question about U.S. domain knowledge working off of a European design. The U.S. will not be in a position of global leadership with this approach.	The other 4 alternatives were equally rated at 3.	

TABLE B-13 Design Elements that Maximize the Most Desirable Attributes and Minimize the Least Desirable Attributes (*concluded*)

Evaluation Criteria	Most Desirable Attributes	Least Desirable Attributes	Design Elements
Cost Implications	Alternative #1 received the best rating (lowest cost implications). The preliminary assessment suggests that this alternative would just add small costs on top of current funding for AEDT development. The evaluators' comments related to this rating would suggest that: • Initial Alt#1 implementation higher but maintenance and life cycle cost lower. • It [Alternative #1] will continue and expand an ongoing project. As such, past investments will continue to see returns. • Cost comparison depends on how far along the build sequence the Datum would go. Alt# 1 would be less expensive to achieve the same end state. • Alternative #1 would probably have lower development costs over the entire cycle, but higher upfront costs and higher risks (due to tightly-coupled integration). User costs: probably greater for Alternative #1 in short term (large, single model). As well, maintenance costs for Alternative #1 is probably more (any advances in sub-models would have to be incorporated into large model).	Alternatives #3 and 4 received the same worst rating (highest cost implications). The preliminary assessment suggests these negative factors: • Prohibitively high license fees for many users • No leverage with FAA's AEDT development • Substantial new funding on top of current levels • Air quality models would need to be added and databases harmonized. The evaluators' comments related to this rating would suggest that: Alternative #3 • All government agencies are used to having zero license fees for current models. I seriously doubt that possibility for this alternative. • Savings on future federal R&D funds is outweighed by high user fees and wasted expenditures on existing projects, such as AEDT. • It will be much more expensive for the user. State DOTs would have to purchase their own, as well as every consultant the does this work for a State DOT. These costs could adversely hinder small, minority or women lead businesses. • Substantial individual seat costs associated with these tools render this a non-viable option • Both the recurring costs to the user base and the maintenance of accessibility to results inventories will be costly for both the agencies and commercial vendors. • Lower costs for DOT, but potentially high costs for users. • Smaller development cost (to the government agencies) offset by higher user costs (purchase of licenses). Alternative#4 • FHWA would still need to fund TNM to keep it operational. • Working with foreign developers would be difficult and time consuming.	

B.6. Results of the Round 2 Evaluation

In the second round, the members of the project team evaluated the winner of Round 1 (Alternative #1 – Build on AEDT) against the new design constructed based on the scores and comments as described in the previous section. The new design concept became the Datum in the second round.

The new concept is an amalgamation of good ideas from the alternative designs evaluated in the first round including the alternative to which it was judged in Round 2. It is a road map like that from Round 1 Datum. Because of the importance of the ongoing investment, the concept builds on AEDT development to bring in other modes. The design leads to a simulation model, but recognizes that it is not politically or economically practical to go straight to simulation (as espoused in Alternative #2 from Round 1), and uses progressive steps to a simulation end state.

Table B-14 contains the median performance criteria ratings, median performance and cost scores, and median value scores as computed from the 9 scorebooks. The shaded cells identified the highest median value for each criterion and score; except in the case of cost score, which is the lowest rating.

TABLE B-14 Round 2 Evaluation Scores

Round 2 Median Values		Concepts	
Performance Evaluation Criteria	Weighting	Datum	Alternative #1
Agency Acceptance	0.30	3.00	2.00
Technical Feasibility	0.20	3.00	3.00
Analytical Proficiency	0.20	3.00	2.00
Scalability	0.15	3.00	2.00
Responsiveness	0.10	3.00	2.00
International Credibility	0.05	3.00	2.00
Performance Score (P)		3.00	2.35
Cost Score (C)		3.00	2.00
Value Score (V = P/C)		1.00	0.93

The Datum is superior to Alternative #1 for 5 of the 6 performance criteria (and achieved the same median rating for the other performance criteria) and received the higher value score. Appendix H contains a compilation of the Round 2 evaluators' comments organized by criteria (e.g., Agency Acceptance, Technical Feasibility, etc.). The comments show that many of the evaluators recognized the incorporation of good design ideas from the first round. Constructed from the first round evaluation and confirmed by the second round evaluation, the recommended design concept is presented in the next section.

B.7. Recommended Model Design

B.7.1. Progressive Build in Sync with Agencies' and Users' Requirements

As the title indicates, the premise of this design concept is to build what the user community and agencies need when they need it. The principal characteristics of the design are:

- Provide a multimodal capability right away with combined output and screening tools;
- Leverage ongoing federal agency model development efforts, such as, FAA's AEDT;
- Coordinate with regulatory agencies to ensure compatibility with official guidance on how to do multimodal environmental analysis;
- Look to the future with the stretch goal of a simulation end state;

- Adapt from other research, such as, EC IMAGINE; and
- Learn from applications and users' experiences.

Rather than initiating a single, large-scale effort to design and develop the end state, the design incorporates a build sequence toward the end state in a series of steps, each step providing an improvement to some facet of the overall model. The build sequence is predicated on giving the users and agencies the tool that they need within expandable system architecture. The model will draw upon ongoing model development projects sponsored by the federal government, such as, FAA's Aviation Environmental Design Tool (AEDT) suite and DoD's Advanced Acoustic Model (AAM).

AEDT is actually a suite of programs working together to perform not only environmental impact estimations, but also to allow policy decisions to be made in an informed way. This alternative explores continued development of the AEDT into a true multimodal noise and emissions model for all modes of transportation.

The stretch goal is the eventual development (end state) of a source (airplane, automobile, truck, marine vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs. The model will simulate the sound propagation and air pollutant emissions for the moving sources.

In May 2007, the European Commission (EC) completed its major noise modeling project, IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment), which proved that it is technically feasible to build a noise model that can compute noise levels from a variety of sources. The results of the IMAGINE project fit in perfectly with the simulation modeling concept.

B.7.2. Functional Specifications

The progressive build sequence of this concept is guided by the principal: "Think big; start small; act now." The first 2 builds are intended to provide low cost multimodal environmental analysis capability based on the existing tools required by the various federal agencies for single mode analyses.

Builds #3 and 4 leverage the ongoing AEDT development effort. The AEDT tool suite has various modules including an economics model and cost and benefit module in addition to the environmental impacts estimation module. The environmental impacts estimation module is based on four proven (nationally and internationally) noise and air quality models: INM, Magenta, EDMS, and SAGE. The noise models, based on the integrated approach, allow for a wide range of outputs including a range of metrics for A- and C-Weighted, and tone perceived levels, and an approximation for time above outputs. For air quality, all criteria pollutants plus carbon dioxide and speciated hydrocarbon outputs are available.

The noise computation modules in AEDT are very detailed including spherical spreading, atmospheric absorption, terrain shielding, lateral attenuation, and ground effects for noise propagation calculations. This would provide a solid platform for modeling the noise from other modes of transportation. The database would have to be expanded to include reference emission levels for other modes of transportation. For air quality, a detailed emission inventory process is included for aircraft-related sources, motor vehicles, and some stationary sources with local dispersion based on the accepted air quality dispersion model, AERMOD. AERMOD has been used for many sources, is now being considered by FHWA for motor vehicles, which would allow for a single air dispersion model to be used although greater detail would be required.

As determined by need and affordability, the remaining build sequences (Builds #5 and beyond) are to create the simulation end state. The ultimate requirement for noise would consist of a time-history of the one-third octave band spectrum produced by each source operation. When combined with numbers of operations of the different sources, the simulation model would use common algorithms and:

- Calculate any noise metric for any transportation source;
- Propagate sound over any terrain, surface, barrier, structural effects (urban canyon reverberation, etc.) and through any meteorological condition;
- Compute that propagation with a precision that is proportional to the effort spent on terrain/meteorological input (will vary by type of project);
- Include complete and validated transportation sources databases;
- Integrate background noise estimation;
- Offer the level of accuracy that meets or exceeds any regulatory requirement; and
- Provide second-by-second noise.

For emissions, the simulation model would:

- Predict fuel consumption which would serve as a basis for energy usage (needs to take into account the different fuel types);
- Provide emissions of both criteria pollutants and Greenhouse Gases (GHG);
- Predict emissions by specific modes (e.g., acceleration, takeoff, etc.) and equipment type (e.g., light-duty vehicles, Boeing 737-200, etc.); and
- Provide second-by-second emissions.

For Air Quality, the simulation model would:

- Generate second-by-second atmospheric concentrations;
- Be able to model both transport and chemical transformations for characterized pollutants including Hazardous Air Pollutants (HAPs) and particulate matter (PM); and
- Take into account structural effects such as building wake effects, urban canyon effects, tunnels, etc.

B.7.3. Justification

Clearly, the development of a multimodal environmental model would require a major expenditure of funds and would take many years to complete. Rather than initiating a single, large-scale effort to design and develop the end state, a more realistic approach, consistent with feasible funding streams and practical stakeholder needs, would be to approach the end state in a series of steps, each step providing an improvement to some facet of the overall model. It is important for the architecture of the model to be sufficiently flexible so as to allow for a scalable roadmap towards a future end state.

Extensive resources have been expended by FAA to build AEDT. This initial expenditure has built a strong base for the aviation sources which would significantly reduce the cost in comparison to other options since implementation time would be greatly reduced and only an expansion of the model would be required. The model has also overcome a large hurdle in that air quality, noise and economic considerations have been considered and integrated into this single model. While the data base sharing would need to be improved and would need to be expanded for other modes of transportation other than aviation, AEDT would provide a platform for inclusion of the other modes of transportation. Additionally, the models used in AEDT have been promulgated and accepted by EPA for air quality and the noise model is accepted on an international basis. Implementation for the other modes of transportation could be done with the accepted modeling processes as well, again reducing the time requirements since these models have been previously accepted by other agencies.

The modular design would allow for easy inclusion of other models so that other modes of transportation could be included without extensive redesign of the basic model platform. Rail, water and highway would have to be included as modes, but again, could be done in the modular design. The database design would allow other reference levels for noise and emission levels for air quality to be included in the same way, again without extensive changes to the system architecture. The advantages are considerable and include:

- Use of established models so that development is not needed nor is the long validation process;
- The database design allow inclusion of modes of transportation in the same way so that model components can be reused and similar;
- Inputs can be shared so that repetition is not required;
- The local and global modeling will work together;
- Algorithms can be repeated, leading to more streamline design;
- Global and regional modeling could be done by model expansion for other modes;
- Future expansion is enhanced because of the modularity of the system; and,
- The model is easily adapted for other cases allowing mitigation and future enhancements to be analyzed using the same model structure reducing cost and time of implementation.

Integrated models, such as, AEDT, have computational limitations for dynamic processes. The Federal Interagency Committee on Aviation Noise (FICAN) has already recognized simulation noise models as having the most potential for accuracy and precision in situations requiring sophisticated analysis. Examples of the adoption of noise simulation include the National Parks Service's adoption of NMSim (Noise Model Simulation), the development of AAM (Advanced Acoustics Model) through SERDP (the US Department of Defense Strategic Environmental Research and Development Program), and the adoption of RNM (Rotorcraft Noise Model) by NASA and NATO as the de-facto standard for helicopters and tilt-rotors outdoor noise propagation. International credibility of this approach is bolstered by the fact that the European Commission has undergone a multinational research and developmental effort resulting in algorithms and technical guidance for using a harmonized ground and air noise source and propagation methodology through the IMAGINE project.

Justification for incorporating these air quality and noise models into a simulation model capable of handling multiple modes of transportation lies in the fact that simulation modeling has already been proven to be more accurate and will provide a step forward in environmental modeling for analysts of all agencies. Considerable advantages include:

- The continued use of the most sophisticated algorithms to most accurately predict results at points of interest.
- Building of current simulation models will circumvent developmental constraints caused by legacy approaches of lesser fidelity.
- Ray tracing algorithms for noise can be applied to any source regardless of transportation mode.

- Proper inclusion of meteorological effects, terrain, and other heterogeneous scenarios.
- Sufficient detail in the output will provide thorough understanding of any scenario.
- Inputs provide accurate representation of sources more closely based on first principles rather than required assumptions or calculated metrics in a static case (as is the case with AEDT).
- Knowledge and validation from existing simulation models will streamline development.
- Updates to propagation and dispersion algorithms can be independent of source definitions.
- Sufficient detail in output will allow any standard or supplemental metric to be calculated.
- Existing tools that model source movements may be used and tracks may be translated into time-varying spatial and conditional source trajectories.
- The main drivers for noise and emissions, such as acceleration and power setting, can be directly listed or inferred from a sufficiently detailed trajectory file.
- Potential exists for a harmonized source definition file to contain noise and air quality data together as well as rules for interpolation and extrapolation thereof.
- The ability to define multiple emissions components emanating from a single source for a single mode (such as separate definitions for both the main and tail rotors of a helicopter).

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APPENDIX C. CURRENT STATES OF THE ART

This appendix reports the results of the examination of detailed information on the current domestic and foreign states of the art in modeling of transportation noise and emissions; building upon the initial list of models that had been identified in the proposal. A model evaluation protocol was prepared to assist in the gathering information concerning what the models do, how they do it, and for whom.

Appendix I contains detailed descriptions on 47 models that are currently in use around the world for noise and air quality assessments. The models are grouped as follows:

- Air Quality Emissions and Dispersion Models
- Noise Models
- Models that do Both Noise and Air Quality

The following sections of this chapter present the results of the gap analyses to identify important capabilities not currently met by existing models or analytical tools. The gap analysis evaluated the models against a desired condition, in this case, the end state of a multimodal tool, which is defined in Exhibits E-1 and E-2 of Appendix E. The gap analysis grouped the models by discipline for each of the elements, identified the gap between the end state and the collective abilities of the models within the particular discipline. Section C.1 covers air quality emissions and dispersion models. Section C.2 addresses noise models.

C.1. Gap Analysis to End State – Air Quality Emissions and Dispersion

Appendix I provides detailed descriptions of several air quality models in use with tables that summarize each model's capabilities. The body of this section is devoted to the gap analysis for the aviation and ground noise models.

C.1.1. Summary

Table C-1 contains a capability gap assessment for emissions modeling and Table C-2 contains a capability gap assessment for dispersion modeling

The "End Capability" categories listed in the tables are meant to provide overall summaries of key areas that could further be separated into finer components. For example, much of the emissions capabilities could include sub-categories on equipment characteristics and operational considerations. Also, the chemical transformation capabilities could include sub-categories on nitrate, sulfate, HAP, etc. chemistries. In addition, the different modes (e.g., aviation, highway, etc.) include many sub-categories of sources including different types of aircraft (e.g., jet, turboprop, and piston), Ground Service Equipment (GSE), etc. for aviation. Therefore, it should be understood that these higher-level categories encompass various sub-categories and are used to help facilitate the overall comparisons and gap analysis.

Overall, the Transit and Maritime sectors have the biggest gaps because of the lack of models. Emissions and dispersion modeling capabilities will either need to be developed or adapted from existing models. Emissions data will need to be collected and incorporated into a model. Dispersion modeling for these modes can probably be handled through existing EPA models such as AERMOD or CALPUFF.

The most significant capabilities missing from all or most of the modes are:

- Second-by-second emissions
- Second-by-second concentrations
- Chemical Transformations

The first two referring to second-by-second results are indicative of a lack of time-varying simulation capabilities. That is, the second-by-second activities of each source are generally not available at this time. Second-by-second results would provide the ultimate starting resolution that could be used to generate various aggregated results. These simulation results would also provide for the ability to better understand the interactions between the source and the emissions or concentrations.

Currently, chemical transformation modeling capabilities are in their infancy, especially with regards to microscale and regional modeling. Although some capabilities exist in Gaussian models like AERMOD, CALPUFF, and CALINE4, they use first order approximations. As is currently being done with EDMS research under the FAA’s PARTNER program, methods from grid-based models (e.g., CMAQ) may need to be adapted for use with these smaller-scale Gaussian models. This gap for chemical transformation capabilities applies to both criteria pollutants and HAPs.

Although there are some data for HAP emissions, most models generally cannot model these emissions at the moment. The capability to report emissions of speciated HAPS was recently incorporated into EDMS but only for aircraft and in a limited fashion. Comprehensive health impact studies will not be possible without quantifying these emissions (as well as dispersion effects).

The other missing items are associated with dispersion modeling capabilities (i.e., building wake effects, urban canyon effects, complex terrain, and tunnels). These are all important but should be considered secondary to the aforementioned gaps. Dispersion modeling capabilities such as building wake effects will not always be necessary (i.e., depends on the nearby presence of buildings), and as a result, are not considered as important as the other core features. Other secondary features not specifically cited include plume rise, initial plume characteristics, etc. All of these secondary effects will need to be considered as the model development plan is established.

Green = Little or No Gap   Yellow = Some Gap   Red = Huge Gap

TABLE C-1 Gap Assessment Matrix – Emissions Models

End Capability	Aviation	Highway	Off-Road	Transit	Marine
Criteria emissions	Yes, mainly from EDMS and the AEDT efforts	Yes in models like MOBILE6.2 and EMFAC	Yes, in models like NONROAD and OFFROAD	Limited data (EFs)	Limited data (EFs)
HAP emissions	Recently added to EDMS – can speciate all HAPs for aircraft only	Limited data (EFs)	Limited data (EFs)	No	No
GHG emissions	Only for some GHGs (CO_2) and aircraft only in EDMS	For some pollutants (e.g., CO_2)	For some pollutants (e.g., CO_2)	Limited data (EFs)	Limited data (EFs)
Second-by-second	No, only steady-state emissions	CMEM can provide these for some vehicle types	No/few data for other than motor vehicles available	No	No
Modal emissions	Yes for some sources (aircraft)	Yes, these can be generated	Some semblance of this from power requirements	No	No
Fuel consumption	Yes for some sources (aircraft)	Yes, these can be generated (e.g., MOVES)	Limited data	Limited data	Limited data
Equipment specificity	Very specific	Very specific	Very specific	No	No

TABLE C-2 Gap Assessment Matrix – Dispersion Models

End Capability	Aviation	Highway	Off-Road	Transit	Maritime
Transport (includes meteorology and terrain)	Yes	Yes	Yes, since models like AERMOD have been applied	No, but existing dispersion models can be adapted	No, but existing dispersion models can be adapted
Chemical transformation	No, but research is undergoing	No	No	No	No
Second-by-second concentrations	No, only steady-state concentrations	TRAQSIM can do this, but limited to research at this time	No	No	No
Building wake effects	Not currently implemented in EDMS, but can be exercised externally through AEDT-Prime	No	No	No	No
Urban canyon effects	N/A	No	N/A	No	N/A
Tunnels	N/A	No	N/A	No	N/A

Note: N/A = Not Applicable

C.2. Gap Analysis to End State – Noise

Appendix I provides detailed descriptions of noise models in use with tables that summarize each model's capabilities. The body of this section is devoted to the gap analysis for the aviation and ground noise models.

C.2.1. Aviation Noise Model Gap Analysis

In the following gap analysis for aviation noise assessment models, the Advanced Acoustic Model (AAM), the Aviation Environmental Design Tool (AEDT), the Heliport Noise Model (HNM), the Integrated Noise Model (INM), the Noise Integrated Routing System (NIRS), and NOISEMAP have been investigated and compared. Although a detailed discussion of their algorithms is not provided, the commercial noise models, CadnaA, IMMI, and LimA have also been considered. These models are, initially, investigated separately and, subsequently, included in the general discussion.

C.2.1.1. Summary for Aviation Noise Models. Table C-3 summarizes the strengths and weaknesses of each of the three models whose algorithms have been explored.

TABLE C-3 Strengths and Weaknesses of INM, NOISEMAP, and AAM

	Source		Propagation*			
Model	**Database**	**Characterization**	**Ground Impedance**	**Terrain Effects**	**Meteo Effects**	**Nonlinear Effects**
INM	Extensive	Fair	Minimal	Minimal	Minimal	No
NOISEMAP	Extensive	Fair	Fair	Fair	Minimal	No
AAM	Limited hemisphere representations	Detailed	Good	Fair	Fair	Yes

**All models include spherical spreading and atmospheric absorption*

C.2.1.2. Discussion of Commercial Models. It is common for the commercial models to be fully integrated methods of calculating both noise levels produced by many types of sources, and air quality. The commercial models can accommodate projects of virtually any size and are often limited only by the memory of the user's computer. They are designed to be user-friendly, accepting different types of data input structures, providing different types of data output structures, and accommodating parallel processing for quicker and larger calculations. They provide an aesthetically pleasing user-interface, which often includes a 3-dimensional visualization of the considered landscape. Because users may come from different countries, a large number of standard algorithms, both national and interim EU calculation methods, are available for selection. The databases used for aviation noise sources may originate from different places. However, they may not be as extensive as the NPD database.

While commercial models do offer many options regarding the noise computation standards used, the types of noise source, and the scale of calculation, their algorithms are not new and their advances seem to be in their efficiency, parallel computing capabilities, flexibility in size of the map, and refined user interface.

C.2.1.3. Ease of Use. The most pervasive of the considered models is INM. Because it was designed to be used by a large number of people who are not as familiar with the complexities of sound production and propagation from aircraft, it is a relatively straightforward program that does not place large demands on the user.

The commercial models go one step further than INM. Unlike INM, which is the standard model used by the FAA, the commercial models compete for business and must, therefore, be more conscious of how at ease a user is with their software. Therefore, the user-interfaces are often more aesthetically pleasing and, perhaps, a little less clunky.

C.2.1.4. Local versus Global. INM is meant to be used for noise assessments around a single airport. Its global counterpart, NIRS, is meant to be a large-scale model, involving noise assessments around multiple airports. AEDT is anticipated to include both the local and global capacities, as a union of these two (among other) models. NOISEMAP, however, is a local model and has no global counterparts. The author hypothesizes that this is a consequence of the density of commercial airports and the relative scarcity of military bases and supersonic aircraft operations.

As previously mentioned, the size of the maps produced by commercial models is often limited only by the memory size of the user's computer. Therefore, they can be applied to both local and global calculations.

C.2.1.5. Conclusions. This gap analysis has investigated six U.S. noise assessment models, paying particular attention to three whose algorithms are representative of all considered models.

In the comparison of INM, NOISEMAP, and AAM, it was found that many of the necessary aviation noise production and propagation effects have been addressed. However, terrain and meteorology were the effects most often neglected.

The comparison also revealed different degrees of accuracy in the models' source representations. These included a simplified representation, with a compact, extensive database and smaller computational requirements, a detailed source representation with a limited database, and a more theoretical source representation, requiring a user equip to supply the many necessary inputs. If an integration of the strengths of each model is sought, these different representations must somehow be reconciled.

The merging of local and global aviation models is (or is anticipated to be) accomplished successfully in both the commercial models and AEDT.

Finally, while INM was designed to be relatively easy to use, advances have been made by commercial models that provide a more refined user-interface, more calculation capabilities, and less computational limitations. The U.S. models could benefit from similar enhancements.

C.2.2. Ground Noise Model Gap Analysis

In the following gap analysis for ground noise assessment models, the Traffic Noise Model (TNM), the Roadway Construction Noise Model (RCNM), the Highway Construction Noise Computer Program (HICNOM), the Chicago Rail Efficiency and Transportation Efficiency (CREATE) model, the High-Speed Rail Initial Noise Evaluation (HSRNOISE) model, and the Horn Model have been investigated and compared. Although a detailed discussion of their algorithms is not provided, the commercial noise models, CadnaA, IMMI, and LimA have also been considered. These models are, initially, investigated separately and, subsequently, included in the general discussion.

C.2.2.1. Source Representation. TNM, CREATE, HICNOM, and RCNM have extensive available source types. Therefore, the variety of sources used in highway, road construction, and railway noise may be satisfactory.

TNM includes a relatively complex source representation with sub-sources and consideration of a 1/3-octave band sound spectrum. HICNOM can include different source geometries and uses frequency and source height to calculate barrier effect. However, frequency is, most often, not considered, and there are built-in limitations on the complexity of the source geometry. All other models provide a simplified model of the source representation. Therefore, source representation in highway noise may be satisfactory, could be improved upon for road construction noise, and should be better addressed in railway noise.

C.2.2.2. Propagation Algorithms. Incorporation of divergence is universal among the different models and handled to similar end depending on the representation of the source as a point or line. No gap is identified.

C.2.2.3. Ground Effects. TNM includes a ground effect that is based on standard and accepted empirical ground impedance models. However, all other models provide a very simplified adjustment for ground impedance, often only providing for a soft ground. Therefore, the incorporation of ground effects in highway noise may be satisfactory and should be better addressed in road construction and railway noise.

C.2.2.4. Uneven Terrain and Barriers. TNM includes many different features of terrain and the effects of diffraction, reflection and scattering those terrain obstacles can produce. However, it does simplify the terrain to decrease computation time for very complicated geometries. HICNOM also provides some consideration of terrain effects, though less thoroughly than TNM. All other models provide a simplified model of terrain effects. Therefore, the incorporation of terrain effects in highway noise may be satisfactory, could be improved upon for road construction noise, and should be better addressed in railway noise.

C.2.2.5. Meteorological Effects. As only an atmospheric absorption correction is applied in any considered model, the incorporation of meteorological effects should be better addressed in highway, road construction, and railway noise.

C.2.2.6. Summary of Source Representations and Propagation Algorithms. Table C-4 summarizes the strengths and weaknesses of each of the four models whose algorithms have been explored above.

Table C-4 Strengths and Weaknesses of TNM, CREATE, HICNOM, RCNM, HSRNOISE, and the Horn Model

	Source		**Propagation***		
Model	**Source Database**	**Source Characterization**	**Ground Impedance**	**Terrain Effects**	**Meteo Effects**
TNM	Extensive	Detailed	Good	Good	Minimal
CREATE	Extensive	Minimal	Fair	Minimal	Minimal
HICNOM	Extensive	Fair	Fair	Fair	Minimal
RCNM	Extensive	Minimal	Minimal	Minimal	Minimal
HSRNOISE	Limited	Minimal	Fair	Minimal	Minimal
Horn Model	Limited	Minimal	Fair	Minimal	Minimal

**All models include divergence*

C.2.2.7. Outputs. TNM is the only program capable of producing detailed contours over extensive areas of the community. Therefore, one of the largest gaps in the ground noise models is the contouring capability. The other models should be interfaced with a contouring program in order to provide the necessary detail of noise levels throughout a community.

C.2.2.8. Conclusions. This gap analysis has investigated six U.S. noise assessment models that calculate, collectively, highway noise, road construction noise, and rail noise, including train horn noise. These models are split between the relatively simple spreadsheet models (CREATE, RCNM, HSRNOISE, and the Horn Model) and more complex models (TNM and HICNOM). The spreadsheet models use basic source representations and simple propagation effect corrections to calculate levels at a limited number of receiver points. The more complex models use a detailed source representation and calculate (some) propagation effects based on empirical models. However, only TNM can calculate detailed contours over an extensive area of the community.

In the comparison of the spreadsheet and complex models, it was found that the spreadsheet models left gaps in most of the important categories of noise prediction capabilities. However, TNM employed a sophisticated source representation and more accurate propagation effect calculations. Still, it left a large gap in the incorporation of meteorological effects and room for some improvement in uneven terrain effects.

The considered models were relatively easy to use. However, sometime the ease existed because the models were basic. Therefore, because they are more complex, the commercial models are less straightforward to use.

Another large gap in the U.S. ground noise prediction models, not previously discussed, is the absence of an industrial noise model (excluding road construction noise). Industrial noise is incorporated in the commercial models. However, it is not addressed by the considered U.S. models.

In conclusion, the largest gaps in the ground noise prediction models are caused by the models' inability to calculate detailed contours, the neglect of meteorological effects, and the omission of industrial noise prediction.

APPENDIX D. STRATEGIC PLAN FOR MODEL OWNERSHIP AND FUNDING

This section offers a concept for an intra/interagency forum to guide the development of a multimodal noise and emissions model. The concept is written in the form of the strategic plans issued annually by the U.S.DOT.

Ownership and Funding Strategy for the Multimodal Noise and Emissions Model

Outcomes

1. Formalized federal ownership of the multimodal noise and emissions model.
2. Model research and development (R&D) funding stream based on modal agency subsidies.
3. Contributing to a more streamlined environmental review of transportation infrastructure projects.

Strategies

The development of a multimodal noise and emissions model contributes to the U.S.DOT environmental stewardship goal to "promote transportation solutions that enhance communities and protect the natural and built environment." The multimodal environmental model could also assist in overcoming some of the obstacles to achieving the U.S.DOT environmental stewardship goal.

The DOT Strategic Plan ("New Ideas for a Nation on the Move," FY2006-2011, September 2006) identified high infrastructure project cost, localized opposition to new transportation projects, and the stovepipe organizational structure of public transportation agencies as impediments to efficient intermodal connections in the U.S. The Plan states: "If this situation persists, intermodal congestion, which increases air pollution from transportation sources, will get worse."

The introduction of a multimodal environmental model as part of the federal environmental analysis and mitigation process could serve as a vehicle for greater collaboration among the various federal, state, and regional transportation agencies. The collaboration should help break through the stovepipe organizational structure leading to an integrated approach to the environmental assessment of intermodal projects. However, nothing can happen until the model sponsor(s) steps forward.

ACRP Project 02-09 has created a Model Development Plan (MDP) that does not have clear ownership—i.e., designation of the federal agency that takes responsibility for the model development. Therefore, it is necessary to describe the possible mechanisms for federal ownership and identify potential sources of funding and alternatives for model builds to address existing constraints and funding limitations.

The multimodal noise and emissions model seems a good fit to the DOT mission, which is to "serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future." The Transportation and Climate Change Clearinghouse (TCCC) provides a blueprint for the establishment of a structure for the coordinated development of a multimodal environmental model and all related research, policies, and procedures. As a result, it would be desirable to coordinate with other federal agencies with related technical and policy responsibilities, such as, the Department of Defense (DoD), the

Environmental Protection Agency (EPA), and the Department of Housing and Urban Development (HUD).

Resources
Successful development of a multimodal noise and emissions model begins with federal sponsorship. The following agencies and offices are vital to the effort:

- The Office of the Secretary (OST) is well positioned to provide overall leadership of the model development as part of its oversight role in the formulation of national transportation policy and promotion intermodal transportation.
- The Research & Innovative Technology Administration (RITA) serves as the DOT focal point for coordinating, facilitating and reviewing crosscutting and cross-modal research, and for enabling new technology deployment across all modes.
- Under the National Environmental Policy Act (NEPA), the DOD modal administrations, FAA, FHWA, FRA, FTA, and MARAD; are responsible for the assessment of the environmental impacts associated with transportation projects under their purview. Each of these agencies has implemented procedures for the conduct of environmental assessment including the models to use. To varying degrees, these agencies support the development of environmental models.
- Like the DOT modal agencies, DoD is responsible for the assessment of the environmental impacts associated with its activities. Each of the armed services has implemented procedures for the conduct of environmental assessment including the models to use. DOD supports the development of environmental models including advances in certain noise modeling technologies that are deemed vital to the future development of the multimodal model.
- EPA protects public health and the environment by regulating air pollution from motor vehicles, engines, and the fuels used to operate them. The agency also promotes emission modeling activities through the distribution of emissions model input formatted inventories and provides leadership on the selection and use of models in regulatory settings through national modeling guidance.
- As part of its mission to provide decent housing and safe living environment for all, HUD has implemented guidelines for the consideration of environmental impacts related to its projects. For example, the Noise Assessment Guidelines describes procedures to assess the exposure of a housing site to present and future noise conditions. The Guidelines offers a rudimentary multimodal noise assessment capability as it provides a means to assess separately airport, road, and rail operations as well as combining the noise exposures for an overall noise assessment.

The prototype for the framework for both intra- and inter-agency coordination is the TCCC mentioned above. Figure D-1 shows how TCCC is organized. The TCCC has become the focal point within DOT for information and technical expertise on transportation and climate change and for the promotion of comprehensive multimodal approaches to reduce GHG emissions. Borrowing heavily from the TCCC Strategic Plan (The DOT Center for Climate Change & Environmental forecasting – Strategic Plan, 2006-2010), the DOT Center on Multimodal Noise & Emissions Modeling would have the following strategies:

- **Research and Policy Analysis:** Leverage ongoing DOT research and act as a catalyst for development of the multimodal model through partnerships with other agencies and research entities.

- **Integrated Approaches and Mutual Benefits:** Encourage decision-makers to take integrated approaches to multimodal environmental assessments that recognize mutual benefits.
- **State and Local Transportation Planning:** Focus on inter- and multimodal transportation initiatives with state and local transportation planning agencies through outreach, capacity building, and other collaboration.
- **Communication, Education, and Capacity Building:** Improve communication and educate transportation decision-makers, disseminating information and tools to increase their ability to address multimodal environmental issues.

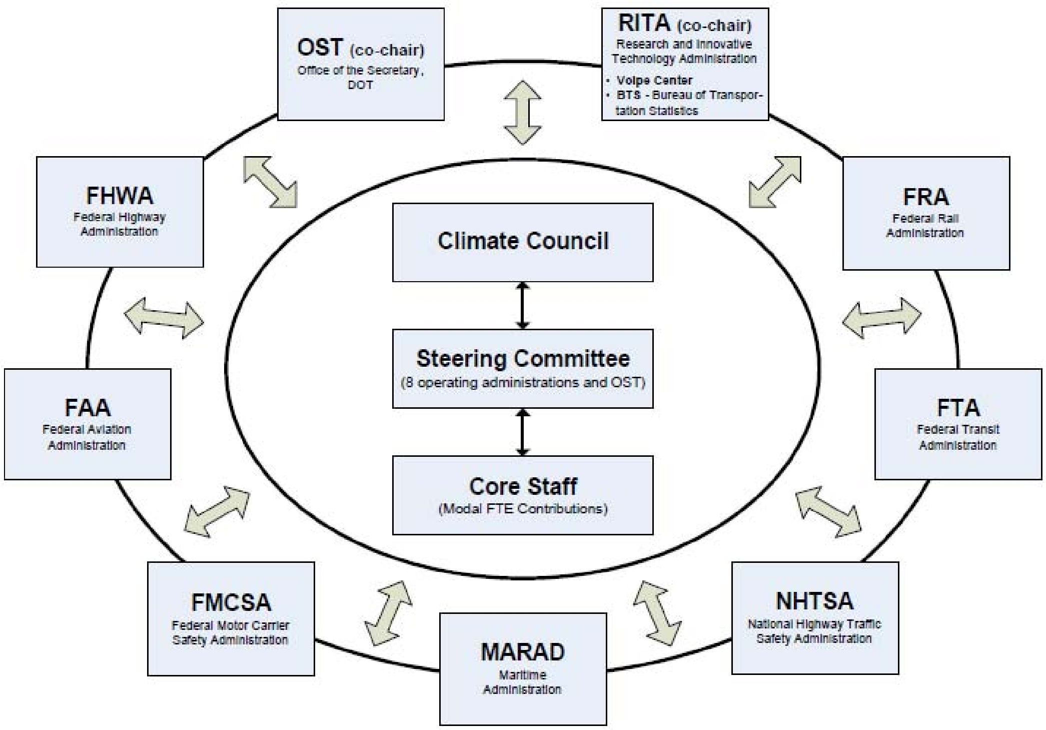


Figure D-1. The Center for Climate Change and Environmental Forecasting: A USDOT-Wide Center

Source: The DOT Center for Climate Change & Environmental forecasting – Strategic Plan, 2006-2010

Like TCC, the new Multimodal Center is a DOT-wide organization with membership from 6 operating administrations (FAA, FHWA, FRA, FTA, MARAD, and RITA), the Office of the Secretary (OST), and from DoD, EPA, and HUD. The U.S.DOT operating administrations support the Center's work through contributions of funds, staff, and technical expertise, and by participating in Center efforts to share information, build partnerships, and coordinate cross-modal activities. A Steering Committee of senior executives from each of the member internal and external organizations leads the Center and approves action plans and spending. The Office of the Assistant Secretary for Transportation Policy and RITA would co-chair the Steering Committee in light of their respective responsibilities to coordinate multimodal activities. Core team members provide staff-level participation from each administration and are responsible for the operations of the Center. Strategic planning and other support would come from the RITA

Volpe National Transportation Systems Center (Volpe Center) drawing on its extensive experience in transportation noise and emissions modeling.

Also like TCCC, the Center would partner with TRB on strategies for the development and use of the multimodal model. For example, the clearinghouse component of the TCCC was developed as part of an NCHRP project (NCHRP 25-25 (44)), which was co-funded by FHWA, to serve as a "one-stop" source of information for the transportation community on transportation and climate change issues. One of the byproducts of the ACRP Project 02-09 is the preparation of a problem statement to develop a prototype of the multimodal model under a future ACRP project.

External Factors

The major challenges to obtain stable level of funding for the development of the multimodal model are:

1. Federal budget process
2. Level of interest among the modal administrations
3. Disparities in the size of research budgets among the modal administrations
4. Stovepipe culture of federal agencies

The problem is further complicated by the fact that these challenges intertwine. For example, while one or more agencies might make a multimodal model a high priority, federal research funding is at the mercy of the annual Congressional budget process, which is subject to shifts in priorities.

One mechanism used by federal agencies to achieve an appropriate level of research funding is through the reauthorization of the federal spending legislation. For example, the federal surface transportation spending legislation, Safe, Accountable, Flexible, and Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU), expired in 2009. It took Congress 2 years to enact SAFETEA-LU during which the administration operated under extensions of the previous spending authority. However, it is unlikely that interested agencies could act on the suggestions of this strategy paper in time for this next reauthorization; thus, making this a more long-term action item.

The initial formation of the DOT Center on Multimodal Noise & Emissions Modeling should produce ways to gauge the interest among the agencies through their actions to identify executives to serve on the steering committee and to commit resources (staff and initial funding). Some of the modal agencies might be more motivated than others in the new endeavor. For example, the FAA 2011 Budget submission now includes an Environment and Energy Research goal to initiate development of environmental models components to enable intermodal analyses (pg. RE&D-137, USDOT Budget Estimates, Fiscal Year 2011 – Federal Aviation Administration). While this is an FAA goal for 2015, the agency could begin building the interagency framework for the effort with a modest investment in the intervening years.

APPENDIX E. SAMPLE QUESTIONNAIRE

Questionnaire Introduction

Transportation hubs are essential to commerce and community activity and an integral part of the surrounding environment. Schools, hospitals, residences, and businesses often exist within the vicinity of airports. Highways and passenger and freight railroad lines lead into and around airports. As a result, rarely does one transportation source dominate the environmental impact in and around the airport. Despite this relatively close proximity, the standard course of action is to qualify airport expansion projects and noise and emissions mitigation decisions using single-modal impact.

Availability of a multimodal noise and emissions model would help inform airport and public policymakers charged with evaluating and making decisions on expanding transportation facilities. The purpose of this study is to create a framework for developing a tool that would allow for the assessment of the noise and air quality impacts on the population from each transportation source, assess the total costs and impacts, and assist in the design and implementation of mitigation strategies. This model would enable more efficient use of federal, state, and local funds. In addition to public sector entities, this capability would be made available to airports, airport consultants, and others as a framework for conducting environmental assessments for regulatory, business, and community purposes.

The objective of research project 02-09 is to produce a comprehensive Model Development Plan (MDP) that will guide future development (by others) of a model to facilitate integrated quantification of multimodal noise and emissions, as well as economic analysis of alternative scenarios.

This questionnaire is an element of the market research to assess the viability and utility of that multimodal environmental model and help in its formulation. The market research will gather information about customers and the market. Customers are the future user communities for the multimodal noise and emissions model, including consultants involved in transportation planning, state and federal agencies that provide the oversight for these modes, and office staff of regional transportation administrations that organize/fund specific projects. Therefore, it is vital to seek input from a broad cross-section of the transportation and environmental communities.

QUESTIONNAIRE

Additional space is provided at the end of the questionnaire for your responses.

Respondent Information

Name:

Affiliation:

Telephone:

Email:

A. Utility

1. Who would use a multimodal noise and emissions model?

2. For what kinds of projects is the model best suited?

3. At what stage of the environmental/design process would it be used?

4. How would you use the model?

5. What output is desired?

6. How could the model improve decision making?

B. Current Thinking on the End State

The cornerstone of the project approach to the Model Development Plan (MDP) is a clear definition of the end state. The end state is the ultimate objective for the multimodal noise and emissions modeling capability. The end state defines the requirements (databases, input/output processes, algorithms, etc) for multimodal planning at the local, regional, and national levels. The end state is the reference point to evaluate the strengths and weaknesses of current states of the art in noise and emissions modeling. **Exhibit E-1** describes the current thinking on the end state for the multimodal noise and emissions model.

7. What do you like about the proposed end state?

8. What's wrong with the proposed end state?

9. What's missing from the proposed end state?

10. What are your ideas for a better end state?

C. Current Thinking on the Build Sequence

Achieving the envisioned end state would require a major expenditure of funds and could take many years to complete. Rather than initiating a single, large-scale effort to design and develop the end state, a more realistic approach, consistent with feasible funding streams and practical stakeholder needs, would be to approach the end state in a series of steps, each step providing an improvement to some facet of the overall model. It is important for the architecture of the model to be sufficiently flexible so as to allow for a scalable roadmap towards a future end state. **Exhibit E-2** describes the current thinking on the model-build sequence to take us from the current state of noise and emission modeling to the desired end state.

11. What do you like about the proposed build sequence?

12. What's wrong with the proposed build sequence?

13. What's missing from the proposed build sequence?

14. What are your ideas for a better build sequence?

15. How would you recommend building the multimodal noise and emissions model?

D. Issues and Concerns

16. What hurdles face the development of a multimodal noise and emissions model?

17. What concerns do you have about this project?

Submitted completed questionnaire to tom.connor@wyle.com.

Additional space for your responses:

Submitted completed questionnaire to tom.connor@wyle.com.

Exhibit E-1 -- Current Thinking on the Multimodal Noise and Emissions Model End State

The proposed end state is a dynamic source (airplane, automobile, truck, marine vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs. The model will simulate the sound propagation and air pollutant emissions for moving sources. The model will meet the emissions and noise assessment requirements (regulatory and policy) of every agency involved in an integrated regional planning process. It will include a highly modular design so that the model can be universally coupled to a wide range of other transportation planning tools, such as traffic simulation models (e.g. SIMMOD, TRANSIMS, etc.).

The ultimate requirement for noise would consist of a time-history of the one-third octave band spectrum produced by each vehicle operation. When combined with numbers of operations of the different vehicle types, the model would:

- Calculate any noise metric for any transportation source;
- Propagate sound over any terrain, surface, barrier, structural effects (urban canyon reverberation, etc.) and through any meteorological condition;
- Compute that propagation with a precision that is proportional to the effort spent on terrain/meteorological input (will vary by type of project);
- Include complete and validated transportation sources databases;
- Integrate background noise estimation;
- Offer the level of accuracy that meets or exceeds any regulatory requirement; and
- Provide second-by-second noise.

For emissions, the model would:

- Predict fuel consumption which would serve as a basis for energy usage (needs to take into account the different fuel types);
- Provide emissions of both criteria pollutants and Greenhouse Gases (GHG);
- Predict emissions by specific modes (e.g., acceleration, takeoff, etc.) and equipment type (e.g., light-duty vehicles, Boeing 737-200, etc.); and
- Provide second-by-second emissions.

For Air Quality, the model would:

- Generate second-by-second atmospheric concentrations;
- Be able to model both transport and chemical transformations for characterized pollutants including Hazardous Air Pollutants (HAPs) and particulate matter (PM); and
- Take into account structural effects such as building wake effects, urban canyon effects, tunnels, etc.

Figure E-1 is a simple schematic of the proposed end state. The attributes of this model would include:

- Centralized source database (vehicle performance, noise, and emissions);
- Common input requirements (where practical);
- Uniform input processes;
- Harmonized algorithms (e.g., sound propagation);
- Harmonized modules (e.g., atmospheric dispersion);
- Unified output processes;
- Compatible output parameters (e.g., metrics);
- Noise and emissions screening tools;
- Benefits evaluator to convert changes in noise exposure and air quality into environmental costs; and
- Highly modular in design.

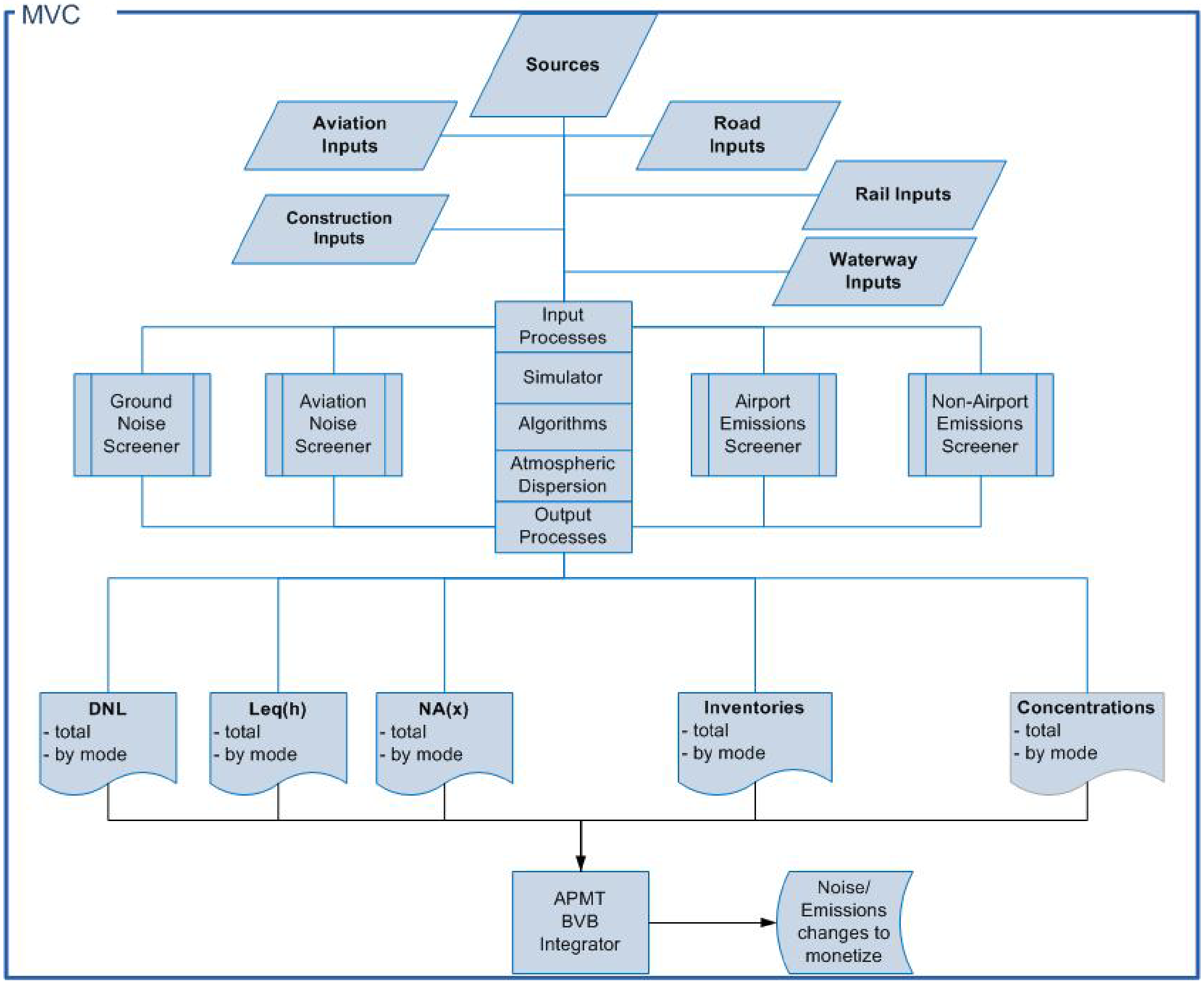


Figure E-1. Simple schematic of multimodal noise and emissions model end state

Exhibit E-2 -- Current Thinking on the Multimodal Noise and Emissions Model Build Sequence

The Model Development Plan (MDP), which this project will produce, will include the roadmap of how we get from where we are now with the current models and development projects to the end state of multimodal model design with emphasis on:

- Cost effectiveness;
- Technical feasibility;
- Acceptability to the regulating agencies;
- International credibility (i.e., compliance with international technical standards and recommended practices);
- Scalability (i.e., flexible architecture and modular design to support airport-centric up to regional applications);
- Analytical proficiency (capability to support alternatives and mitigation analyses); and
- Responsiveness (flexible to changing demands).

The roadmap is a sequence of model builds, and the task is to choose the order of builds that would best achieve the above-listed design goals. The current thinking on the preferred model build sequence is guided by the phrase: "Think big, start small, and act now." This model form meets the end state objective and the ground rules that are set forth in the overall approach. The build sequence is predicated on giving the users and agencies the tool that they need within expandable system architecture. The builds and associated rationale are provided in Table E-1.

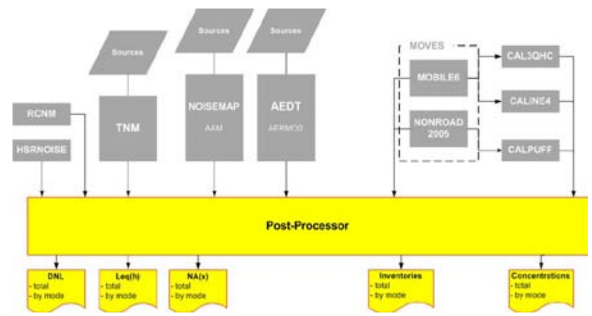
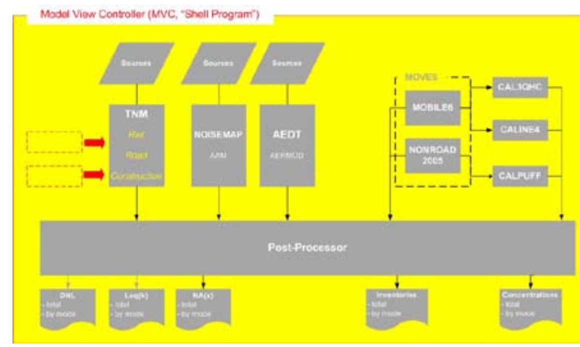
The third column in Table E-1 offers rationale to support the current thinking on the recommended build, which can be summarized as follows:

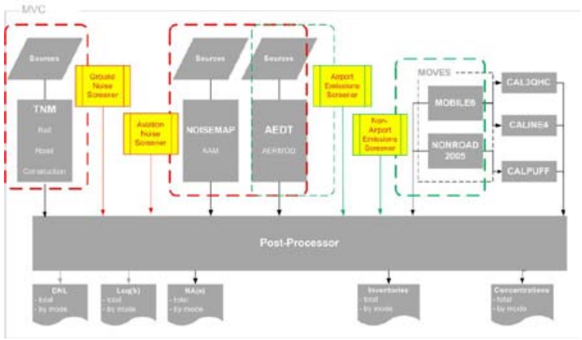
1. Because of the prevailing "stovepipe" culture, the first build provides some basic capability at relatively low cost. A post-processor is justified because it simply takes output from the existing tools and combines it in ways that should be helpful to multimodal planning. The first build is an entry-level capability to get the various stakeholders familiarized with the environmental effects of other modes.
2. The premise of the second build is that the stakeholders would see utility in what the first build provides and would prefer a tool that is easier to use; thus a shell program. The stakeholders of ground-based modes (road, rail, and transit) would be amenable to harmonizing noise computation modules after they have had some experience with the first build. The timing for initiating this build would be subsequent to the planned Federal Highway Administration (FHWA) release of Traffic Noise Model (TNM) Version 3 in the early 2010 timeframe.
3. The third build draws on the stakeholder experiences in the application of the first two builds with the introduction of capabilities that are intended to enhance the practicality of the model for their typical projects. Based on some of the discussions in the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT) Design

Review Group (DRG), it is believed that users will want noise and emissions screening tools.

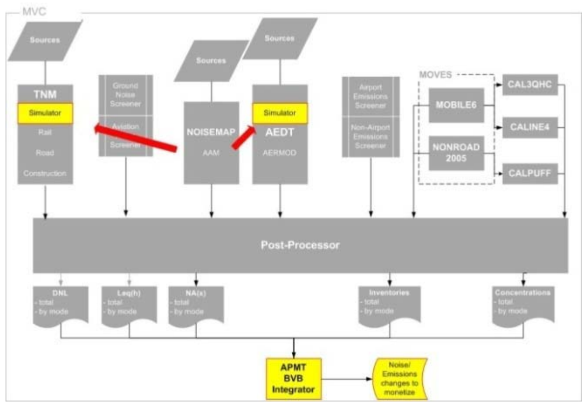
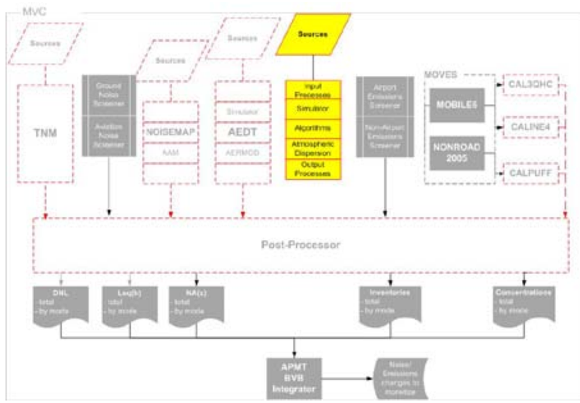
4. The fourth build is the entry to new concepts for many of the stakeholders; namely, simulation modeling and benefit (impact) valuation. This build is a “research” version to provide the stakeholders with the opportunity to evaluate the simulation capability while awaiting interagency agreement on how to apply impact evaluations in environmental assessments. The build is also partially predicated on the timing of the Department of Defense (DOD) noise simulation model development. DOD is to release the Advanced Acoustic Model (AMM) in the coming months and that should provide a few years for the simulation capability to mature in the user community in time for this build.

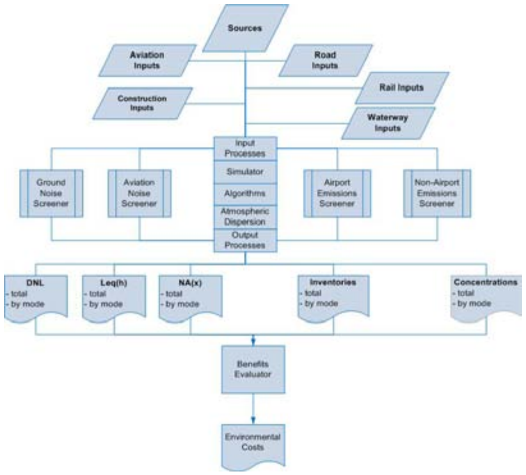
TABLE E-1 Current Thinking on Model Build Sequence

Build	Description	Rationale	Schematic
1	Develop a post-processor to combine outputs of the executions of each of the standard noise and/or air quality models used for each transportation mode. Elements of this build: ▪ Produces common outputs, such as, DNL and combined emission inventories. ▪ Includes ability to produce the standard output (metric) of each of the models. ▪ Incorporates feedback loops for iterative assessments, such as, integrated analysis of highway sound barrier design. ▪ The user is responsible for keeping current in the versions of the standard tools.	Agencies' acceptance expected because: ▪ Draws from agencies' ongoing model development projects. ▪ No invasive changes to existing models ▪ Produces output required by current agencies' regulations and policies ▪ Cost effective because: ▪ Draws from agencies' ongoing model development projects. ▪ Allows users to perform integrated analyses using existing noise and emissions engines. ▪ Existing GIS tools can easily facilitate this effort.	
2	1. Create a harmonized ground (including marine) noise computation module from the existing tools, which was recommended in the original ACRP problem statement. This build would take advantage of the existing TNM infrastructure, but would include rail (including horns and other warning devices) and marine sources.	Agencies' acceptance expected because: ▪ Draws from FHWA/FRA project proposals. ▪ Other agencies' noise and emissions model untouched. ▪ Produces output required by current agencies' regulations and policies. Cost effective because: ▪ Learn from other projects such as	

Build	Description	Rationale	Schematic
	2. Develop a shell program to control input preparation, execution, and output processing of each of the standard noise and/or air quality models used for each transportation mode.	EUROCONTROL HARMONOISE and FAA MAGENTA. ▪ Improves ease-of-use.	
3	Construct screening tools to allow primary agency to use the full power of its current model (like AEDT), combined with low-precision versions of the current models for other modes (like TNM). The screening tools (preprocessors) include: ▪ Ground Noise Screener. ▪ Aviation Noise Screener. ▪ Airport Emissions Screener. ▪ Non-airport Emissions Screener.	Agencies' acceptance expected because: ▪ Lessons learned from FAAAEDT DRG discussion about AEDT complexity. ▪ Produces output required by current agencies' regulations and policies. ▪ Noise and emissions screening criteria would comply with agencies' requirements. Cost effective because the users can put appropriate level of effort to the environmental area of prime concern (like aircraft) while also assessing the other contributors (road, rail, construction, etc.).	

E-14

Build	Description	Rationale	Schematic
4	1. Incorporate noise and emissions simulation into the system architecture alongside the segmented noise component. 2. Integrate output with APMT benefits valuation block (BVB) requirements for economic impact assessments.	Agencies' acceptance expected because: ▪ Produces output required by current agencies' regulations and policies. ▪ DOD AAM development has already proven that simulation (NMSIM) and segmented (NOISEMAP) can work together. Cost effective because will learn from DOD AAM project and leverage on the FAA APMT effort; specifically the benefits evaluation block within APMT. This release is likely to serve as a "research model" to evaluate the simulation capability and to await interagency agreement on how to apply impact valuations in environmental assessments.	
5+	Version 5 begins the process of integrating the ground and air components into a single multimodal model with the objective to have: ▪ Centralized sources database (vehicle performance, noise, and emissions indices). ▪ Common input requirements (where practical) and uniform input processes. ▪ Harmonized computational algorithms (e.g., sound	This approach depends on an almost interactive design review group (DRG) to understand how the model is being used and what is most needed next. Supporting technical and policy infrastructures are needed to achieve interagency agreement on policies and procedures. This approach also calls for the delivery of workable software in shorter intervals so that new elements can be tested across the user community before field implementation to ensure that the new	

Build	Description	Rationale	Schematic
	propagation). ▪ Harmonized modules (e.g., atmospheric dispersion). ▪ Unified output processes (e.g., metrics). The priorities for harmonization, unification, and centralization will be based on user needs, agency acceptance, and affordability.	version meets the needs of the broadest audience. In collaboration with the user communities and agencies, the developers could use evaluation criteria from Task 3 to reach agreement on build priorities	
End State	Dynamic source (airplane, automobile, truck, vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs.	▪ Meet the emissions and noise assessment requirements (regulatory and policy) of every agency involved in an integrated regional planning process. ▪ Highly modular design so that the model can be universally coupled to a wide range of other transportation planning tools, such as traffic simulation models (e.g. SIMMOD, TRANSIMS, etc.).	

APPENDIX F. ALTERNATIVE DESIGN CONCEPTS

There were five multimodal model design concepts in the first round. The first concept, which was referred to as the Datum in the first round evaluation, is the design that was in the Wyle proposal; the initial preferred design concept. The remaining 4 are distinct alternatives for the multimodal noise and emissions model design.

The design concept papers, which are presented in this appendix, are identically structured with the following sections:

Description	*Executive Summary on the concept drawing distinctions to the other concepts*
Functional Specifications	*Description of what this design of the multimodal model will do.*
Justification	*Reasons why the design is a good idea by identifying benefits related to the evaluation criteria.*
Issues	*Addresses concerns about this design by identifying potential drawbacks related to the evaluation criteria.*
Design Elements	*Storyline on the ways and means to achieve this design end state from the current model environment.*

F.1 Design Alternative #0 (Datum): Step by Step Integration (Initial Preferred Design)

F.1.1 Description

The end state is a source (airplane, automobile, truck, marine vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs. The model will simulate the sound propagation and air pollutant emissions for the moving sources. Rather than initiating a single, large-scale effort to design and develop the end state, the design incorporates a build sequence toward the end state in a series of steps, each step providing an improvement to some facet of the overall model. The build sequence is predicated on giving the users and agencies the tool that they need within expandable system architecture. The model will draw up ongoing model development projects sponsored by the federal government, such as, FAA's Aviation Environmental Design Tool (AEDT) suite and DoD's Advanced Acoustic Model (AAM).

F.1.2 Functional specifications

The ultimate requirement for noise would consist of a time-history of the one-third octave band spectrum produced by each vehicle operation. When combined with numbers of operations of the different vehicle types, the model would:

- Calculate any noise metric for any transportation source;
- Propagate sound over any terrain, surface, barrier, structural effects (urban canyon reverberation, etc.) and through any meteorological condition;
- Compute that propagation with a precision that is proportional to the effort spent on terrain/meteorological input (will vary by type of project);
- Include complete and validated transportation sources databases;
- Integrate background noise estimation;
- Offer the level of accuracy that meets or exceeds any regulatory requirement; and
- Provide second-by-second noise.

For emissions, the model would:

- Predict fuel consumption which would serve as a basis for energy usage (needs to take into account the different fuel types);
- Provide emissions of both criteria pollutants and Greenhouse Gases (GHG);
- Predict emissions by specific modes (e.g., acceleration, takeoff, etc.) and equipment type (e.g., light-duty vehicles, Boeing 737-200, etc.); and
- Provide second-by-second emissions.

For Air Quality, the model would:

- Generate second-by-second atmospheric concentrations;
- Be able to model both transport and chemical transformations for characterized pollutants including Hazardous Air Pollutants (HAPs) and particulate matter (PM); and
- Take into account structural effects such as building wake effects, urban canyon effects, tunnels, etc.

F.1.3 Justification

We believe a simulation model framework is the appropriate form for the end state model. The Federal Interagency Committee on Aviation Noise (FICAN), as a result of its findings and recommendations for modeling aircraft noise in national parks, concluded that "the simulation approach is considered to have the greater potential [compared to integrated models] and it is only a shortage of the comprehensive aircraft acoustic data required, and the higher demands on computing capacity, that presently limit this approach to special applications or augmentation of the more traditional integrated modeling approach."[1]

Currently, Wyle is developing a military aircraft noise simulation model for DOD that will eventually replace the currently-used NOISEMAP integrated noise model. Hence, simulation modeling is a realistic end state. Moreover, we are examining ways of applying the existing noise database currently in NOISEMAP in order to overcome the data concerns mentioned above. Naturally, the introduction is being handled in a phased manner as a comprehensive supporting database is being developed. We envision a similarly phased strategy as we migrate towards the end state model.

As an example of the limitations of air quality models that are not simulation-based, the EPA's CAL3QHC allows for modeling of 1-hour average concentrations near roadways and intersections. However, due to the static mixing zone used in this model (and others of this type like CALINE3 and CALINE4), receptors can not be placed closer than 3 meters from each side of the roadway. As a result, health effects of pedestrians on sidewalks and crosswalks cannot be modeled. Also, microscale modeling of hotspots that take into account the relationship between traffic operations and concentrations is difficult.

Wyle developed the Traffic Air Quality Simulation Model (TRAQSIM) that provides an unconstrained spatial and temporal environment that overcomes limitations of models like CAL3QHC. Using a moving source concept under a simulation framework, TRAQSIM provides a vision for a flexible, next generation highway air quality model.

Feedback from the potential user communities should provide some insights on the general desirability of the proposed end state. The end state is the reference point that we will use to evaluate the current states of the art in noise and emissions modeling. We will examine the strengths and weaknesses

[1] May 12, 2005 letter from the FICAN chair, Mr. Alan Zusman, to Ms. Sharon Pinkerton, Assistant Administrator for Aviation Policy, Planning, and Environment at the FAA.

of existing noise and emissions models. We will identify viable model design candidates drawing from various model development efforts both here and abroad. As such, we will recommend a model design that has undergone thorough evaluation and thoughtful consideration using structured criteria.

F.2.4 Issues

Previous and ongoing efforts indicate that a multimodal model is certainly feasible. But, it is essential for the design and development plan for such a model to consider (a) who will use it and (b) how it will be used.

Task 1 of ACRP Project 02-09 included a preliminary market research effort to assess the viability and utility of a multimodal environmental model and help in the formulation of the model design and plan. Through widely distributed questionnaire, literature review, and personal interviews; the market research attempted to gather information from the future user communities for the multimodal noise and emissions model. A questionnaire was used to contact consultants involved in transportation planning, state and federal agencies that provide the oversight for these modes, and office staff of regional transportation administrations that organize/fund specific projects. The results were reported to the ACRP panel in the form of a Wyle Technical Note (TN09-01, Preliminary Findings on Future Utility of a Multimodal Noise and Emissions Model). The technical note discusses respondents' reactions to this design concept.

The respondents generally like the all encompassing design of the proposed end state from the aviation perspective. It indicates the potential for a comprehensive evaluation of both noise and air quality parameters, looking at the individual contribution of different modes to a location as well as the total contributions they make. The respondents also raised the following concerns about the design:

- End state as an admirable goal, but not practically achievable as evidenced by failure of other complex model development projects, such as, FHWA's TRANSIM and EPA's MOVES.
- Size and complexity of the end state suggest that it will be difficult to use and extremely data hungry.
- The apparent complexity of this model renders it expensive to use and thus prohibitive to all but the largest of airport operators.
- Requires considerable more specialized expertise to use than is done for current studies.
- Challenging to ensure that the model and all the data can reside on a desktop computer offering reasonable runtimes.
- The tool could be used to unfairly penalize modes of transportation if the disparity among noise metrics and impact criteria are not resolved.
- The proposed build sequence just assumes each preceding build worked successfully and does not provide a clear roadmap for full testing of each build.

F.1.5 Design Elements

Clearly, achieving the envisioned end state would require a major expenditure of funds and would take many years to complete. Rather than initiating a single, large-scale effort to design and develop the end state, a more realistic approach, consistent with feasible funding streams and practical stakeholder needs, would be to approach the end state in a series of steps, each step providing an improvement to some facet of the overall model. It is important for the architecture of the model to be sufficiently flexible so as to allow for a scalable roadmap towards a future end state. For instance, when Wyle first developed the MAGENTA software back in 1997, little was known about the type and detail of the operations and noise data that would be available as inputs, or of the required outputs of the model. As a result, the architecture of MAGENTA was designed with maximum flexibility to incorporate any input or output, and any noise engine. This has proved to be invaluable to the subsequent development of the model and its integration with SAGE into AEDT Global. This is the mindset that we propose to adopt in the design of the MDP.

Our current thinking on the preferred model build sequence is guided by the phrase: "Think big, start small, and act now." This model form meets the end state objective and the ground rules that we set forth in the overall approach. The build sequence is predicated on giving the users and agencies the tool that they need within expandable system architecture. The builds and associated rationale are provided in Table F-1.

For this preferred model form of build sequences in Table F-1, we believe that the iterative and incremental software development process is the best fit. This approach is actively responsive to the needs of a broad community of transportation planning users. This approach takes the form of a collaborative decision process for choosing what component (GUI, systems databases, and harmonization of inputs, outputs, or modules) should be pursued based on the most pressing user needs and their associated funding levels; while also keeping true to the design goals of the end state.

The third column in Table F-1 offers some of our rationale to support our current thinking on the recommended build. The rationale for our current thinking on the model build sequence can be summarized as follows:

- Due to the prevailing "stovepipe" culture, we recommend that the first build provide some basic capability at relatively low cost. A post-processor is justified because it simply takes output from the existing tools and combines it in ways that should be helpful to multimodal planning. We see the first build as an entry-level capability to get the various stakeholders familiarized with the environmental effects of other modes.
- The premise of the second build is that the stakeholders would see utility in what the first build provides and would prefer a tool that is easier to use; thus a shell program. We envision that the stakeholders of ground-based modes (road, rail, and transit) would be amenable to harmonizing noise computation modules after they have had some experience with the first build. The timing for initiating this build would be subsequent to the planned FHWA release of TNM Version 3 in the early 2009 timeframe.
- Our third build draws on the stakeholder experiences in the application of the first two builds with the introduction of capabilities that are intended to enhance the practicality of the model for their typical projects. Based on some of the discussions in the FAA AEDT DRG, we believe that they will want noise and emissions screening tools.

TABLE F-1 Current Thinking on the Model Build Sequence to the End State Design

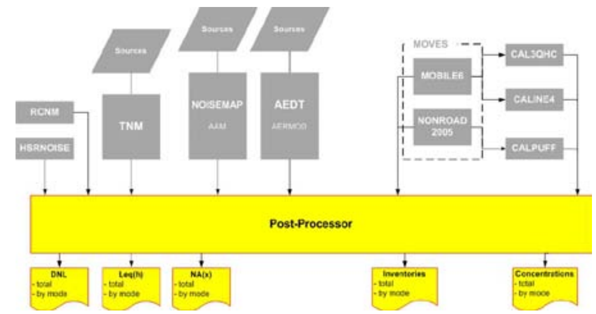
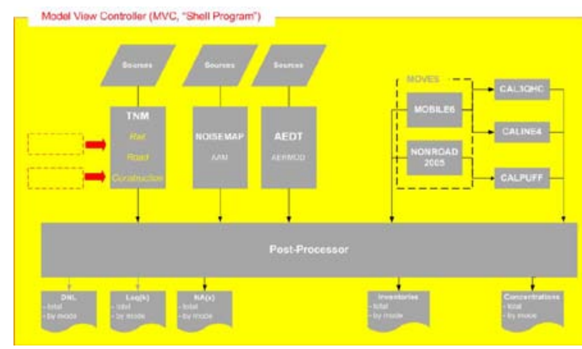
	Description	Rationale	Schematic
1	Develop a post-processor to combine outputs of the executions of each of the standard noise and/or air quality models used for each transportation mode. Elements of this build: ▪ Produces common outputs, such as, DNL and combined emission inventories. ▪ Includes ability to produce the standard output (metric) of each of the models. ▪ Incorporates feedback loops for iterative assessments, such as, integrated analysis of highway sound barrier design. ▪ The user is responsible for keeping current in the versions of the standard tools.	Agencies' acceptance expected because: ▪ Draws from agencies' ongoing model development projects. ▪ No invasive changes to existing models ▪ Produces output required by current agencies' regulations and policies ▪ Cost effective because: ▪ Draws from agencies' ongoing model development projects. ▪ Allows users to perform integrated analyses using existing noise and emissions engines. ▪ Existing GIS tools can easily facilitate this effort.	
2	1. Create a harmonized ground (including marine) noise computation module from the existing tools, which was recommended in the original ACRP problem statement. This build would take advantage of the existing TNM infrastructure, but would include rail (including horns and other warning devices) and marine sources. 2. Develop a shell program to control input preparation, execution, and output processing of each of the standard noise and/or air quality models used for each transportation mode.	Agencies' acceptance expected because: ▪ Draws from FHWA/FRA project proposals. ▪ Other agencies' noise and emissions model untouched. ▪ Produces output required by current agencies' regulations and policies. Cost effective because: ▪ Learn from other projects such as EUROCONTROL HARMONOISE and FAA MAGENTA. ▪ Improves ease-of-use.	

TABLE F-1 Current Thinking on the Model Build Sequence to the End State Design (*continued*)

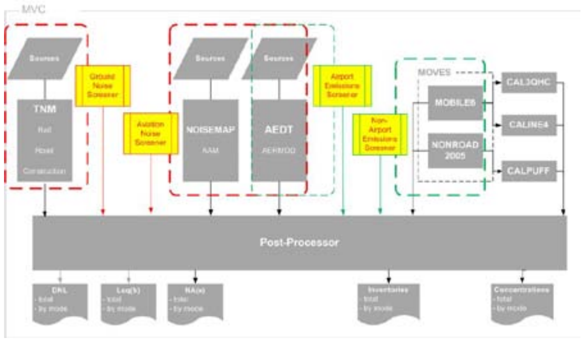
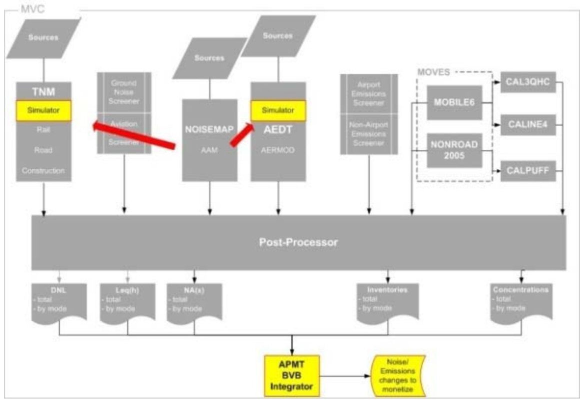
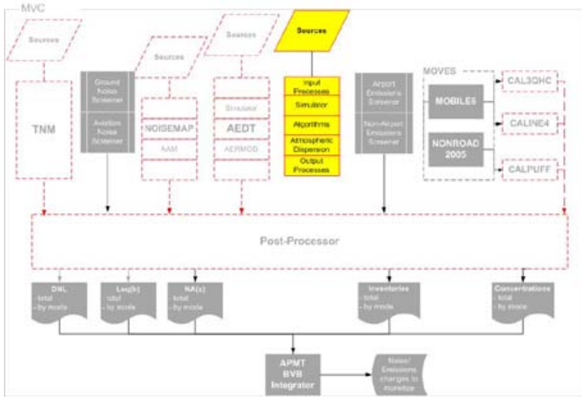
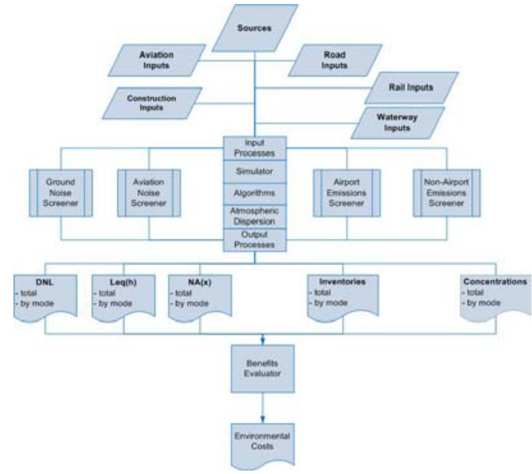
	Description	Rationale	Schematic
3	Construct screening tools to allow primary agency to use the full power of its current model (like AEDT), combined with low-precision versions of the current models for other modes (like TNM). The screening tools (preprocessors) include: ▪ Ground Noise Screener. ▪ Aviation Noise Screener. ▪ Airport Emissions Screener. ▪ Non-airport Emissions Screener.	Agencies' acceptance expected because: ▪ Lessons learned from FAAAEDT DRG discussion about AEDT complexity. ▪ Produces output required by current agencies' regulations and policies. ▪ Noise and emissions screening criteria would comply with agencies' requirements. Cost effective because the users can put appropriate level of effort to the environmental area of prime concern (like aircraft) while also assessing the other contributors (road, rail, construction, etc.).	
4	1. Incorporate noise and emissions simulation into the system architecture alongside the segmented noise component. 2. Integrate output with APMT benefits valuation block (BVB) requirements for economic impact assessments.	Agencies' acceptance expected because: ▪ Produces output required by current agencies' regulations and policies. ▪ DOD AAM development has already proven that simulation (NMSIM) and segmented (NOISEMAP) can work together. Cost effective because will learn from DOD AAM project and leverage on the FAA APMT effort; specifically the benefits evaluation block within APMT. This release is likely to serve as a "research model" to evaluate the simulation capability and to await interagency agreement on how to apply impact valuations in environmental assessments.	

TABLE F-1 Current Thinking on the Model Build Sequence to the End State Design (*concluded*)

	Description	Rationale	Schematic
5+	Version 5 begins the process of integrating the ground and air components into a single multimodal model with the objective to have: ▪ Centralized sources database (vehicle performance, noise, and emissions indices). ▪ Common input requirements (where practical) and uniform input processes. ▪ Harmonized computational algorithms (e.g., sound propagation). ▪ Harmonized modules (e.g., atmospheric dispersion). ▪ Unified output processes (e.g., metrics). The priorities for harmonization, unification, and centralization will be based on user needs, agency acceptance, and affordability.	This approach depends on an almost interactive design review group (DRG) to understand how the model is being used and what is most needed next. Supporting technical and policy infrastructures are needed to achieve interagency agreement on policies and procedures. This approach also calls for the delivery of workable software in shorter intervals so that new elements can be tested across the user community before field implementation to ensure that the new version meets the needs of the broadest audience. In collaboration with the user communities and agencies, the developers could use evaluation criteria from Task 3 to reach agreement on build priorities	
End State	Dynamic source (airplane, automobile, truck, vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs.	▪ Meet the emissions and noise assessment requirements (regulatory and policy) of every agency involved in an integrated regional planning process. ▪ Highly modular design so that the model can be universally coupled to a wide range of other transportation planning tools, such as traffic simulation models (e.g. SIMMOD, TRANSIMS, etc.).	

F.2 Design Alternative #1: Build on AEDT

F.2.1 Description

The Federal Aviation Administration (FAA) has developed a design tool named the Aviation Environmental Design Tool (AEDT). This tool is actually a suite of programs working together to perform not only environmental impact estimations, but also to allow policy decisions to be made in an informed way. This alternative explores continued development of the AEDT into a true multimodal noise and emissions model for all modes of transportation. This alternative would also include the construction of an environmental study clearinghouse where federal agencies could make available inputs and outputs of past modal studies for assistance in multimodal environmental assessments.

F.2.2 Functional specifications

AEDT is a tool suite that has incorporated both global and local noise and air quality modeling for aviation sources. As shown in Figure F-1, the tool suite has various modules including an economics model and cost and benefit module in addition to the environmental impacts estimation module. The environmental impacts estimation module is based on four proven (nationally and internationally) noise and air quality models: the Integrated Noise Model (INM), Magenta, Emission and Dispersion Modeling System (EDMS), and SAGE. The noise models, based on the integrated approach, allow for a wide range of outputs including a range of metrics for A- and C-Weighted, and tone perceived levels, and an approximation for time above outputs. For air quality, all criteria pollutants plus carbon dioxide and speciated hydrocarbon outputs are available.

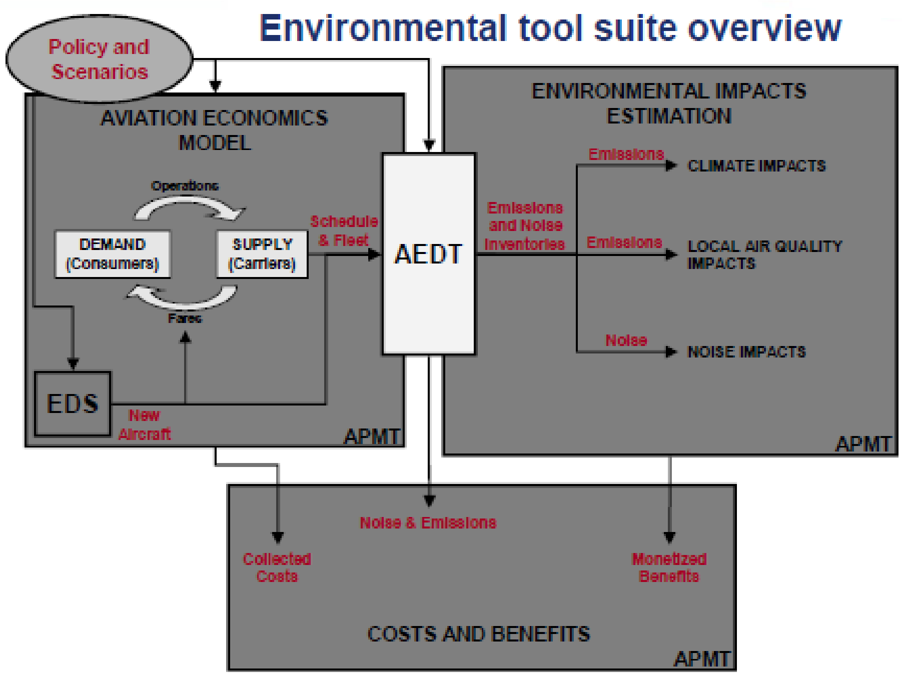


Figure F-1. AEDT tool suite overview.

Source: Fleming, G.G., Aviation Environmental Design Tool (AEDT), Presentation at the 22nd Annual UC Symposium on Aviation Noise and Air Quality, Prepared by U.S. DOT/Volpe Center, March 5, 2007.

The models used are very detailed including spherical spreading, atmospheric absorption, terrain shielding, lateral attenuation, and ground effects for noise propagation calculations. This would provide a solid platform for modeling the noise from other modes of transportation. The database would have to be expanded to include reference emission levels for other modes of transportation. For air quality, a detailed emission inventory process is included and local dispersion based on the accepted air quality dispersion model, AERMOD. AERMOD has been used for many sources, is now being considered by FHWA for motor vehicles, and as such could allow for a single air dispersion model to be used.

Movements of aircraft are well documented and included in AEDT. This includes simulation of vertical profiles by aircraft type and allocation of aircraft per runway, taxiway, and gate. Movement of other vehicle types would have to be included to account for all modes.

The model has both local and global capabilities in predictions. Subsets of the global capability for emission inventories can be used in regional analysis.

F.2.3 Justification

Extensive resources have been expended by FAA to build the AEDT for aviation sources. This initial expenditure has built a strong base for the aviation sources which would significantly reduce the cost in comparison to other options since implementation time would be greatly reduced and only an expansion of the model would be required. The model has also overcome a large hurdle in that air quality, noise and economic considerations have been considered and integrated into this single model. While the data base sharing would need to be improved and would need to be expanded for other modes of transportation other than aviation, AEDT would provide a platform for inclusion of the other modes of transportation. Additionally, the models used in AEDT have been promulgated and accepted by EPA for air quality and the noise model is accepted on an international basis. Implementation for the other modes of transportation could be done with the accepted modeling processes as well, again reducing the time requirements since these models have been previously accepted by other agencies.

Local modeling is accomplished with established, completely developed models (Emission & Dispersion Modeling System (EDMS) using AERMOD for dispersion and the Integrated Noise Model (INM)) so that no extensive validation is needed for implementation of other sources than aviation. Again, use of established models for the other transportation sources would significantly reduce implementation time which would result in a substantial cost savings. The model is designed to allow quick changes to input allowing mitigation and future projects to be analyzed efficiently.

Global modeling is accomplished with the already existing models for aviation which include SAGE for air quality and MAGENTA for noise. While this may not be needed at this time, it could be expanded for other sources allowing climate change impacts to be evaluated. Additionally, regional modeling could be based on the same process by selection of a subset of the global database.

The modular design would allow for easy inclusion of other models so that other modes of transportation could be included without extensive redesign of the basic model platform. Rail, water and highway would have to be included as modes, but again, could be done in the modular design. The database design would allow other reference levels for noise and emission levels for air quality to be included in the same way, again without extensive changes to the system architecture. The advantages are considerable and include:

- Use of established models so that development is not needed nor is the long validation process;
- The database design allow inclusion of modes of transportation in the same way so that model components can be reused and similar;
- Inputs can be shared so that repetition is not required;
- The local and global modeling will work together;
- Algorithms can be repeated, leading to more streamline design;
- Global and regional modeling could be done by model expansion for other modes;
- Future expansion is enhanced because of the modularity of the system; and

- The model is easily adapted for other cases allowing mitigation and future enhancements to be analyzed using the same model structure reducing cost and time of implementation.

F.2.4 Issues

Expansion of AEDT would require establishment of a common data base, inclusion of new transportation modes, and should be initially expanded in some areas such as counting time above events. Even so, it could be implemented faster than the datum alternative. However, while this end state reduces work effort and includes all in a single output, it does not result in increased fidelity, it does not lead to advancement in the understanding of the phenomenon it describes, nor does it lead to increased flexibility in use. It does not represent the most advanced noise modeling possible, nor does it allow for easy adaptation of algorithms to calculate additional supplemental metrics. Accuracy and usability remain static.

To overcome these problems, expansion to the system design, further advancement of the models being used, and development of new reference levels/emission levels would be required. These are not trivial changes but in addition to the inclusion of other modes of transportation listed above would result in a more advanced model. Unfortunately, this would not result in the flexibility offered by a true simulation model.

During this expansion of AEDT, other problems would need to be overcome such as a common noise metric that could be expanded for the various metrics now required by various agencies. This assumes agencies would be resistant to change to a single metric making the base metric that and post-processing necessary. Again, this can be done in the platform as provided but requires significant programming.

Another issue would be the advancement of the way various vehicle movements are modeled. Changes are needed since AEDT only works for aviation sources at the current time and in the case of emissions has a simplistic approach to motor vehicles. Inputs for trains and water craft would have to be included. Algorithms that could be shared with all modes would need to be implemented to make a streamline, flexible model.

Overall model efficiency needs to be increased by the using the same algorithms, ideally for both the noise and air estimations, whenever possible. For example, the same sound propagation algorithms could be used regardless of source and the same air quality dispersion algorithms could be used. Instead of simple call statements to models in various programming languages, this streamline approach would require all models to be in the same language and porting of models not in the chosen computer language. Again, this is not trivial but should result in increased speed for the model.

Finally, additional improvements in model flexibility must be considered. This requires addition of sources not currently in the models and they must be included in a consistent manner. Also, the overall interaction of the outputs from the various modes must be combined. For example, contours produced by INM would be changed when other modes were present and distances from the highway and rail where impacts existing would be increased requiring addition of noise levels from the same sources, again in the same metric. The same is true for air pollutants.

In sum, a simple inclusion of exiting models, or the model data bases, into AEDT would result in time and cost savings to produce an overall transportation model, but no major advancement to the analyst's tools. For this to occur, many non-trivial changes would be needed as described.

F.2.5 Design Elements

The AEDT architecture is based on the "common thread" approach. This allows a streamlined model and modular inclusions. This would work well for the implementation of other modes of transportation. The implementation could be done in a near-term process to get to a useable model quickly, then advancements made in the mid-term, and finally major advancements made in the longer term. Table F-2 includes the major tasks and research efforts that would be required. Of course many alternatives are possible and Table F-2 is only one possible path.

Getting to the final end state in the near-term would be straight-forward, but not trivial. Models for other modes of transportation would need to be included. The data bases would need to be included in a consistent manner as AEDT now operates. Noise propagation and air quality dispersion models would most likely be left out of the model import, using the common thread approach in AEDT. Sharing of algorithms would be crucial for flexibility and streamlined design.

In the mid-term, advancements based on research during the near term could be implemented. Sharing of databases is crucial to the model and better ways to do this could be explored. Updates to the databases could also include advancements as they occur. For example, particulate matter estimation is advancing at a rapid pace and could be updated. Also in the mid-term, improvements in single metric analysis, post processing advancements, and improvement to the movement data base could be implemented. Care in implementing the movement algorithm advancement could be done in such a way that it could lead to true simulation modeling in the longer-term. User flexibility and improvements to user friendliness could also be accomplished in this time frame.

Noise and air quality estimation is still very dynamic field. In the longer-term, advancements in modeling and data are sure to occur and could be implemented since the modular platform would be easily adapted. Additionally, Federal agencies needs and desires could change over this time period. For example, climate change modeling most likely will become more important in the longer-term. The flexibility of the modeling process would allow these changes to be implemented as well. Flexibility also extends to the manner in which multimodal noise and emissions assessments are conducted. Preliminary reactions from potential future users provide some insight on additional actions that the federal agencies could take to promote effective environmental assessments.

Task 1 of ACRP Project 02-09 included a preliminary market research effort to assess the viability and utility of a multimodal environmental model and help in the formulation of the model design and plan. A questionnaire was used to contact consultants involved in transportation planning, state and federal agencies that provide the oversight for these modes, and office staff of regional transportation administrations that organize/fund specific projects. The results were reported to the ACRP panel in the form of a Wyle Technical Note (TN 09-01, Preliminary Findings on Future Utility of a Multimodal Noise and Emissions Model).

Respondents are concerned that the new model would significantly increased study costs; making it prohibitively expensive for anything smaller than a regional study. They suggested that federal agency approval is important and specific guidance on when the model is to be used in the environmental process is needed. One of the respondents' suggestion to improve study efficiency is the "ability to automatically grab via the internet project required available databases – census data, current fleet mix and operations by airport, state highway traffic data, radar data for identified time period, etc. Current methods require considerable user time and effort to collect the necessary available input data that are not project specific."

This design incorporates and expands upon this suggestion with the inclusion of action to create a federally-sponsored clearinghouse of transportation environmental study data (inputs and outs) accessible to the public. There is already federal precedent for making transportation environmental study data available to the public. For example, the Vision 100-Century of Aviation Reauthorization Act (Public Law 108-176) required the FAA to "make noise exposure and land use information from noise exposure maps [prepared under 14 CFR part 150] available to the public via the Internet on its website in an appropriate format." FAA met the requirement with the creation of a website with links to airport noise and land use information pages and copies of the noise exposure maps. The site is:

http://www.faa.gov/airports_airtraffic/airports/environmental/airport_noise/noise_exposure_maps

This design proposal extends the precedent to the other modal agencies and suggests centralizing the study information at a single internet clearinghouse under the auspices of the appropriate federal agency, such as the Office of the Secretary of Transportation (OST). Since the intent is to provide data that would be useful in multimodal studies, the agencies need to establish standards for the type of data to be placed in the clearinghouse. For example, they need to agree on the geographic information system (GIS) for the management of the various input and out data including roads, railways, waterways, runways, flight tracks, meteorological data, computed noise contours, computed noise grids, pollutant concentrations (monitored and computed), etc.

The agencies would also need to provide guidance on how the GIS data is to be used; including reaching a meeting of the minds on the common metrics to use in multimodal noise and air emissions studies. The endeavor to create the data clearinghouse is a major activity to occur in parallel with the AEDT expansion. In addition to the technical tasks in establishing an internet clearinghouse; regulatory and policymaking activities would need to be completed to establish the requirement to gather study data from mandated studies, such as Environmental Assessments (EAs) and FAA Part 150 studies, and standardize the data format and collection method.

This new aspect also places the need to build into the AEDT expansion a previous study data integration module to extract necessary input and output information from the data clearinghouse. The objective is that a user would have automatic access to any previous transportation environmental study, such as, FHWA highway construction EA or FAA Part 150, to incorporate into a multimodal study covering the same geographic region.

TABLE F-2 Key Milestones in the Development of the AEDT Expansion End State

Implementation and Study Data Clearinghouse Track	R&D Track
Near-term (3 year period)	
• Establishment of interagency exploratory team for the development of an environmental study clearinghouse. • Implementation of post-processing modules to permit output as required by the various agencies. • Expansion of GUI to allow additional data to be included • Agreement on the architecture of the data clearinghouse • Implementation of initial model version based on existing models without use of similar algorithms. • Notice(s) of Proposed Rulemaking (NPRM) by the modal agencies to require input and outputs from federally mandated environmental studies.	• Research task force and work program to develop listing of key parameters and databases for model advancement. • Development of expanded GUI and database format to include additional modes of transportation in a more exacting manner with error checking. • Development of movement data base by mode for other forms of transportation. • Development of single metric output of models to permit change to any form needed (noise). • Development of a plan for expansion of other sources than aircraft for global/regional modeling.
Mid-term (3 to 6 year period)	
• Revision to changes in architecture, components, and data elements of the study data clearinghouse. • Implementation of generic algorithms for all sources to allow single metric analysis with post processing to permit any metric needed to meet agency requirements for noise and same dispersion algorithms for air. • Implementation of improved GUI • Initial prototype of streamlined model for testing on the Internet. • Initiate final rulemaking process(es).	• Advanced movement data base development (all moving sources controlled by single algorithm). • Advanced data base control techniques. • Improved GUI control. • Updates to noise emission levels and air quality emission factors. • Development of global/regional modeling data for sources other than aviation. • Integration of cost and economics model for all sources. • Initial review of including refraction effects for noise.

TABLE F-2 Key Milestones in the Development of the AEDT Expansion End State (*concluded*)

Implementation and Study Data Clearinghouse Track	R&D Track
Longer-term (after 6 years)	
• Implementation of advanced movement data base which could include simulation components • Draft agencies' policies and guidance for study data submission. • Interagency agreement on clearinghouse operation and maintenance. • Implementation of advanced data base control features (relational data base features). • Improved emission level and factor implementation including global/regional modeling capabilities for sources other than aircraft. • Implementation of cost and economic modules for all modes.	• Exploration of hybrid options going toward a true simulation model. • Research of implementation of advanced dispersion analysis (puff modeling and regional modeling). • Refraction effects included for noise analysis.
End state	
• Promulgation of final rule. • Implementation of study data clearinghouse. • Advanced version of AEDT for all modes of transportation based on changing modeling practices, new data, and agencies needs/desires. • Inclusion of more advanced climate change modeling capabilities	• Research version of the end state based on advanced propagation models for noise (including refraction effects) and dispersion models for air (puff modeling).

F.3 Design Alternative #2: Build on Existing Simulation Models

F.3.1 Description

This alternative design proposal outlines an approach to the development of a multimodal noise and emissions model centered on time-based simulation of source movements, source emissions, and propagation scenarios resulting in detailed output reports at receptor locations. The end-state of the model will functionally be the same as other design alternatives resulting in time-based simulation, such as the Datum.

This proposal suggests a multimodal model development plan should be founded on existing single transportation mode simulation model implementations. Research and validation reports of outdoor noise and emissions algorithms are abundant both domestically and internationally. Fostering these efforts – which include studies of both heuristic and simulation approaches – will result in a model more scalable, accurate, and usable than one tethered to legacy approaches and limitations.

F.3.2 Functional specifications

This model provides detailed, time-varying propagation results at receptor points from which any standard or supplemental metric may be calculated for noise and emissions during the design process. This is accomplished by simulating ground, marine, and air traffic environments with discrete moving or stationary sources with detailed fundamental source characteristics.

Propagation of noise is simulated via ray-tracing techniques and dispersion of pollutants is simulated via Gaussian puff dispersion algorithms when appropriate. These approaches are generally considered to be the current state-of-the-art with regards to trade-offs of analytical proficiency with respect to analysis scenarios, implementation feasibility, and computer processing requirements. For example, the US Department of Defense has already taken steps to develop and deploy a simulation model for military aviation noise – the Advanced Acoustics Model (AAM). This was a result of the recognition of a simulation model's superior capability to handle routine scenarios in addition to the identification of the need to model high performance aircraft in a more appropriate, realistic, and accurate manner.

By defining source emanation characteristics in terms of first principles – such as spectral directivity for noise and modal fuel-burn rates for emissions – the model's propagation algorithms may be varied according to an analyst's scenario. For example, an analyst may perform a sophisticated environmental simulation analysis requiring careful input parameters or he may choose to default certain elements of the analysis to heuristic approaches or previous studies where appropriate.

The foundation of the model's output is a report at a receptor including time-dependent spectral noise and emissions metrics. Aggregation of these reports provides a means to not only calculate any integrated metric on a grid, but transient supplemental metrics such as *number of events* and *time above ambient*. Additionally, the inclusion of the time dimension in the output reports allows spatial and time dependent visualizations of the environmental simulation.

F.3.3 Justification

The Federal Interagency Committee on Aviation Noise (FICAN) has already recognized simulation noise models as having the most potential for accuracy and precision in situations requiring sophisticated analysis. Examples of the adoption of noise simulation include the National Parks Service's adoption of NMSim (Noise Model Simulation), the development of AAM (Advanced Acoustics Model) through SERDP (the US Department of Defense Strategic Environmental Research and Development Program), and the adoption of RNM (Rotorcraft Noise Model) by NASA and NATO as the de-facto standard for outdoor noise propagation helicopters and tilt-rotors. International credibility of this approach is bolstered by the fact that the European Commission has undergone a multinational research and developmental effort resulting in algorithms and technical guidance for using a harmonized ground and air noise source and propagation methodology known as IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment).

Domestic examples of noise simulation models also exist for traffic and railway noise. CNM (Community Noise Model) simulates five motor vehicle types of sources (autos, medium trucks, heavy trucks, buses, and motorcycles) as well as multiple rail engines with trailing cars plus stationary sources such as compressors and rail yard activities. The Florida Department of Transportation funded development of a true noise simulation model called FRM (Florida Rail Model), which applies ray acoustics to rail and limited community sources with reference levels capable of being adjusted at each time step to account for vehicle operational mode and type.

In terms of air quality, the U.S. Environmental Protection Agency has adopted CALPUFF – a CARB (California Air Resources Board) air-quality dispersion model – as its preferred model for assessing long range transport of pollutants and proposes its use on certain near-field applications involving complex meteorological conditions in its Guideline on Air Quality Models. Other air quality simulation models exist such as TRAQSIM (Traffic Air Quality Simulation Model, developed as part of a PhD dissertation at the University of Central Florida) and HYROAD (developed by Systems Applications International, Inc., under sponsorship of the National Cooperative Highway Research Program). HYROAD uses a particle in cell approach for close in receptors and Gaussian plume for farther away receptors. Both of these models use CALPUFF as their calculation engines, but provide modules to simulate movement of discrete sources with appropriate modal movements and puffs associated with each mode for each time step.

Justification for incorporating these air quality and noise models into a simulation model capable of handling multiple modes of transportation lies in the fact that simulation modeling has already been proven to be more accurate and will provide a step forward in environmental modeling for analysts of all agencies. Considerable advantages include:

- The use of sophisticated algorithms to most accurately predict results at points of interest;

- Building of current simulation models will circumvent developmental constraints caused by legacy approaches of lesser fidelity;
- Ray tracing algorithms for noise can be applied to any source regardless of transportation mode;
- Proper inclusion of meteorological effects, terrain, and other heterogeneous scenarios;
- Sufficient detail in the output will provide thorough understanding of any scenario;
- Inputs provide accurate representation of sources based on first principles rather than assumptions or calculated metrics (as is the case with AEDT);
- Knowledge and validation from existing simulation models will streamline development;
- Updates to propagation and dispersion algorithms can be independent of source definitions;
- Sufficient detail in output will allow any standard or supplemental metric to be calculated;
- Existing tools that model source movements may be used and tracks may be translated into time-varying spatial and conditional source trajectories;
- The main drivers for noise and emissions, such as acceleration and power setting, can be directly listed or inferred from a sufficiently detailed trajectory file;
- Potential exists for a harmonized source definition file to contain noise and air quality data together as well as rules for interpolation and extrapolation thereof; and
- The ability to define multiple emissions components emanating from a single source for a single mode (such as separate definitions for both the main and tail rotors of a helicopter).

F.3.4 Issues

A desire of federal environmental agencies is the capability to simulate most accurately as possible the air and noise pollution affecting wildlife, vegetation, and humanity. The most accurate solution is not always the most easily constructed. A simulation model with advanced logic could be costly to develop, but it would pay dividends by providing a means to an end-state as accurate and scalable as present technology allows.

Sophisticated modeling requires the existence and development of an adequate source database. Simulation modeling of noise, for example, requires source directivity patterns and reference levels for each vehicle and vehicle condition. Obtaining such data may involve costly measurement protocols or an acceptable method of converting an existing database into one which may be applied to a new model.

Another issue is the computing power required to simulate detailed scenarios in a time-dependent fashion. Current runtimes for an analysis may increase by an order of magnitude. Additionally, complex analyses may require more extensive input. Simulation modeling, while providing the potential for increased accuracy and fidelity of output could be a burden on an analyst and lead to a process for environmental analysis that is more costly and time consuming. Some users may find a full-blown simulation analysis environment too complex to use for standard environmental analyses; this may be more of an issue for one particular transportation mode than another.

F.3.5 Design Elements

Most air and noise emissions problems have three fundamental drivers – the source's movement and operational states, the paths and scenarios of propagation, and the receiver locations and metrics of interest. In terms of noise, for example, the lowest common denominator for an output report is time dependent spectral data at points of interest. Only by reporting results as a function of time may realistic scenarios be modeled and may all metrics be calculated. From this output, one may deduce such standard noise metrics as L_{dn} in addition to supplemental metrics such as *Number of Events* and *Time Above*

Ambient. A time history of air quality indices such as NO_X, CO_2, and *HC* allows an analyst to focus not only on the worst time period of a day, but also hone in on less polluted time periods or locations to which traffic patterns and mitigation efforts may be appropriately shifted.

Consideration at all times and frequencies of the three fundamental drivers could lead to a burden on the user for extensive input. Additionally, a true-to-life representation of every source would literally be impossible – there are too many unpredictable trends of spectra and in traffic patterns for an intersection, for instance, to be fully simulated a priori.

For these reasons, careful development and an analyst's use of such a model must pay special attention to logical implementation of physics-based simulation algorithms. Rather than brute-force calculation of all ray paths and trajectory steps independently (the current simulation modeling state-of-the-art) internal calculation and database engines must know when a detailed analysis need be done given scenarios tied directly to mathematical functions to prioritize error and run time. This means both detailed and nominal source data and propagation algorithms would be leveraged by both a user and the model itself. The user may decide how accurate the results should be, and the model would document this accuracy in terms of the trade-offs and methodologies of its processes.

For instance, consider noise simulation modeling of a highway. Traffic patterns can be sporadic and, although modal tracking data may be obtainable, historical data synchronized with real time are only of interest to emissions scientists. Emissions planners, of course, must look to the future. Using yesterday's traffic data to model tomorrow's emissions will never amount to anything more than educated guessing.

Stochastic source movement algorithms such as those used in TRAQSIM would be leveraged for each source type to describe typical modes of operation. An environmental planner would want to be able to input some simple items, like traffic counts, time of day, fleet ratios, etc., and a time-based simulation of cars on a freeway would be run using semi-imperial traffic input data with programmed randomness, or jitter. Applying adjustable jitter to data sets and running simulations with multiple source movement and propagation class scenarios would provide results that deviate from the mean. It is important that an environmental analysis tool be able to transparently represent the limitations and applicability of its results by giving the user appropriate virtual solution boundaries representative of the inherent randomness of realistic variables such as traffic patterns and weather.

For example, if enough point sources exist in a line, the sound wave from each point source will merge with adjacent sources' spherically spreading waves and propagation will then cylindrically spread. As this limit is approached with a steady stream of traffic, environmental traffic noise levels tend to remain relatively constant with respect to time. As such, a heuristic approximation may consider this behavior as an ambient noise level for an area. On the other hand, fidelity may be lost in calculation of heterogeneous effects on emissions due to factors such as terrain, weather gradients, and turbulence. Rather than a user remaining ignorant of what is and is not is factored in, he may choose to model these effects by forcing point source propagation for each vehicle rather than allowing any heuristic approximations. The results of such a run would contain not only a grid with time-relative data, but also metadata documenting its accuracy and potential interpretation for use in planning for other modes of transportation.

Moving straight to simulation modeling requires a lengthy developmental phase and, once ready for release, a complete change in modeling techniques from the current state of the art. The potential for a lengthy developmental phase for the new models means, rather than incremental improvements to existing analysis tools, the existing tools must be used as-is while the simulation model is being developed. Once deployed, training workshops to demonstrate how and why simulation modeling is to be used may be required to get analysts and engineers up to speed. Table F-3 outlines key milestones for the development of this multimodal design alternative.

TABLE F-3 Key Milestones in the Development of this Model's Multimodal End State

Operational Track	R&D Track
Near-term (1-2 years)	
• Agency guidelines on Environmental Assessments (EA) using time simulation • Continue using existing models for all EA's • Train current environmental analysts on the utility of using simulation-based approach	• Identify current state-of-the art modeling techniques, algorithms, and data sources • Evaluate utility of currently implemented simulation models • Establish methods for conversion of existing noise and emissions source databases • Develop numerical methods of propagation • Develop GUI for source movement and data input by transportation mode • Implement above R&D into a usable multimodal model of the highest fidelity
Mid-term (3-4 years)	
• Train analysts on using simulation-based approaches • Use full simulation techniques to augment EA's where data is available • Convert legacy source databases into new format • Agency guidelines on required levels of accuracy for EA's	• Identify heuristic algorithms available for implementation • Establish levels of accuracy for heuristic algorithms • Develop GUI that provides heuristic options as screening tools for auxiliary transportation and emissions modes • Merge noise and emissions source definitions of a source into one data file with interpolation and extrapolation rules for modes of operation • Implement stochastic movement and propagation algorithms for multiple-scenario modeling
Longer-term (5-6 years)	
• Use agency guidelines, new source database, latest simulation modeling for EA's • Utilize stochastic movement and propagation algorithms and report EA findings in terms of multiple possible scenarios	• Develop more computationally efficient algorithms • Establish level of accuracy as a function of model input, assumptions, and user fidelity options
End state	
• A simulation model for sophisticated analysis with heuristic approaches for screening tools and scenarios with lower fidelity requirements	• Evaluate current propagation algorithms utility versus more advanced algorithms that may be implemented

F.4 Design Alternative #3: Federal Adoption of Commercial Software

F.4.1 Description

The concept promotes a market-based option for the development of the multimodal noise and emissions model. Commercially designed software has been leveraged by engineers and designers of all disciplines to provide an efficient and documentable path to solutions of problems ranging from the simple to the complex. Commercial software is already available to noise and air quality engineers. This document focuses on two such software packages. One is maintained by the German company Braunstein + Berndt GmbH and is named *SoundPLAN*. The second is *CadnaA*, the product of another German company – DataKustik.

This document does not determine which of CadnaA and SoundPLAN is the best commercially available software package. Rather, the purpose is to introduce elements of the idea that models sold commercially to the public domain could be adopted, regulated, validated, and provided with developmental assistance by the federal government.

F.4.2 Functional specifications

The SoundPLAN and DataKustik names imply an emphasis on noise modeling and mapping. However, the developers of the models have acknowledged the utility of incorporating modules for air pollution evaluation along with their existing, highly flexible noise modeling frameworks. This incorporation was presumably a relatively straightforward task, considering the modular structure of their software architectures. The user interfaces act as hubs for calculation modules and other tools. For example, the *SoundPLAN Manager* copes with the organizational aspects of projects to allow for common resources such as geographical, meteorological, source definitions, etc. to be shared amongst multiple solution scenarios of varying fidelity and/or scope.

The existing implementations of SoundPLAN and CadnaA have many commonalities amongst each other, and their modular approach is similar to that of the Datum. These software packages may already be considered multimodal; the breadth of modules provide access to a multitude of accepted, documented, and/or preferred methods of noise calculation for road, rail, aviation, parking lot, and industrial sources. This allows an analyst to compare different methodologies and even benchmark current states of the art versus legacy calculation methods.

Each software package provides air pollution dispersion models. SoundPLAN provides both a Gaussian dispersion module as well as a more accurate non-hydrostatic flow and dispersion model. CadnaA utilizes a Lagrange particle model that processes time-dependent emissions.

Exhibit F-1 outlines various modules of calculation for each software package, as compiled from the SoundPLAN and CadnaA evaluation tables assembled in Task 1 of this project. These commercial platforms are widespread, in spite of the cost burden of the end-user's license agreement. The modular design allows competitive pricing to be maintained by offering customers customizable software packages. The SoundPLAN distribution package contains all the modules, and a customer may purchase license codes to unlock modules intended for use.

F.4.3 Justification

These tools are already being used, and may be considered multimodal with respect to their ability to handle both air and noise emissions from multiple types of sources. Their position in the marketplace proves their utility. This is especially true in Europe, where some of the available modules satisfy certain government requirements for mapping. Companies and analysts in the United States have chosen to use commercial environmental software packages for various reasons, including the flexibility and portability of the input and output data, access to various calculation methods, and the built-in features for mapping and report making.

In the process of establishing their positions in the marketplace, competitive software platforms implement more advanced utilities as requested by the user community or as required to keep up with the competition. Modern operating systems now have application programming interfaces (API) that give access to powerful computational tools such as multiple-core processors, parallel processing on a network, and 64-bit system architecture. SoundPLAN and CadnaA take advantage of such API. Other utilities include commercial software's ability to import and export to many standardized or proprietary file formats. With these, a user may now leverage other software packages within his workflow. For example, SoundPLAN can read in a noise directivity file written to the *Common Loudspeaker Format* (www.clfgroup.com) and use it in a standard noise calculation. CadnaA possesses the ability to read in projects saved from within SoundPLAN.

Modules include the required geographical database and other optional components for definition of source properties of multiple modes of transportation; customizable propagation and transmission calculations founded on multiple internationally accepted standards; mapping and visualization utilities; data importing, exporting, and manipulation tools; and there even exists screening calculators for quick access to estimates and mitigation design cost optimization tools for noise barriers.

Exhibit F-1

Existing Calculation Methodologies and Accepted Standards Implemented Within SoundPLAN and CadnaA

a. Road Noise

Module Name	Availability		Further Information such as Associated Country Acceptance / Validation
	SoundPLAN	CadnaA	
RLS 90, VBUS	X	X	Germany
DIN 18005	X	X	Germany
CoRTN	X	X	United Kingdom – "Calculation of Road Traffic Noise"
Statens Planverk 48	X		Nordic Road Noise Prediction
FHWA	X		Federal Highway Model
NMPB-Routes-96	X	X	France, EC Interim
STL 86		X	Switzerland
Nord2000	X		Nordtest method NT ACOU 107
Czech Method		X	Czech Republic
TemaNord 1996:525		X	Scandinavia
RVS 04.02.11		X	Austria
RVS 3.02	X		Austria

b. Rail Noise

Module Name	Availability		Further Information such as Associated Country Acceptance / Validation
	SoundPLAN	CadnaA	
SCHALL-03, Schall Transrapid, VBUSch	X	X	Germany
ONR 305011		X	Austria
DIN 18005	X	X	Germany
CRN 99	X	X	United Kingdom – "Calculation of Rail Noise"
Ö-Norm S 5011	X		Austria
RMR, SRM II		X	Netherlands, EC-Interim
RMR 2002	X		Netherlands
SEMIBEL	X	X	Switzerland
NMPB-Fer		X	France
NMT 98	X		Nordic Prediction Method for Train Noise
Kilde Report 130	X		Nordic Rail Prediction Method
Japan Narrow Gauge Railways	X		Japan
ÖAL 30	X		Austria
TemaNord 1996:525		X	Scandinavia
Nord2000	X		Nordtest method NT ACOU 107
FTA/FRA		X	USA

<u>Exhibit F-1</u> (*continued*)

Existing Calculation Methodologies and Accepted Standards Implemented Within SoundPLAN and CadnaA

c. Aviation Noise

Module Name	Availability		Further Information such as Associated Country Acceptance / Validation
	SoundPLAN	CadnaA	
AzB	X	X	Germany
AzB-MIL		X	Germany
AzB 2007 Draft		X	Germany
AzB (free)	X		Germany
AzB-L (revision from 1997)	X		Germany
DIN 45643 strict	X		Germany
DIN 45643 (free)	X		Germany
DIN 45684		X	Germany
LAI-Landeplatzleitlinie		X	Germany
ÖAL 24	X		Austria
ECAC Doc 29	X	X	International, EC Interim

d. Industrial Noise

Module Name	Availability		Further Information such as Associated Country Acceptance / Validation
	SoundPLAN	CadnaA	
VDI 2714	X	X	Germany
VDI 2720	X	X	Germany
ISO 9613	X	X	International
ÖAL Richtlinie Nr. 28		X	Austria
BS 5228		X	UK
Ljud från vindkraftverk		X	Sweden
General Prediction Method	X	X	Scandinavia
HARMONOISE		X	International - EC
CONCAWE	X	X	International - EC

e. Air Pollution and Emissions

Module Name	Availability		Further Information such as Associated Country Acceptance / Validation
	SoundPLAN	CadnaA	
TA-Luft	X		Gaussian dispersion model from smoke stacks
AUSTAL2000		X	Lagrange particle model – time-dependent emissions
MISKAM	X		Fulfills German VDI 3782 /8; tested in wind tunnel; 3-D non-hydrostatic flow & dispersion model

Exhibit F-1 (***concluded***)

Existing Calculation Methodologies and Accepted Standards Implemented Within SoundPLAN and CadnaA

f. Other Modules

Module Name	Availability		Further Information such as Associated Country Acceptance / Validation
	SoundPLAN	CadnaA	
DIN 18005	X	X	German Parking Lot Noise Utility
RLS 90	X		Parking Lot Noise Utility
Bavarian Parking Lot Study	X		
VDI 3760E	X		Indoor Noise
The Indoor Factory Noise Module Calculation Method	X		Indoor Noise
Air Absorption via 3 unique standards	X		ANSI 126, ISO 3891, ISO 9613 Part 1
Screening Tools			Long Straight Road, City Noise Screening

The federally accepted emissions models are behind the times because they are driven by modal policy and their code and interfaces are written by scientists and engineers rather than software developers. Professional developers have the ability to take off-the-shelf API and get them to operate effectively and efficiently. Specialized scientists and engineers do not necessarily have the training or expertise to effectively develop complex software architecture.

Advantages include:

- Professionally developed software;
- Modular structure allows for alternative algorithms and independent updates;
- Already multimodal with respect to both multiple modes of transportation and the availability of both noise and air quality analysis tools;
- Integration of input and output data with other commercial software;
- Modules may be updated independently and new technology may be easily inserted;
- Many analysts are already familiar with the software;
- Competition for federal adoption will fuel development;
- A federal advantage is the burden of developmental cost is shifted away from federal agencies and towards commercial entities; and
- Specific modules may be licensed separately to maintain reasonable prices.

F.4.4 Issues

The fundamental issues associated with the government's adoption of commercially developed models will likely stem from the balance of a company's desire to maintain propriety of their software with the government's desire for transparent analysis results. A company may not want to disclose certain aspects of their product that could help position their competitors in the global marketplace.

Another issue will be the cost to the users. Depending on modules and customer service options, current prices for commercial engineering tools can be in the range of $20,000. This is a lot of money to ask a small environmental firm to pay, and it is not clear if an appropriate cost-sharing precedent has been set based on a federal mandate to use a commercial product for an environmental analysis. However, it may be possible to glean some guidance from software licensing of models in other realms of analysis, such as SIMMOD – an airport and airspace simulation model validated by the FAA and maintained by ATAC.

In the examples of SoundPLAN and CadnaA, the commercial models do not include U.S. databases of source data (noise levels, emissions factors, etc.). SoundPLAN contains a very limited source database; expecting the user to supply that data. CadnaA contains noise and emissions data obtained from various European environmental agencies.

Allowing software design companies to periodically compete for adoption of their product by the government may require an analyst to purchase new software periodically and also learn how to properly use new software releases. This justifies providing the opportunity for renewable licensing and support contracts, but without careful consideration of contracts implementation difficult situations may arise, such as the proper course of action should a software company go out of business while analysts throughout the county are relying on them for support. Similar implications may result from changes to a software company's business model such as management restructuring or a decision that continuing to develop or support federal environmental models is no longer a good business venture.

F.4.5 Design Elements

While federal regulations and requirement for environmental analyses tend to remain static for long periods of time, government funded and independent research will always advance the state of the art. The current balance of regulatory requirements and emerging technology directs the development of commercial software packages in such a way that they remain marketable to various users. For the federal government to adopt a commercial software package as an accepted medium for analysis, software developers will be required to implement mandated standards for calculation of noise and air emissions. The federal agencies also determine and approve the source data to be used.

Several software developers may propose their packages and compete for federal adoption. Once a package is chosen by the government, the developers of this package will benefit from the federal requirement that accepted analyses must have been calculated with a licensed version of the federally accepted commercial model. Changing federal requirements along with emerging technologies will result in a periodic reevaluation of the chosen model and the opportunity for other software companies to develop competitive packages and propose their use. The period of time for which a certain commercial package is adopted by the government will depend on the package's current utility compared to the existing state of the art in addition to the current users' desire to switch to something more user-friendly, computationally efficient, and/or less expensive.

Government appointed scientists and engineers provide the physics-based algorithms to the developers and the developers would provide programs to the scientists and engineers for testing. To assess a software package's compliance with mandated modules for databases and calculations, benchmark scenarios will be used. At the very least, the inputs and results of these benchmark tests will be available to the public and may function as sample problems for an analyst to learn the functional aspects of a new software package. One way to satisfy a company's need to meet such benchmarks would be for the government to provide explicit source code on the mandated modules so developers may compile them and use as program extensions or developers may port the algorithms to fit within their software's framework. The federal agencies would retain responsibility for the construction of the source data to be used in the approved commercial model, such as, the process that the FAA uses to obtain aircraft noise and performance data. Table F-4 attempts to outline the general procedural requirements for implementation of this multimodal environmental model design alternative.

TABLE F-4 Key Milestones in the Development of the Commercially-based Multimodal Model End State

Operational Track	R&D Track
Near-term (1-3 years)	
• Continued use of existing federal tools • Federal agencies specify which tools shall be implemented • Government announces a commercial tool will be required and accepts proposals • Analysts purchase existing tools to familiarize themselves with their use	• Software companies prepare prototype versions for US • Software companies propose versions for US call for proposals • Emerging companies see future development opportunity, begin writing their own software packages
Mid-term (4-5 years)	
• Government chooses software package • Chosen software developer releases software • Analysts now use adopted software packages • Government announces requirements for next generation model	• Benchmark tests with commercial software vs. former models • Competing software companies develop model improvements for next generation
End state	
• Next generation model is chosen and used • Government periodically chooses new model to adopt based off ongoing development (every 4 years)	• Competing companies continue development • New modules and methods introduced

F.5 Design Alternative #4: Build on EC IMAGINE Project

F.5.1 Description

Drawing on research completed by the European Commission (EC), the fundamental principle of the model design is the separation of description of the transportation source in terms of sound energy and exhaust emissions from the description of transmission to the receiver in terms of sound propagation and emissions dispersion. In May 2007, the EC completed its major noise modeling project, IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment), which proved that it is technically feasible to build a noise model that can compute noise levels from a variety of sources. The results of the IMAGINE project fit in perfectly with the simulation modeling concepts, such as, DoD Advanced Acoustic Model (AAM). The end state is the same as the current preferred design (Datum). However, this end state is geared toward application on large, regional transportation projects where the environmental outcomes for more than one transportation mode are critical elements of the decision making.

F.5.2 Functional specifications

The goal is the same end state envisioned in the current preferred design (Datum), i.e., a source (airplane, automobile, truck, marine vessel, etc.) simulation model with benefits evaluator to convert noise exposure and air quality changes into environmental costs. The functional specifications are identical to the Datum.

F.5.3 Justification

In May 2007, the EC completed its major noise modeling project, IMAGINE - Improved Methods for the Assessment of the Generic Impact of Noise in the Environment. IMAGINE and its predecessor, Harmonoise (Harmonized Accurate and Reliable Methods for the EU Directive on the Assessment and Management of Environmental Noise), produced guidelines for the common assessment methods to produce the strategic transportation and industrial noise maps as required by European Direction on the Assessment and Management of Environmental Noise 2002/49/EC. The IMAGINE and Harmonoise projects were necessary because the EC found that there did not exist harmonized methods of sufficient accuracy for the prediction and assessment of transportation and industrial noise. None of the available methods were sufficient to satisfy the requirements of the EC Directive 2002/49/EC. Similar to the current state of transportation noise modeling in the United States, no harmonized methodologies and data were available.

The basic layout of the IMAGINE/Harmonise model is shown in Figure F-2.

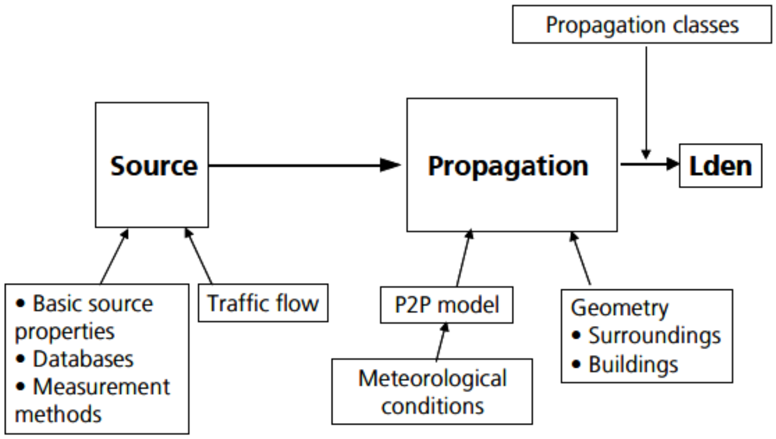


Figure F-2. Schematic of IMAGINE/Harmonise Model

Source: Beuving, M. and B. Hemsworth, *IMAGINE, Final Synthesis Report, Guidance on the IMAGINE methods*, Doc. ID IMA10TR-06116-AEATNL10, Funded by EC 6th Framework Program, 11/16/2006.

Figure F-2 shows how the model separates the source descriptions for road, rail, industry and aircraft sources, from propagation to the receiver. The result of the source models is a sound power level per source type for each source height relevant to that source, together with directivity. For example, the sound emission of an aircraft is defined in terms of sound power spectrum with directivity (longitudinal and lateral).

The propagation model describes the transmission of sound along a set of propagation paths, linking the source positions to the receiver point. The number and type of the propagation paths depend on the complexity of the site. The P2P module estimates the effects of ground and obstacles on the propagation of the sound along these paths, under various meteorological conditions. For example, an aircraft flight is treated as a set of discrete point sources and the sound power spectrum at each point is consistent with the aircraft flight condition (engine thrust and speed). The result of the propagation model is a noise level at a specific receiver point for a given propagation class (the meteorological influence on the propagation paths is divided into 4 different propagation classes).

By de-coupling the description of the source from the description of noise propagation, the IMAGINE/Harmonoise project provides the basis for a generic noise propagation model which can be coupled to almost any noise source. The authors claim that methods are pre-eminently suitable for harmonization of noise calculation because:

- Separation between emission and propagation allows flexibility;
- Source models are adaptable to local conditions;
- Propagation incorporates arbitrary meteorological conditions;
- Accounts for different ground conditions;
- Handles complex geometries, and;
- Usable at different fields of application.

The IMAGINE/Harmonoise project teams recognized that the quality and accuracy of the results depends upon the level of detail of the input data, especially data associated with sound propagation calculations. Therefore the project provided two kinds of propagation method: a reference model based on the numerical solution of the wave equations and an engineering model based on analytical formulae and heuristics. The reference model is able to deal with complex descriptions of the atmosphere whereas the engineering model relies on a simplified description. For example, the reference propagation model for aircraft noise is a hybrid model combining the parabolic equation (PE) model and two-ray model for application at appropriate elevation angles. The engineering propagation model for aircraft noise combines analytical models for basic phenomena, such as, ground reflections and diffraction by obstacles along with heuristic models to account for factors, such as, non-uniform ground impedances, non-flat terrain, multiple diffraction, etc.

The project addresses the application of the reference or engineering propagation models as part of guidelines on modeling requirements in accordance with the following levels of application:

- High accuracy for highly critical situations where the outcome is a critical element in decision making, i.e. when noise levels are contested, possibly up to legal proceedings.
- Medium accuracy corresponds to the level of detail necessary to evaluate the costs and benefits of a specific intervention or action plan or to check conformance with regulations and limit values.
- Low accuracy may be sufficient for the more global assessment of existing situations, such as, for strategic noise mapping required by the EC.

The IMAGINE/Harmonoise project achieved the EC objective to provide a harmonized, accepted and reliable method for the assessment of environmental noise from road, rail, airports and industrial sites.

F.5.4 Issues

The IMAGINE project team identified subjects for further work including the following:

- Investigation of propagation over built up areas as the model was validated over flat terrain.
- The aircraft noise mapping capability lacks appropriate source data. The logical sources of such data are the manufacturers, but the data is proprietary or expensive to purchase. A separate measurement campaign to obtain the data would extremely expensive.
- Pragmatic method for typical urban situations, such as effects of crossroads on road noise.
- Propagation of sound in complex geometrical situations, such as, “canyon effect.”
- Further simplification and optimization of the models because, depending on level of accuracy, the runs can tax the hardware and computation power typically used for noise mapping.

The project produced executable files of the propagation models, but not a complete model. Complete models are then open to alternative implementations of many components by software developers bringing into question the reproducibility and reliability of these future models.

The IMAGINE/Harmonoise project dealt strictly with noise mapping. It does not include emissions. On the subject of road noise mapping, the project team noted the existence of similar work done in the field of road traffic air pollution and suggested that a combined approach would be beneficial to both fields. Therefore, a major air quality modeling initiative is needed.

While the architecture of the Department of Defense (DoD) Advanced Acoustic Model (AAM) is conducive to the harmonized methods produced by IMAGINE; the other major federal initiative, FAA's Aviation Environmental Design Tool (AEDT), is not.

The IMAGINE project team recognized that a critical shortcoming to the development of a practical source-receptor noise model is the lack of appropriate aircraft source noise data, which would mean the need to rebuild source databases for both noise and air quality modeling.

The preparation of this concept paper did not include verification of every algorithm and method put forth in the IMAGINE/Harmonoise project reports. Therefore some of the capabilities might fall short of expectations, which would require additional research to produce working capabilities in the development of the multimodal model.

F.5.5 Design Elements

The AEDT development team has referred to their model architecture design concept as the "common thread." The starting concept is the identification of a minimum operation that can be configured for an environmental analysis. The objective is to find a common thread across both the noise-emissions dimension and the local-global dimension. This common thread provides the context for both distinguishing modularity and removing redundancy in the module breakdown of the system architecture. The Build on EC IMAGINE[2] design concept also has a common thread based on the source-receptor relationship. The IMAGINE schematic in Figure F-2 conveys the design concept for the source-receptor multimodal noise and emissions model.

The sources in Figure F-2 are the vehicle source representatives from the various transportation modes (airplanes, helicopters, automobiles, trucks, motorcycles, locomotives, railcars, and maritime vessels). Each vehicle source is a pollutant emitter defined in terms of sound power level and exhaust emissions indices (NO_X, CO_2, HC, etc.). The vehicle traffic flow along flight paths, roadways, railways, or waterways are defined as consecutive vehicle source points. The transmission of pollution emissions from a vehicle source point to a receptor (home, school, hospital, park, etc.) is handled by a sound propagation model or dispersion model that is appropriate for that vehicle mode and operational situation. Unlike the IMAGAINE schematic, the multimodal model would be able to calculate any noise metric and any air pollutant associated with the various transportation modes.

The EC IMAGINE/Harmonoise project claims to have proven that it is technically feasible to build a noise model that can compute noise levels from a variety of sources, including all transportation sources, and produce noise maps on a common noise metric. The propagation algorithms and modeling definitions developed by this project serve as a basic blueprint for the core computation component for a future multimodal noise model. Of particular interest to ACRP Project 02-09, the EC project produced detailed guidance on:

- Railway source "traffic noise model" that interfaces with the IMAGINE Propagation Method to produce set of sound energy "source lines."
- Road noise emission model describing the noise emission of an "average" European road vehicle in terms of a sound power level.
- Reference and engineering sound propagation models for aircraft noise emissions.
- Use of road traffic models (demand and flow management) for noise mapping and noise action planning.

[2] Information and work products on the European Commission IMAGINE and Harmonoise projects can be found at http://www.imagine-project.org/.

The EC approach is to turn the algorithms and technical guidance over to commercial software developers who will create the models to be used for strategic noise mapping for the Member States. For development of the domestic multimodal noise and emissions model, federally funded research and development (R&D) seems the more pragmatic approach drawing upon the resources, capabilities, and knowledge gained over the years in the development of such legacy tools as INM, EDMS, NOISEMAP, NMSIM, TNM, etc.

The results of the IMAGINE/Harmonoise project fit in perfectly with the DoD Advanced Acoustic Model (AAM). AAM has been developed with a spectral time series approach and uses simulation to calculate any of the temporal or spectral based noise metrics. AAM can produce the traditional integrated metrics such as Ldn, but with added capability to calculate supplemental metrics such as audibility, probability of detection, time above ambient noise levels, building transmission loss, and number of events. It also makes sense to draw in elements of the design of FAA's ongoing AEDT development for the construction of an IMAGINE-based multimodal noise and emissions model in areas, such as, system architecture, data processing and user interface. The project would also benefit by bringing in members of the IMAGINE team to collaborate on the implementation of their algorithms and model guidance.

The IMAGINE project team recognized that a critical shortcoming to the development of a practical source-receptor noise model is the lack of appropriate aircraft source noise data. The Federal Interagency Committee on Aviation Noise (FICAN) noted the same in finding that the simulation model is superior to integrated models but lacks the comprehensive aircraft acoustic data required. Therefore, the first major R&D initiative for the noise model, envisioned under this design, is the development of a practical method to create noise source data from available sources, such as aircraft noise certification testing.

The IMAGINE project dealt strictly with noise; not exhaust emissions or air quality. However, that does not mean that the development of IMAGINE-based transportation emissions model is behind the development of its noise counterpart. Air quality modeling already separates source emissions from propagation (dispersion). Thanks to the Environmental Protection Agency (EPA) many components of emissions and dispersion modeling are harmonized and standardized, but this standardization has focused on static modeling for the most part and work would need to be done for simulation modeling.

EPA's Air Quality Modeling Group (AQMG) provides leadership and direction on the full range of air quality models and other mathematical simulation techniques used in assessing control strategies and source impacts. This office publishes EPA's Guideline on Air Quality Models to provide consistency in the use of modeling. These guidelines are periodically revised to ensure that new model developments or expanded regulatory requirements are incorporated. The current preferred dispersion models are:

AERMOD Modeling System - A steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. However, this would not work with the simulation approach without numerous adaptations.

CALPUFF Modeling System - A non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.

Where R&D is needed is in the integration of simulation with the preferred dispersion models and source emissions models. For example, EPA's CALINE and CAL3QHC-series roadway models provide static environments with time-averaged, aggregate variables. A simulation approach provides more realistic and robust modeling environment with no temporal or spatial constraints. The TRaffic Air Quality Simulation Model (TRAQSIM) demonstrates the possibility of modeling the effects of road grade. TRAQSIM has been shown to facilitate the emissions and dispersion modeling of both particulate matter (PM) and chemically reactive pollutants. Therefore, the R&D effort would examine expansion of the capability demonstrated by TRAQSIM to the other transportation modes.

Taking the Build on EC IMAGINE design approach means that a fully realized multimodal noise and emissions model is years away. EC faced a similar issue for strategic noise mapping and decided to implement "Interim Methods" for preparation of the current series of maps while the noise modeling research is underway. Annex II of EC Directive 2002/49 lays down four interim computation methods for the production of strategic noise maps. They are as follows:

- **Road traffic noise**: the French national computation method NMPB-Routes-96 referred to as "XPS31-133."
- **Railway n oise**: the Netherlands national computation method published in Reken- en MeetvoorschriftRailverkeerslawaai 96, Ministerie Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (20 November 1996), referred to as "RMR."
- **Aircraft n oise**: ECAC.CEAC Doc. 29, *Report on Standard Method of Computing Noise Contours around Civil Airports* (1997), referred to as "ECAC doc. 29."
- **Industrial no ise**: ISO 9613-2: *Acoustics — Abatement of sound propagation outdoors, Part 2: General method of calculation*, referred to as "ISO 9613."

The federal government could decide to take a similar approach concerning the models to use for the environmental assessment of multimodal transportation projects. The first set of interim methods would provide specific guidance on how to use the existing approved noise and emissions models (AEDT, TNM, RCNM, HSRNOISE, NOISEMAP, NIRS, MOBILE6, etc) and screening tools (AEM, ATNS, etc.) for the full range of multimodal projects from airport-centric to system wide. The Environmental Working Group (EWG) under the Joint Program Development Office (JPDO) seems an appropriate forum to reach inter-/intra-agency agreement on interim methods for multimodal noise and emissions assessment. Specifically, the Policy and Analytical Tools Standing Committees under EWG appear to have the mandate and representation to do the job.

This proposal assumes that the federal agencies act on interim methods and well. Flexibility also extends to the manner in which multimodal noise and emissions assessments are conducted. Preliminary reactions from potential future users provide some insight on additional actions that the federal agencies could take to promote effective environmental assessments.

Task 1 of ACRP Project 02-09 included a preliminary market research effort to assess the viability and utility of a multimodal environmental model and help in the formulation of the model design and plan. A questionnaire was used to contact consultants involved in transportation planning, state and federal agencies that provide the oversight for these modes, and office staff of regional transportation administrations that organize/fund specific projects. The results were reported to the ACRP panel in the form of a Wyle Technical Note (TN 09-01, Preliminary Findings on Future Utility of a Multimodal Noise and Emissions Model).

Respondents are concerned that the new model would significantly increased study costs; making it prohibitively expensive for anything smaller than a regional study. They suggested that federal agency approval is important and specific guidance on when the model is to be used in the environmental process is needed. One of the respondents' suggestion to improve study efficiency is the "ability to automatically grab via the internet project required available databases – census data, current fleet mix and operations by airport, state highway traffic data, radar data for identified time period, etc. Current methods require considerable user time and effort to collect the necessary available input data that are not project specific."

This design incorporates and expands upon this suggestion with the inclusion of action to create a federally-sponsored clearinghouse of transportation environmental study data (inputs and outs) accessible to the public. There is already federal precedent for making transportation environmental study data available to the public. For example, the Vision 100-Century of Aviation Reauthorization Act (Public Law 108-176) required the FAA to "make noise exposure and land use information from noise exposure maps [prepared under 14 CFR part 150] available to the public via the Internet on its website in an appropriate format." FAA met the requirement with the creation of a website with links to airport noise and land use information pages and copies of the noise exposure maps. The site is:

http://www.faa.gov/airports_airtraffic/airports/environmental/airport_noise/noise_exposure_maps

This design proposal extends the precedent to the other modal agencies and suggests centralizing the study information at a single internet clearinghouse under the auspices of the appropriate federal agency, such as the Office of the Secretary of Transportation (OST). Since the intent is to provide data that would be useful in multimodal studies, the agencies need to establish standards for the type of data to be placed in the clearinghouse. For example, they need to agree on the geographic information system (GIS) for the management of the various input and out data including roads, railways, waterways, runways, flight tracks, meteorological data, computed noise contours, computed noise grids, pollutant concentrations (monitored and computed), etc.

The agencies would also need to provide guidance on how the GIS data is to be used; including reaching a meeting of the minds on the common metrics to use in multimodal noise and air emissions studies. The endeavor to create the data clearinghouse is a major activity to occur in parallel with the AEDT expansion. In addition to the technical tasks in establishing an internet clearinghouse; regulatory and policymaking activities would need to be completed to establish the requirement to gather study data from mandated studies, such as Environmental Assessments (EAs) and FAA Part 150 studies, and standardize the data format and collection method.

This new aspect also places the need to build into the AEDT expansion a previous study data integration module to extract necessary input and output information from the data clearinghouse. The objective is that a user would have automatic access to any previous transportation environmental study, such as, FHWA highway construction EA or FAA Part 150, to incorporate into a multimodal study covering the same geographic region.

This proposal assumes that the federal agencies act on interim methods and Table F-5 lays out milestones on a dual track system leading to the end state. The operational track lists the steps that the federal government would take to update guidance on multimodal environmental modeling in coordination with the model developments achieved on the R&D track. The idea is that the developers and policymakers both learn through practical application and adjust the interim methods, accordingly.

A simulation model is more computationally intensive than existing integrated models. Multimodal environmental assessments would require a greater array of data and specialized expertise than current single mode projects. Therefore, it would be reasonable for the federal agencies to require a simulation multimodal model for those applications where the environmental outcome for more than one transportation mode are critical elements of the decision making, such as, the regional transportation solutions envisioned by the NextGen Metropolitan Areas Solution Set that emphasizes innovative approaches to regional planning and multimodal systems. For other, smaller projects, such as individual airport or highway construction projects, the agencies would retain interim methods guidelines for use of existing tools.

TABLE F-5 Key Milestones in the Development of the "Build on EC IMAGINE Project" Multimodal End State

Operational Track	R&D Track
Near-term (Years 1-3)	
• Inter- and intra-agency guidelines for application of existing noise and emissions models to environmental assessments (EAs) of multimodal transportation projects (airport to system level) • Inter- and intra-agency agreement on levels of accuracy (high, medium, or low) for multimodal noise modeling in EAs.	• Research task force and work program to develop technical guidelines for IMAGINE-like transportation emissions modeling • Practical methods to create detailed noise source data from available sources, such as, aircraft noise certification tests. • Prototype simulation noise model based on DoD AAM and EC IMAGINE reference model algorithms.
Mid-term (Years 4-6)	
• All new source noise data for existing model databases meet data requirements for simulation source-receptor modeling • Release of hybrid simulation (for aircraft) /integrated noise model. • Revised inter-/intra-agency guidelines on multimodal modeling to integrate new hybrid noise model. • Inter- and intra-agency agreement on levels of accuracy (high, medium, or low) for multimodal air quality and emissions modeling in EAs.	• Prototype simulation noise model based on DoD AAM and EC IMAGINE engineering model algorithms integrating output with APMT benefits valuation block (BVB) requirements for economic impact assessments. • Simulation noise model Version 2 (reference model). • Simulation transportation emissions model algorithms and source data definitions. • Practical methods to create detailed exhaust emissions source data from available sources, such as, aircraft engine emissions certification tests.
Longer-term (Years 7-11)	
• All new source emissions data for existing model databases meet data requirements for simulation modeling • Release of hybrid simulation (all sources) /integrated noise model (source data availability) • Revised inter-/intra-agency guidelines on multimodal modeling to integrate new model.	• Prototype simulation emissions model (reference model) based on TRAQSIM approach and EPA preferred source and dispersion models. • Simulation noise model Version 2 (engineering) • Prototype simulation emissions model (engineering model) integrating output with APMT BVB requirements for economic impact assessment.
End state	
• Dynamic source (airplane, automobile, truck, vessel, etc.) simulation model using "best available" engineering propagation models with benefits evaluator to convert noise exposure and air quality changes into environmental costs. • New inter-/intra-agency guidelines requiring simulation model for multimodal EISs and continued use of existing tools for smaller projects.	Research version of the end state based on reference propagation models.

APPENDIX G. ROUND 1 EVALUATION – RATINGS, SCORES, AND STATISTICS

Twenty members of ACRP 02-09 Panel and the project team evaluated 5 model design concepts based on the modified Pugh Matrix.

Tables G-1 to G-6 present the performance criteria ratings. The identities of the evaluators are anonymous as they are not pertinent to the scoring. Nonparametric statistics, median, and quartiles, are provided below the individual ratings. Nonparametric statistics are used instead of typical (parametric) statistics, like mean and standard deviation. The reason is that there is not enough information to determine whether the evaluators' ratings conform to a normal distribution; a necessary requirement for use of parametric statistics.

The median is the middle value of an ordered set of values. Quartiles divide an ordered distribution into four parts each containing one quarter of the scores. The 1st quartile is the point in a given distribution at which 25% of the observations fall below that point and 75% of the observations fall above it. The 3rd quartile is the point in a given distribution at which 75% of the observations fall below that point and 25% of the observations fall above it. The statistics are also shown graphically with a legend. Since the ratings are ordinal values (1, 2, 3, 4, and 5), it is possible that the median, first, and/or third quartile might be the same. Table G-1 (Agency Acceptance) contains 2 examples of this for Alternatives #3 and 4.

Table G-7 contains the ratings for the cost implications criterion and is identical in structure to the previous performance rating tables. The horizontal axis of the cost implications statistic chart is reversed from the previous performance charts to denote that the best rating is 1 (lowest cost implications) and 5 is the worst (highest cost implications).

Table G-8 contains the performance score (P), which is the weighted sum of the evaluation scores according to the following equation

$$P = \sum_{i=1}^{6} w_i \cdot R_i$$

Where;

R_i is the performance criterion rating

w_i is the performance criterion weighting

Table G-9 contains the cost score (C), which is identical to Table G-7 because the cost implications weight is 1.

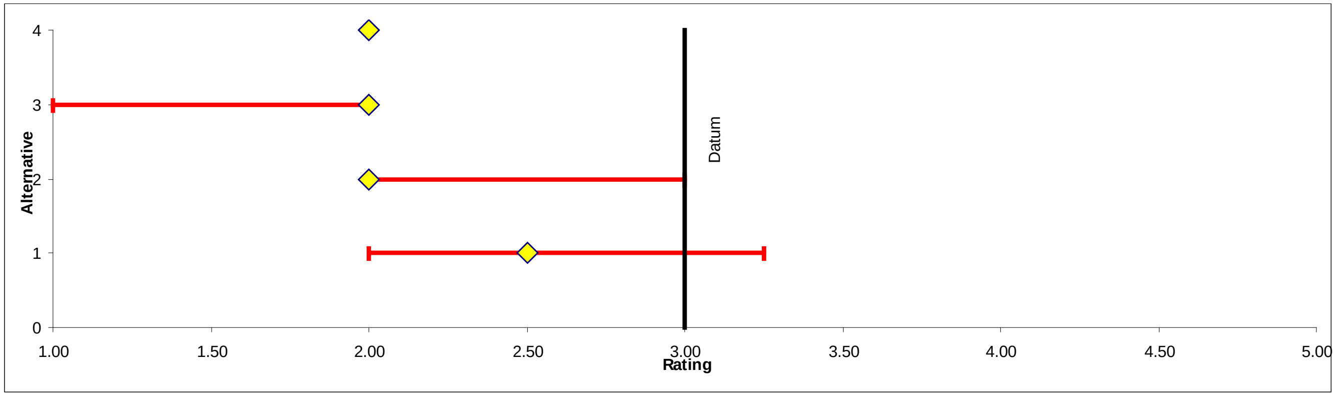
Table G-10 contains the value score (P/C). Alternative #1 (Build on AEDT) received the highest median value score of 1.31 making it the winner in Round 1.

Figure G-1 combines the rating statistics charts for the 6 performance criteria and one cost criterion.

Figure G-2 combines the statistics charts for the performance, cost, and value scores.

TABLE G-1 Round 1 Scores - Agency Acceptance

Performance Evaluation Criteria	Weight					
Agency Acceptance	0.30	Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	3	3	3	2	2
Evaluator	2	3	5	2	3	3
Evaluator	3	3	3	3	3	4
Evaluator	4	3	3	2	1	1
Evaluator	5	3	2	1	1	2
Evaluator	6	3	4	3	2	2
Evaluator	7	3	2	4	1	2
Evaluator	8	3	5	2	1	2
Evaluator	9	3	2	1	2	2
Evaluator	10	3	2	2	2	2
Evaluator	11	3	2	2	2	2
Evaluator	12	3	3	2	1	1
Evaluator	13	3	1	2	1	2
Evaluator	14	3	5	5	2	2
Evaluator	15	3	3	2	2	3
Evaluator	16	3	2	2	2	2
Evaluator	17	3	2	2	1	2
Evaluator	18	3	2	3	2	2
Evaluator	19	3	4	3	1	2
Evaluator	20	3	2	2	2	2
Median		3.00	2.50	2.00	2.00	2.00
1st Quartile		3.00	2.00	2.00	1.00	2.00
3rd Quartile		3.00	3.25	3.00	2.00	2.00



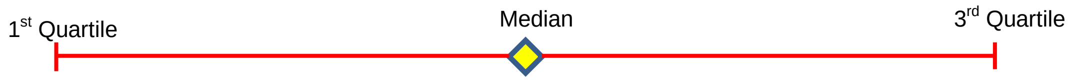
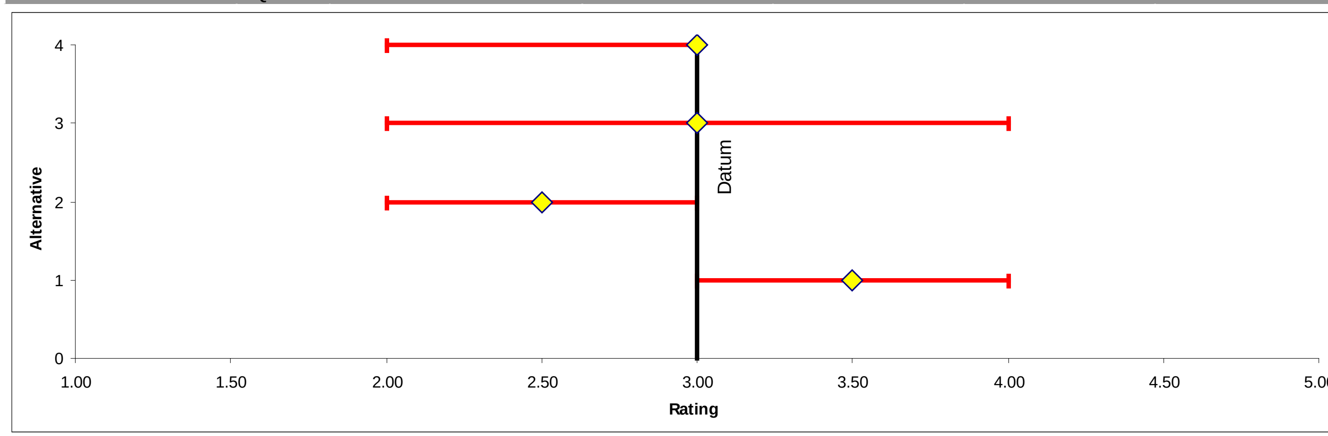


TABLE G-2 Round 1 Scores - Technical Feasibility

Performance Evaluation Criteria		Weight					
Technical Feasibility		0.20	Design Concepts				
Evaluator			Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1		3	4	2	3	3
Evaluator	2		3	5	3	4	4
Evaluator	3		3	3	4	5	4
Evaluator	4		3	3	3	2	4
Evaluator	5		3	2	2	2	2
Evaluator	6		3	4	2	3	2
Evaluator	7		3	2	1	4	2
Evaluator	8		3	3	4	3	3
Evaluator	9		3	3	1	3	2
Evaluator	10		3	4	3	3	3
Evaluator	11		3	4	2	2	3
Evaluator	12		3	3	3	3	2
Evaluator	13		3	3	1	1	1
Evaluator	14		3	5	3	4	1
Evaluator	15		3	4	3	4	3
Evaluator	16		3	5	2	3	3
Evaluator	17		3	3	3	3	3
Evaluator	18		3	3	2	2	2
Evaluator	19		3	5	4	4	3
Evaluator	20		3	4	2	2	2
Median			3.00	3.50	2.50	3.00	3.00
1st Quartile			3.00	3.00	2.00	2.00	2.00
3rd Quartile			3.00	4.00	3.00	4.00	3.00



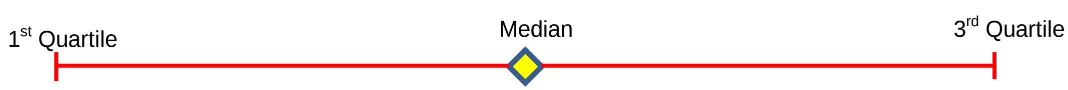
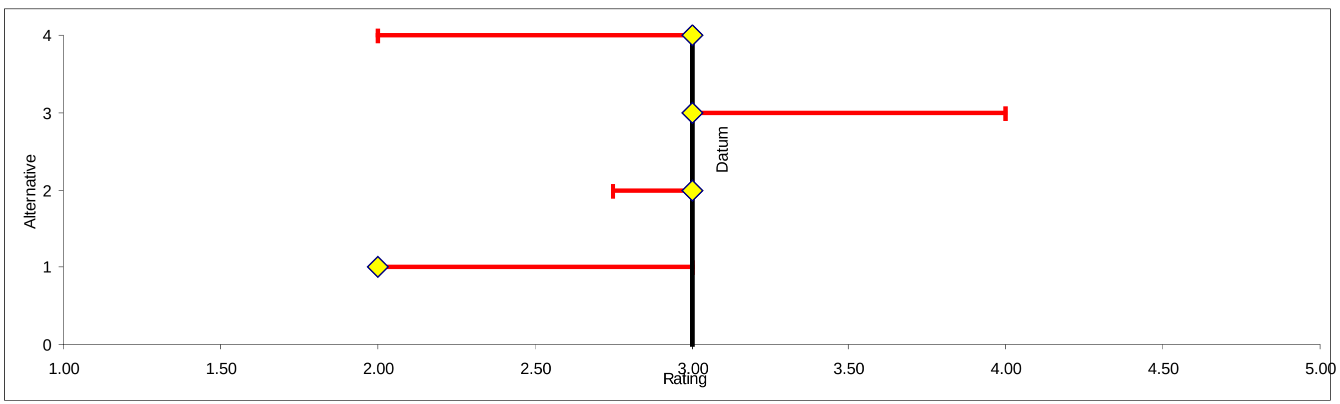


TABLE G-3 Round 1 Scores - Analytical Proficiency

Performance Evaluation Criteria	Weight					
Analytical Proficiency	0.20	Design Concepts				
Evaluator		**Datum** Current Preferred Design	**Alternative #1** Build on AEDT	**Alternative #2** Build on Existing Simulation Models	**Alternative #3** Federal Adoption of Commercial Software	**Alternative #4** Build on EC IMAGINE
Evaluator	1	3	3	3	3	2
Evaluator	2	3	3	3	4	4
Evaluator	3	3	1	3	4	3
Evaluator	4	3	1	3	3	3
Evaluator	5	3	2	4	3	4
Evaluator	6	3	2	3	2	3
Evaluator	7	3	2	4	4	2
Evaluator	8	3	4	2	3	3
Evaluator	9	3	3	4	4	4
Evaluator	10	3	2	3	3	3
Evaluator	11	3	2	3	3	3
Evaluator	12	3	3	3	2	2
Evaluator	13	3	1	2	4	1
Evaluator	14	3	4	3	3	3
Evaluator	15	3	3	3	4	3
Evaluator	16	3	2	2	4	3
Evaluator	17	3	2	3	3	2
Evaluator	18	3	3	2	3	3
Evaluator	19	3	3	2	4	2
Evaluator	20	3	2	4	2	2
Median		3.00	2.00	3.00	3.00	3.00
1st Quartile		3.00	2.00	2.75	3.00	2.00
3rd Quartile		3.00	3.00	3.00	4.00	3.00



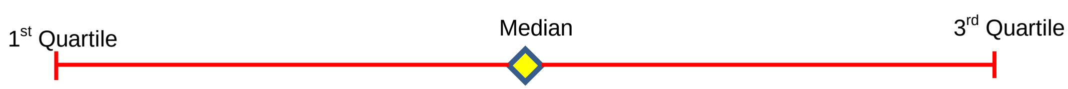
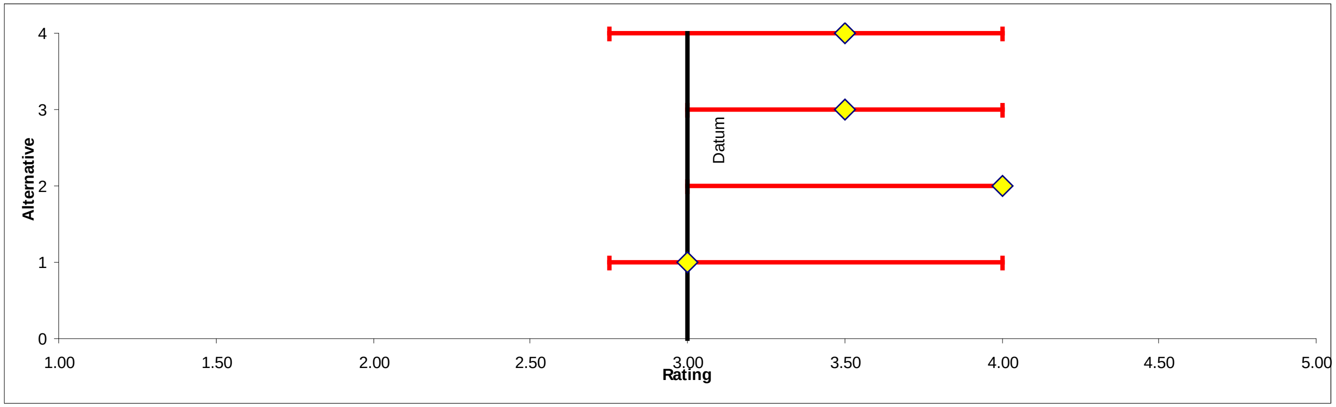


TABLE G-4 Round 1 Scores - Scalability

Performance Evaluation Criteria	Weight					
Scalability	0.15	Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	3	4	3	3	3
Evaluator	2	3	4	3	3	4
Evaluator	3	3	2	2	3	5
Evaluator	4	3	2	4	4	4
Evaluator	5	3	3	4	3	4
Evaluator	6	3	3	4	3	2
Evaluator	7	3	3	4	4	2
Evaluator	8	3	2	4	2	2
Evaluator	9	3	4	4	4	4
Evaluator	10	3	4	4	4	4
Evaluator	11	3	3	3	4	4
Evaluator	12	3	3	3	3	3
Evaluator	13	3	3	4	4	2
Evaluator	14	3	5	3	5	4
Evaluator	15	3	4	3	4	3
Evaluator	16	3	4	4	4	4
Evaluator	17	3	2	3	3	3
Evaluator	18	3	2	3	3	3
Evaluator	19	3	4	5	3	4
Evaluator	20	3	3	4	4	2
Median		3.00	3.00	4.00	3.50	3.50
1st Quartile		3.00	2.75	3.00	3.00	2.75
3rd Quartile		3.00	4.00	4.00	4.00	4.00



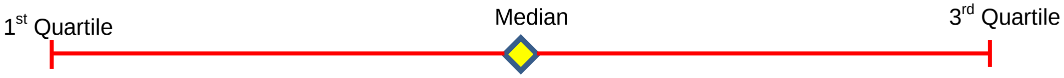
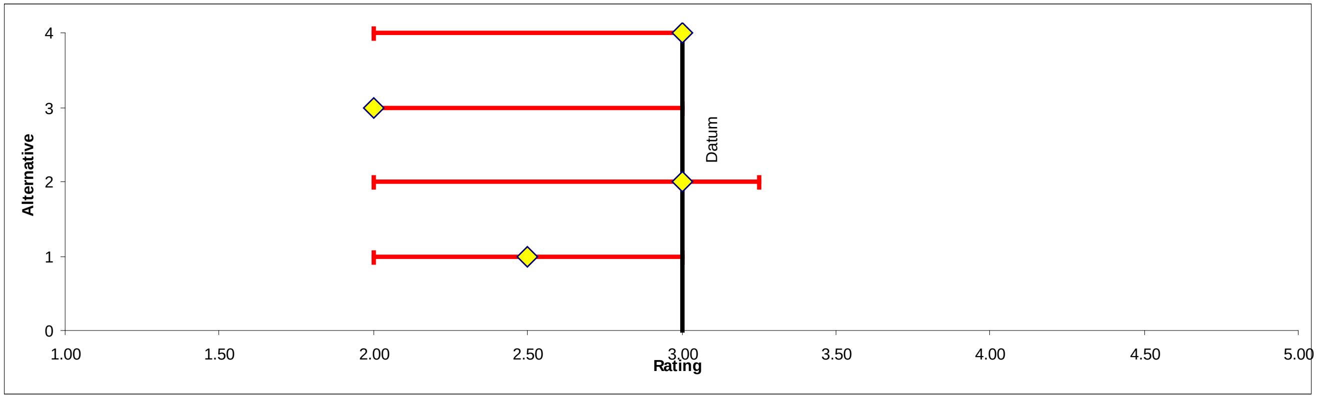


TABLE G-5 Round 1 Scores - Responsiveness

Performance Evaluation Criteria	Weight					
Responsiveness	0.10	Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	3	4	2	2	1
Evaluator	2	3	3	2	3	3
Evaluator	3	3	2	2	4	3
Evaluator	4	3	2	2	2	3
Evaluator	5	3	2	2	4	2
Evaluator	6	3	3	4	3	3
Evaluator	7	3	3	4	4	3
Evaluator	8	3	2	3	2	2
Evaluator	9	3	2	3	2	3
Evaluator	10	3	3	3	2	3
Evaluator	11	3	2	3	1	3
Evaluator	12	3	2	3	1	1
Evaluator	13	3	3	4	2	3
Evaluator	14	3	4	3	1	3
Evaluator	15	3	3	2	2	3
Evaluator	16	3	3	4	4	4
Evaluator	17	3	2	2	1	2
Evaluator	18	3	3	2	2	3
Evaluator	19	3	2	3	3	3
Evaluator	20	3	2	4	2	2
	Median	3.00	2.50	3.00	2.00	3.00
	1st Quartile	3.00	2.00	2.00	2.00	2.00
	3rd Quartile	3.00	3.00	3.25	3.00	3.00



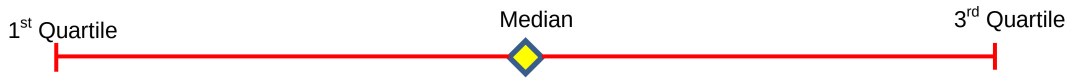
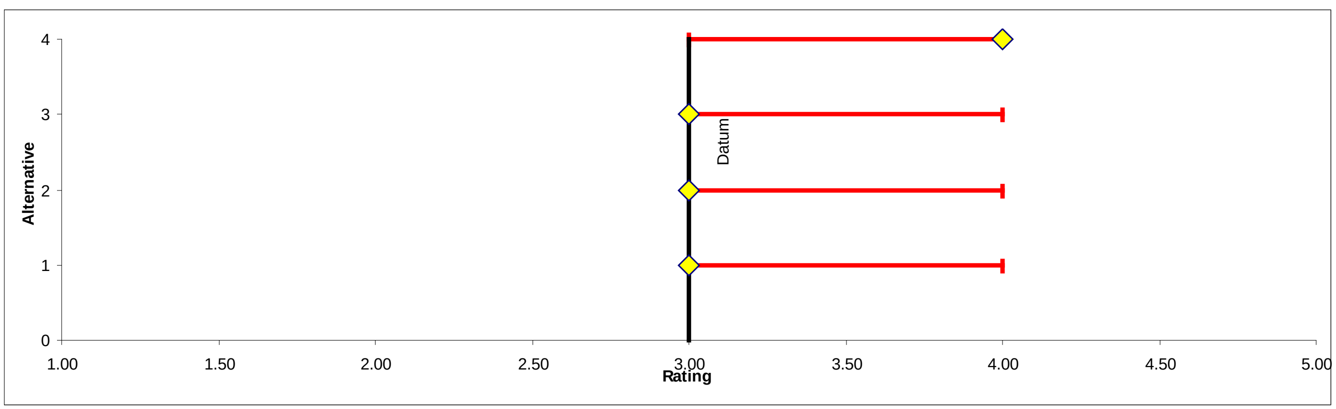


TABLE G-6 Round 1 Scores - International Credibility

Performance Evaluation Criteria	Weight					
International Credibility	0.05	Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	3	3	4	3	4
Evaluator	2	3	4	3	4	5
Evaluator	3	3	1	4	5	5
Evaluator	4	3	3	4	4	4
Evaluator	5	3	3	4	5	4
Evaluator	6	3	4	2	3	2
Evaluator	7	3	3	3	3	3
Evaluator	8	3	4	2	1	4
Evaluator	9	3	2	3	3	4
Evaluator	10	3	3	3	3	3
Evaluator	11	3	4	3	4	4
Evaluator	12	3	3	3	1	2
Evaluator	13	3	2	3	3	3
Evaluator	14	3	4	3	5	5
Evaluator	15	3	3	3	4	4
Evaluator	16	3	4	3	2	4
Evaluator	17	3	2	3	2	4
Evaluator	18	3	4	4	3	3
Evaluator	19	3	4	3	3	4
Evaluator	20	3	3	4	4	5
Median		3.00	3.00	3.00	3.00	4.00
1st Quartile		3.00	3.00	3.00	3.00	3.00
3rd Quartile		3.00	4.00	4.00	4.00	4.00



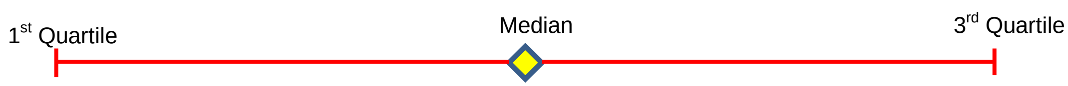
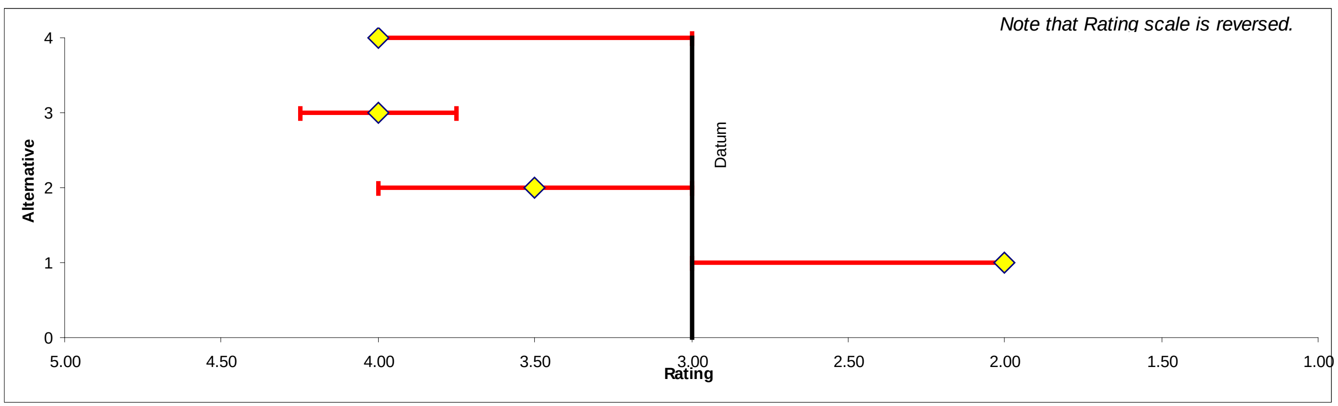


TABLE G-7 Round 1 Scores - Cost Implications

Performance Evaluation Criteria	Weight					
Cost Implications	1.00	Design Concepts				
Evaluator		**Datum** Current Preferred Design	**Alternative #1** Build on AEDT	**Alternative #2** Build on Existing Simulation Models	**Alternative #3** Federal Adoption of Commercial Software	**Alternative #4** Build on EC IMAGINE
Evaluator	1	3	2	4	3	4
Evaluator	2	3	2	3	2	2
Evaluator	3	3	2	3	3	2
Evaluator	4	3	2	4	4	4
Evaluator	5	3	4	3	3	3
Evaluator	6	3	1	2	5	4
Evaluator	7	3	4	5	5	5
Evaluator	8	3	2	3	5	3
Evaluator	9	3	2	4	4	4
Evaluator	10	3	2	4	4	4
Evaluator	11	3	2	4	4	3
Evaluator	12	3	4	4	5	4
Evaluator	13	3	3	4	4	3
Evaluator	14	3	1	2	3	1
Evaluator	15	3	2	4	5	3
Evaluator	16	3	2	2	4	5
Evaluator	17	3	2	3	4	4
Evaluator	18	3	4	2	4	5
Evaluator	19	3	3	3	4	3
Evaluator	20	3	2	5	4	5
	Median	3.00	2.00	3.50	4.00	4.00
	1st Quartile	3.00	2.00	3.00	3.75	3.00
	3rd Quartile	3.00	3.00	4.00	4.25	4.00



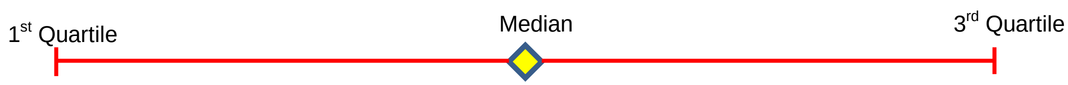
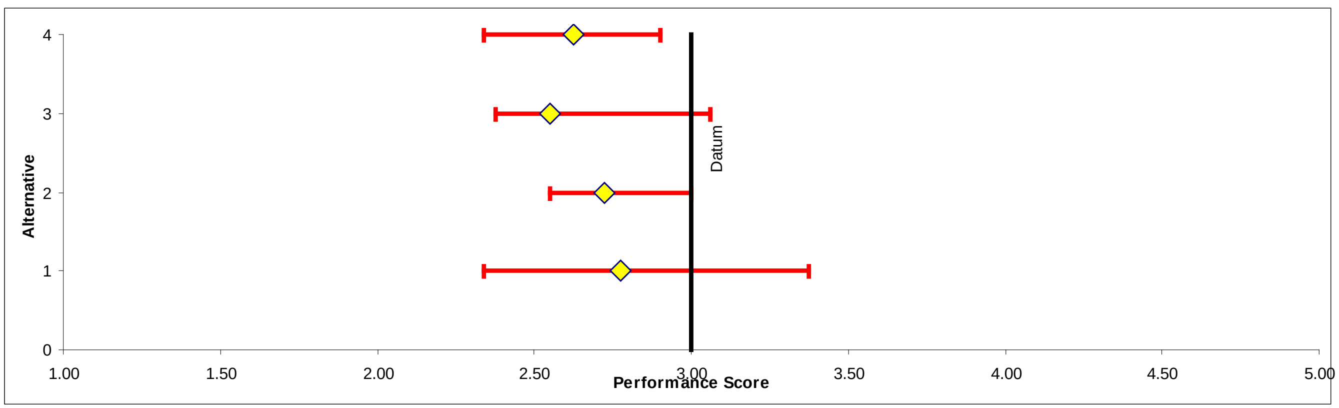


TABLE G-8 Round 1 Scores - Performance Score

Performance Score						
		Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	3.00	3.45	2.75	2.60	2.35
Evaluator	2	3.00	4.20	2.60	3.45	3.65
Evaluator	3	3.00	2.25	3.00	3.80	3.90
Evaluator	4	3.00	2.35	2.80	2.30	2.80
Evaluator	5	3.00	2.20	2.50	2.40	2.80
Evaluator	6	3.00	3.35	3.00	2.50	2.30
Evaluator	7	3.00	2.30	3.35	3.05	2.15
Evaluator	8	3.00	3.60	2.80	2.05	2.50
Evaluator	9	3.00	2.70	2.35	2.95	2.90
Evaluator	10	3.00	2.85	2.85	2.75	2.85
Evaluator	11	3.00	2.65	2.50	2.50	2.90
Evaluator	12	3.00	2.90	2.70	1.90	1.75
Evaluator	13	3.00	1.95	2.35	2.25	1.75
Evaluator	14	3.00	4.65	3.60	3.10	2.55
Evaluator	15	3.00	3.35	2.60	3.20	3.05
Evaluator	16	3.00	3.10	2.55	3.10	3.00
Evaluator	17	3.00	2.20	2.60	2.15	2.45
Evaluator	18	3.00	2.60	2.55	2.40	2.50
Evaluator	19	3.00	3.80	3.30	2.80	2.70
Evaluator	20	3.00	2.60	3.00	2.40	2.15
Median		3.00	2.78	2.73	2.55	2.63
1st Quartile		3.00	2.34	2.55	2.38	2.34
3rd Quartile		3.00	3.38	3.00	3.06	2.90



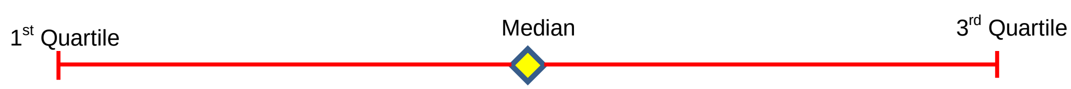
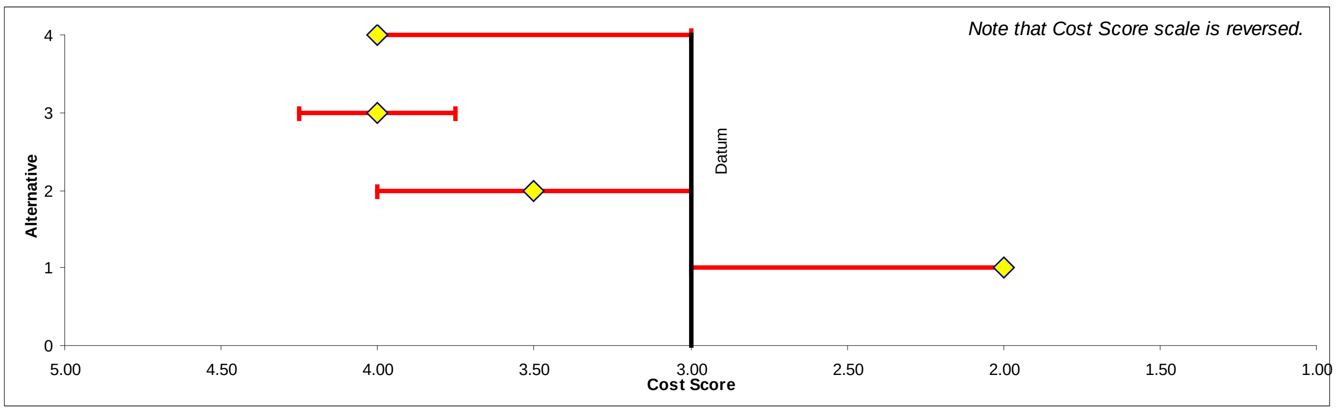


TABLE G-9 Round 1 Scores - Cost Score

Cost Score						
		Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	3	2	4	3	4
Evaluator	2	3	2	3	2	2
Evaluator	3	3	2	3	3	2
Evaluator	4	3	2	4	4	4
Evaluator	5	3	4	3	3	3
Evaluator	6	3	1	2	5	4
Evaluator	7	3	4	5	5	5
Evaluator	8	3	2	3	5	3
Evaluator	9	3	2	4	4	4
Evaluator	10	3	2	4	4	4
Evaluator	11	3	2	4	4	3
Evaluator	12	3	4	4	5	4
Evaluator	13	3	3	4	4	3
Evaluator	14	3	1	2	3	1
Evaluator	15	3	2	4	5	3
Evaluator	16	3	2	2	4	5
Evaluator	17	3	2	3	4	4
Evaluator	18	3	4	2	4	5
Evaluator	19	3	3	3	4	3
Evaluator	20	3	2	5	4	5
	Median	3.00	2.00	3.50	4.00	4.00
	1st Quartile	3.00	2.00	3.00	3.75	3.00
	3rd Quartile	3.00	3.00	4.00	4.25	4.00



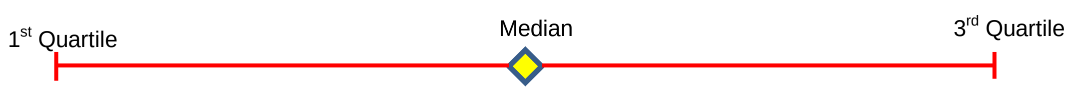
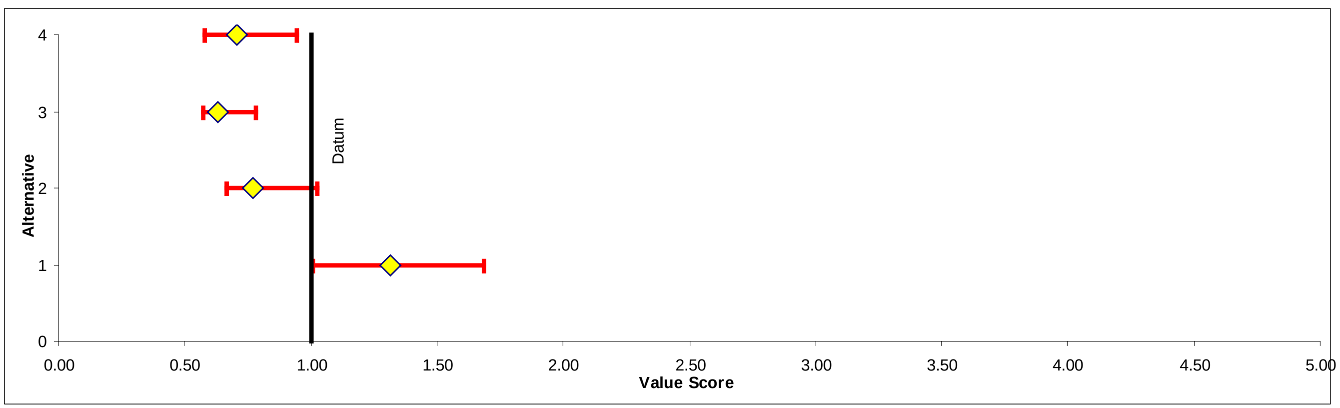
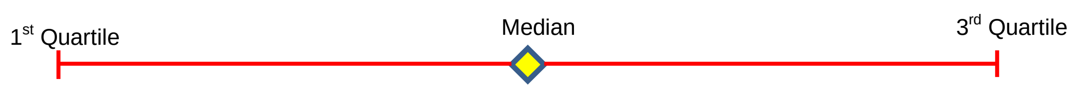


TABLE G-10 Round 1 Scores - Value Score

Value Score						
		Design Concepts				
Evaluator		Datum Current Preferred Design	Alternative #1 Build on AEDT	Alternative #2 Build on Existing Simulation Models	Alternative #3 Federal Adoption of Commercial Software	Alternative #4 Build on EC IMAGINE
Evaluator	1	1.00	1.73	0.69	0.87	0.59
Evaluator	2	1.00	2.10	0.87	1.73	1.83
Evaluator	3	1.00	1.13	1.00	1.27	1.95
Evaluator	4	1.00	1.18	0.70	0.58	0.70
Evaluator	5	1.00	0.55	0.83	0.80	0.93
Evaluator	6	1.00	3.35	1.50	0.50	0.58
Evaluator	7	1.00	0.58	0.67	0.61	0.43
Evaluator	8	1.00	1.80	0.93	0.41	0.83
Evaluator	9	1.00	1.35	0.59	0.74	0.73
Evaluator	10	1.00	1.43	0.71	0.69	0.71
Evaluator	11	1.00	1.33	0.63	0.63	0.97
Evaluator	12	1.00	0.73	0.68	0.38	0.44
Evaluator	13	1.00	0.65	0.59	0.56	0.58
Evaluator	14	1.00	4.65	1.80	1.03	2.55
Evaluator	15	1.00	1.68	0.65	0.64	1.02
Evaluator	16	1.00	1.55	1.28	0.78	0.60
Evaluator	17	1.00	1.10	0.87	0.54	0.61
Evaluator	18	1.00	0.65	1.28	0.60	0.50
Evaluator	19	1.00	1.27	1.10	0.70	0.90
Evaluator	20	1.00	1.30	0.60	0.60	0.43
	Median	1.00	1.31	0.77	0.63	0.71
	1st Quartile	1.00	1.01	0.67	0.57	0.58
	3rd Quartile	1.00	1.69	1.03	0.78	0.94





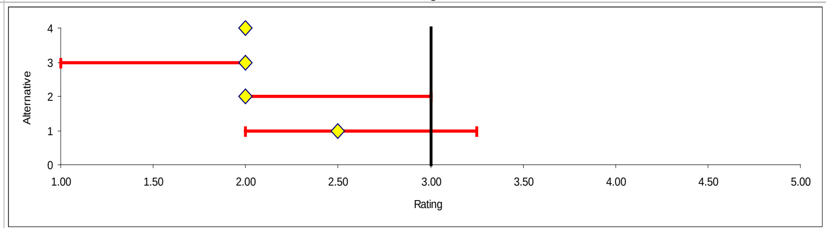
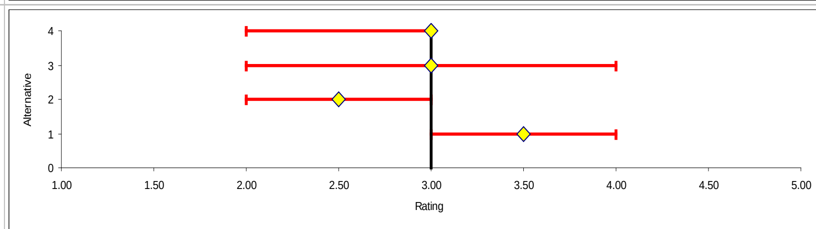
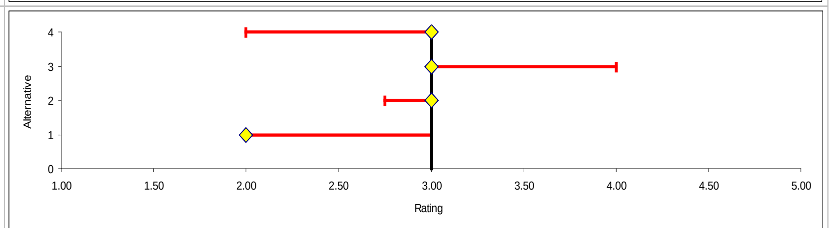
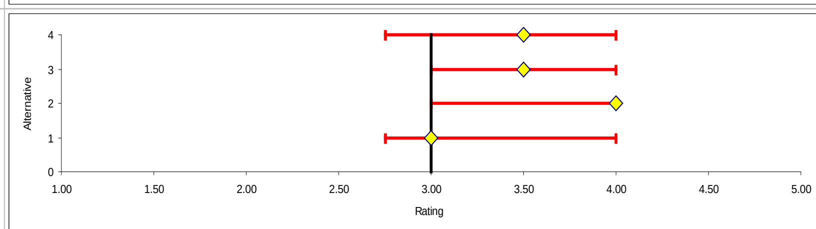
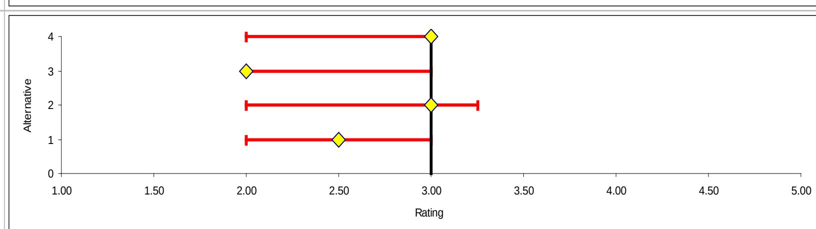
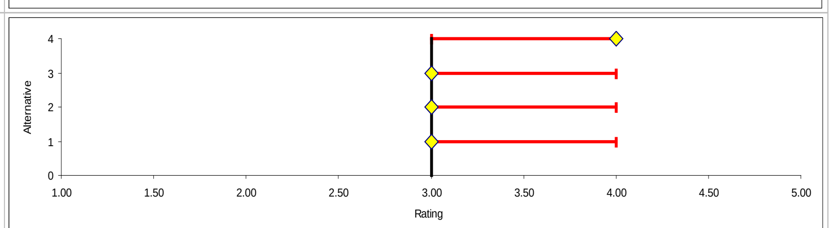
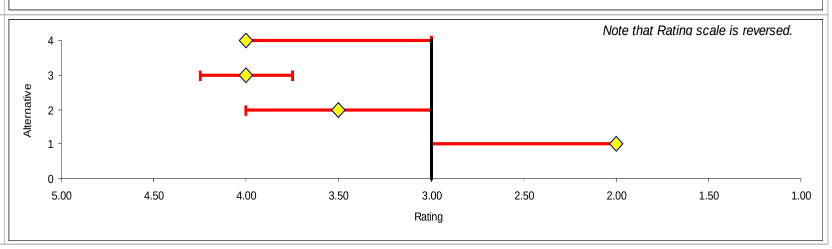
Criteria	Weight	Rating
Agency Acceptance	0.30	
Technical Feasibility	0.20	
Analytical Proficiency	0.20	
Scalability	0.15	
Responsiveness	0.10	
International Credibility	0.05	
Cost Implications	1.00	

Figure G-1. Round 1 evaluation performance and cost rating statistics.

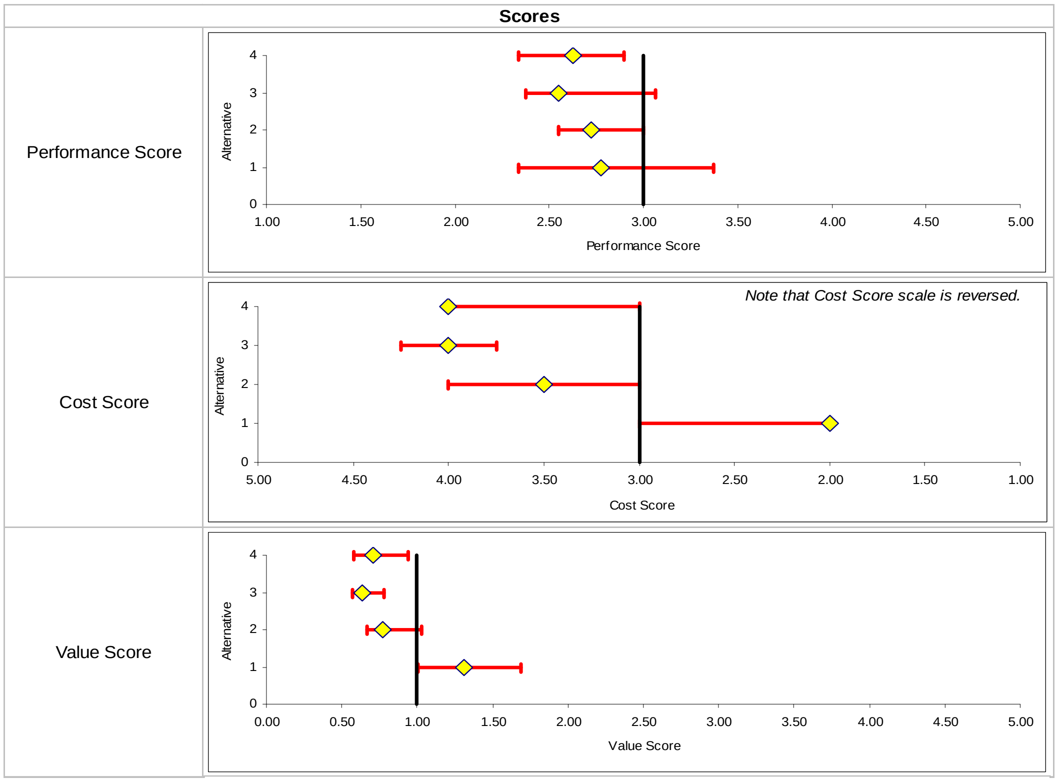


Figure G-2. Round 1 score statistics.

Figures F-3 through F-9 contain histograms showing the distribution of ratings (6 performance and 1 cost criterion), given by the 20 evaluators in Round 1, for the design alternatives. The shapes of the distributions give credence to the decision to use nonparametric rather than parametric statistics. That is because most of the rating distributions do not conform to a normal distribution, which is characterized by a symmetrical, bell-shape cluster of data around some mean. The presence of a normal distribution is a prerequisite for the use of parametric statistics.

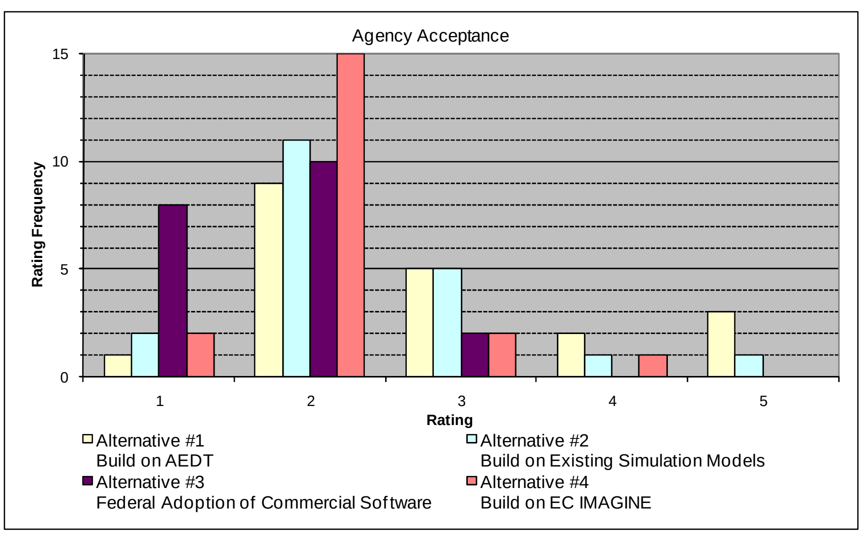


Figure G-3. Distribution of ratings for performance criterion – agency acceptance.

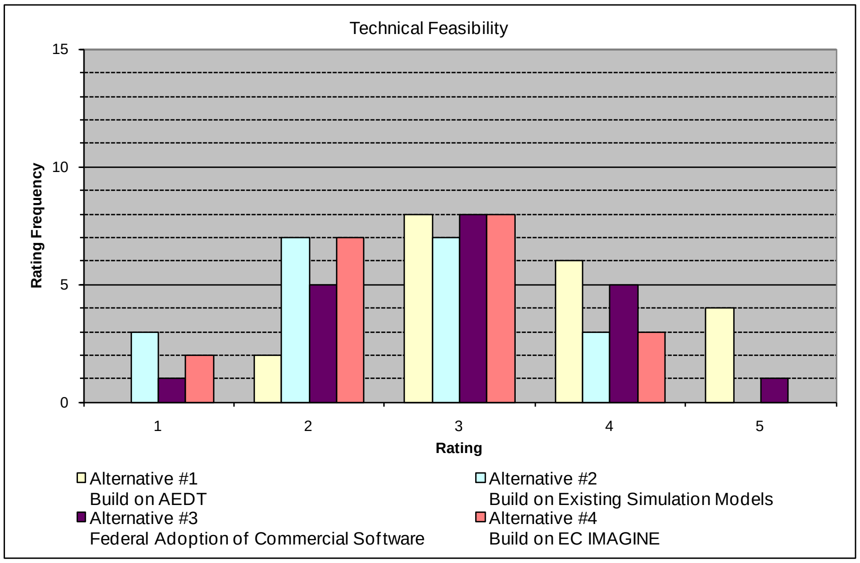


Figure G-4. Distribution of ratings for performance criterion – technical feasibility.

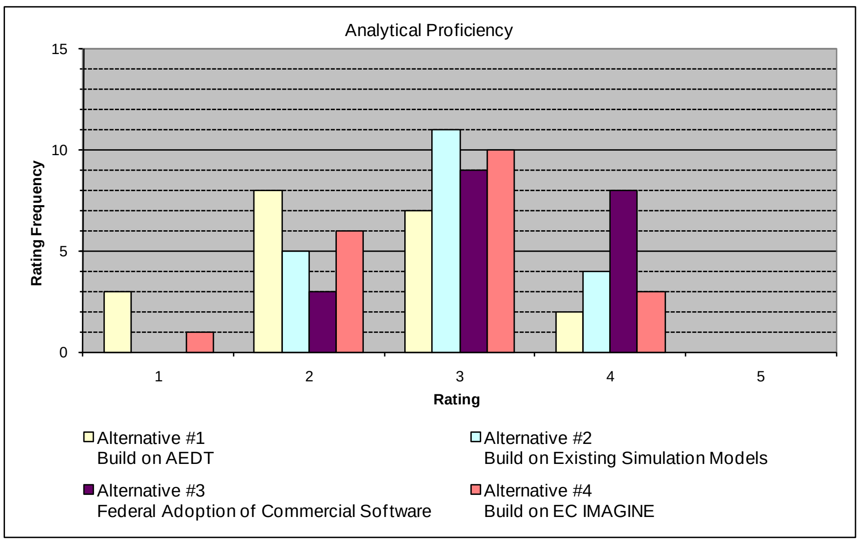


Figure G-5. Distribution of ratings for performance criterion – analytical proficiency.

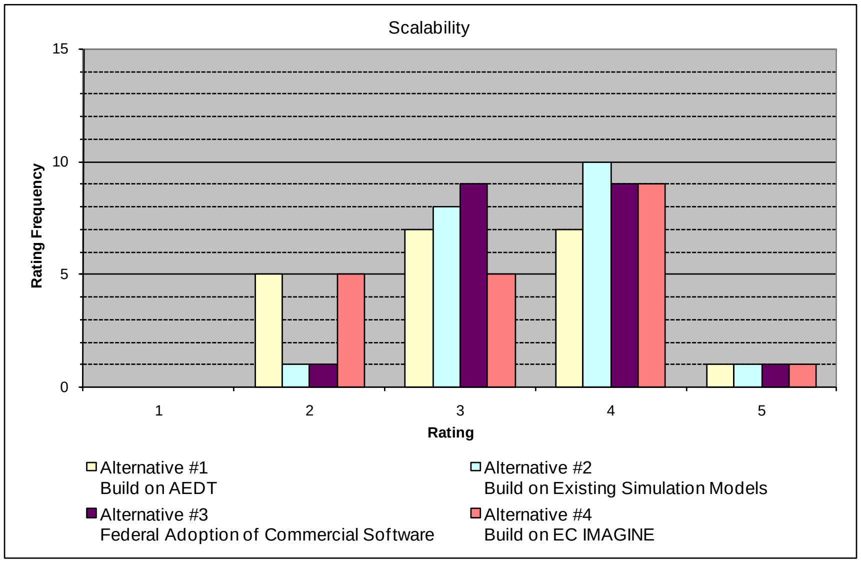
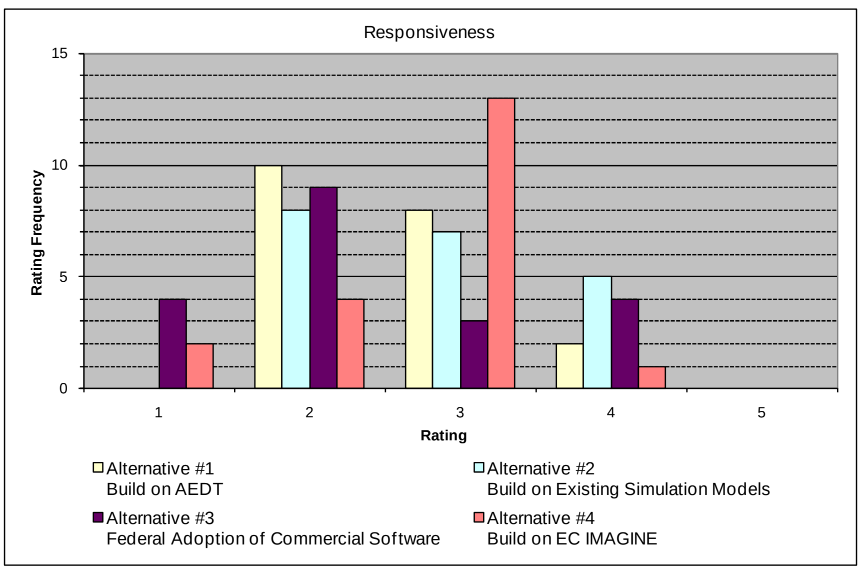


Figure G-6. Distribution of ratings for performance criterion – scalability



FigureF-7. Distribution of ratings for performance criterion – responsiveness.

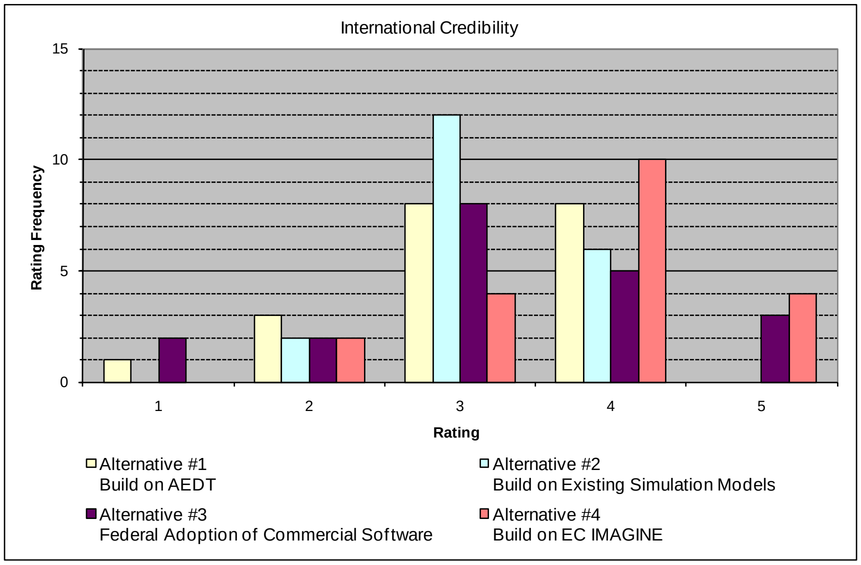


Figure G-8. Distribution of ratings for performance criterion – international credibility.

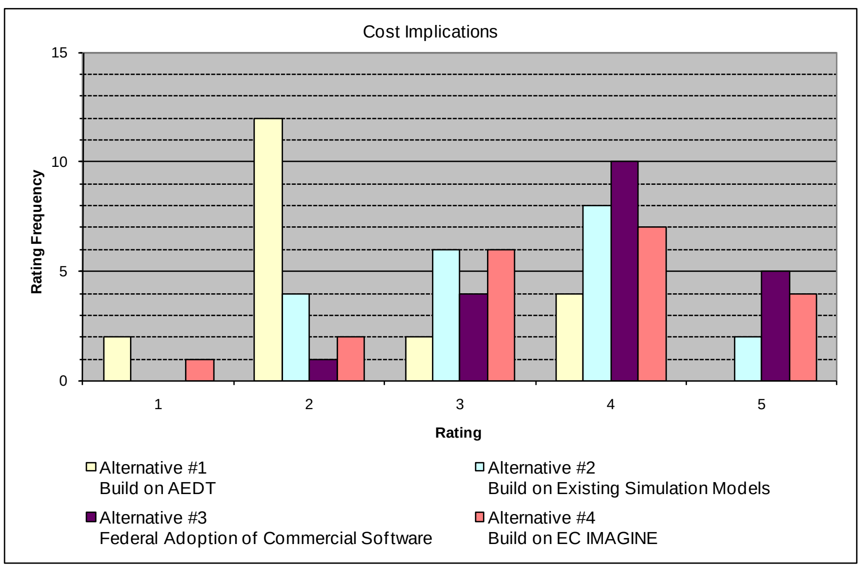


Figure G-9. Distribution of ratings for cost criterion – cost implications.

APPENDIX H. EVALUATORS' COMMENTS FROM ROUNDS 1 AND 2

In both rounds of the evaluations of alternative design concepts, the evaluators had the option to provide comments along with their ratings and many did. Section H.1 compiles the evaluators' comments on the 5 design concepts from Round 1. Like the scoring, the evaluators expressed their views of the Datum design compared to each of the alternatives. Section H.2 compiles the comments on the two designs evaluated in Round 2.

H.1 Evaluators' Comments from Round 1

H.1.1 Datum vs. Alternative #1

Datum		Alternative #1
Current Preferred Design with Build Sequence	**vs.**	Build on AEDT

H.1.1.1 Agency Acceptance

- Because the AEDT method would initially incorporate agency-approved computations for rail/road, I think that agency acceptance would be much higher for AEDT than for the Datum.
- In addition, if the Datum's Screening Tools were added to this AEDT alternative (easy to do, quick, multimodal), then this alternative would have multimodal capability very quickly. I assumed this will be added in my score here, since so easy to do.
- In addition, I don't think that DoD's ultimate goals are very important to this current DOT effort.
- It is building upon a current DOT model (FAA), but it will result in multimodal capabilities much later than Datum.
- This is a difficult criterion to judge, as it begs the question -- what agency. One could argue that for the FAA, building on AEDT is better than the datum. But that would not be the case for FHWA, or even DOD. This criterion may need some discussion for this alternative. As such, I've rated it neutral.
- Cons of integrated models by some agencies, noted. Likewise, the lack of inherent fidelity improvement in Alt#1 also noted. However, establishment of an enterprise system that is further supported by a data clearinghouse offers significant currency for agencies looking to demonstrate results to their constituents. The datum progression offers quick results but on a narrow base unless significant resources are applied to establish a broad archive of simulation based results.
- FAA would undoubtedly accept an expansion of AEDT, but other DOT agencies might be less willing.
- FAA would be OK with Alternative #1 (in this regard). However, other agencies might be reluctant to adopt this model as their standard. For one thing, they might get resistance from their "user community", who would need to undergo a sizeable conversion effort.

H.1.1.2 Technical Feasibility

- Because the AEDT method would initially incorporate agency-approved computations for rail/road, I think that agency acceptance would be much higher for AEDT than for the Datum.
- In addition, if the Datum's Screening Tools were added to this AEDT alternative (easy to do, quick, multimodal), then this alternative would have multimodal capability very quickly. I assumed this will be added in my score here, since so easy to do.
- In addition, I don't think that DoD's ultimate goals are very important to this current DOT effort.
- Similar technical challenges exist with both approaches, but the sequencing in different.

- While the ability to run individual analyses is probably easier in the datum alternative, the configuration management of the software, databases, and results as well as the information management of the input and output data is significantly improved making larger and more complex analyses more feasible.
- Datum approach has higher probability of success (at least in the short term) due to less ambitious scope.
- Seemingly easier to implement and build upon existing methodologies or those already in development.

H.1.1.3 Analytical Proficiency

- FICAN opinion was based, I believe, on the need for aircraft audibility computations for aircraft. Simulations of rail/road were not considered by FICAN, nor are audibility computations needed for rail/road/marine.
- AEDT approach to motor vehicles would be greatly improved under this alternative, thus eliminating the fourth negative bullet for AEDT.
- In addition, the third negative bullet for AEDT applies really just to TA, which is not needed for road/rail/marine.
- Integrated approach has reached its computational limits.
- Would require the use of the same metric. If FHWA would consider changing its metric, it would have to through the Federal Register rulemaking process.
- The end state of the two approaches is essentially identical.
- The proficiency of the two alternatives is roughly equivalent. However in particular settings there are individual advantages. Specifically in the datum, a broader class of problems can be addressed, e.g. from screening as noted to high fidelity simulations, which is a positive. However in Alt #1, the system would be more adept at fully analyzing the somewhat narrower field of problems to which it is tailored which is a positive. Likewise, in establishing a system which covers the "fat" part of the curve enumerating the multimodal problems of interest and not the tails on either end, there is reduced development and maintenance cost which is also a positive.
- It will not advance the state of the art
- In the short term, the 'loosely integrated' Datum approach allows one to take advantage of progress in developments of individual models (TNM, NOISEMAP, AEDT). With Alternative #1, it is harder to incorporate future progress.

H.1.1.4 Scalability

- Both designs are too complicated for small projects, but at least Datum builds in screening tools.
- Both approaches equally scalable.
- Formal information management of the underlying structure enhances analyst capabilities and reduces work load. Computational scalability would be about the same as the datum.
- The basic architecture is established and might be difficult or expensive to change significantly. The datum has the flexibility for scaling for different size projects.
- For large-scale projects, Alternative #1 would be preferable, achieving an economy of scale through an integrated approach. For small-scale projects, Datum approach is preferable - especially if one is interested primarily (or exclusively) in one mode.

H.1.1.5 Responsiveness

- I do not believe that the simulation end state of the Datum alternative gives FHWA, FTA or FRA anything that they need. Instead, only the Screening Tools of that alternative would be of use to these three administrations. And development of those screening tools could easily be incorporated in the AEDT alternative, as well.
- Since I don't believe that simulation is at all responsive to these three administrations, then most all of the Datum alternative is wasted for them. I see much less "waste" under AEDT, so therefore have rated it higher than the Datum.
- AEDT project has not demonstrated much responsiveness to the user community.
- With a multimodal capability being the focus, the datum gets us there more rapidly.
- More formal structure will inherently have more development and analysis inertia but is a trade with the credibility criteria.
- By virtue of the build sequence, the Datum could be considered the most responsive. Also, AEDT may not allow for new noise metrics
- Datum approach facilitates responsiveness due to its 'loosely-coupled', highly modular approach.

H.1.1.6 International Credibility

- Better because its core components are currently accepted worldwide.
- I am aware that other countries are using the FHWA TNM, but they are not my main concern. My primary customers are the State DOTs, therefore I gave this a "same" listing.
- Both approaches equally credible.
- More structured information technology support and accessibility across a wider stakeholder base. The data clearinghouse in particular would establish credibility.
- EC has already identified modeling processes more advanced than these and is in the process of implementing them
- So far, the international community has not been overly willing to accept AEDT
- Both approaches are roughly equal in this regard.

H.1.1.7 Cost Implications

- I don't think the development costs here will be as low as anticipated, since the propagation algorithms for road/rail will have to be very much more complex than those for aircraft (to gain administration approval). And so the algorithm for ground shielding and ground attenuation cannot be shared among these modes.
- However, if sharing in enforced for propagation, then the aviation computations will have to bear the "computation burden" required by the ground modes--a gross increase in computation time compared to what is truly needed for aviation computations.
- Note that this also will require entire different input datasets for topography---for ground-mode vs. aviation computations.
- In spite of all this, AEDT will still be much cheaper in my view.
- Assumed the Datum funding went all the way to the end state.

- If all capabilities are adopted the overall costs will likely be very similar when comparing the two approaches. But, I prefer the priority-driven approach, which by definition will lead to investment only if the need is there.
- Initial Alt#1 implementation higher but maintenance and life cycle cost lower.
- It will continue and expand an ongoing project. As such, past investments will continue to see returns.
- Cost comparison depends on how far along the build sequence the Datum would go. Alt 1 would be less expensive to achieve the same end state.
- Alternative #1 would probably have lower development costs over the entire cycle, but higher upfront costs and higher risks (due to tightly-coupled integration). User costs: probably greater for Alternative #1 in short term (large, single model). As well, maintenance costs for Alternative #1 is probably more (any advances in sub-models would have to be incorporated into large model).
- Some tools already under development.

H.1.2 Datum vs. Alternative #2

Datum		**Alternative #2**
Current Preferred Design with Build Sequence	**vs.**	Build on Existing Simulation Models

H.1.2.1 Agency Acceptance

- Agency acceptance will not be known till after the effectiveness of early training is known--and probably not even then.
- Lack of an intermediate screening method, in the meantime, is a shortcoming here. I am assuming that the Datum's screening task will be added to this alternative, as well.
- Although I've rated this as "5," it's not as high as rating as the "5" for Alt.1.
- FAA large R&D effort on AEDT does not include or plan for simulation.
- Multimodal capability in the near term is more important than the simulation capability in the near term since many of the advantages of simulation modeling cannot be realized until adequate source data are available.
- Commonality of first principle algorithms and roughly equivalent existing body of results.
- Agencies will be hesitant to scrap ongoing projects, but should recognize the superiority of simulation modeling.
- Agencies would prefer a step-by-step build sequence to re-evaluate progress versus needs.
- Alternative #2 would require all agencies (and their respective user communities) to accept this tool.

H.1.2.2 Technical Feasibility

- Because this end state is essentially the same (potentially) as that of the Datum, I have rated it technically the same.
- In my view, the second "negative" of this alternative (to the left) is equally shared by the Datum.
- [Equally feasible] Based on the similar end states.

- I am severely concerned about the impossibility of modeling intersections - FHWA project very often involve intersections. If this is not a possibility, then this option is much worse then datum.
- Both technically feasible, but the question comes down to sequencing, and due to data availability and other reasons, having the multimodal capability before the simulation capability makes more sense.
- Demonstrated framework of Alt#2 for multimodal analysis offers more confidence in success of the system
- Starting directly with a bottom's-up design approach using simulation techniques will likely be easier than evolving legacy approaches of fixed formats. I do not regard lack of source data as a problem, as simply converting existing data to a simulation-compatible. Format of equal fidelity will provide the opportunity for more advanced propagation techniques to be used off-the-bat.
- On one hand, Alternative #2 is very ambitious (in that it is creating a program from scratch). On the other hand, it is not encumbered by any legacy issues. On balance, though, the Datum approach has the edge in technical feasibility.

H.1.2.3 Analytical Proficiency

- In my view, all of this alt's negatives are equally shared by the Datum.
- Based on the similar end states.
- I believe the "+" outweigh the "-" in this case. Most of the "-" are common with any type of sophisticated model.
- The end state in terms of analytical capability is very similar if not identical.
- Although individual modal simulations in Alt#2 are more sophisticated, bringing the individual pipelines of results together only at presentation stage mitigates some of that benefit. With the lack of screening ability the higher fidelity simulation fidelity of Alt#2 would only benefit well endowed stakeholders with the resources to conduct such analyses.
- As a program that is designed from the start to be a comprehensive state-of-the-art simulation tool, Alternative #2 can be expected to provide better results.

H.1.2.4 Scalability

- Datum not conducive to small projects (except screening) while building from scratch offers opportunity to incorporate appropriate scalability.
- The end state in terms of scalability is very similar if not identical.
- Pipelining simulations within modes affords a very scalable architecture both for the analyst in constructing studies and computationally for the system carry out the evaluations.
- The Datum's building-block approach will provide a means for scaling not only algorithmic complexity but also a means for legacy algorithms to be used.
- Alternative #2 has the potential for increased scalability due to its 'clean-sheet' design. However, this would require a disciplined development effort to ensure that the scalability potential is realized.

H.1.2.5 Responsiveness

- Same very bad responsiveness as the Datum, in my view.
- Abandonment of legacy approach seems to abandon/ignore the regulatory requirements that necessitated the legacy tools.
- Both approaches equally responsive.
- Although on balance the same, again there are competing strengths and weaknesses of the datum and Alt#2. For some categories of stakeholders the Datum system will be more responsive, e.g. compliance oriented users. For other categories, say, those seeking state-of-the-art models Alt#2 are more so.
- Going straight to simulation is committing to an all-or-nothing approach
- Lack of a build sequence
- Alternative #2 is more of a labor-intensive effort, especially in the short term. Because of this, there might be pressure to freeze the design as early as possible, and thus be less responsive to evolving needs.
- Seemingly more difficult to modify to respond to changes in regulations/agency requirements.

H.1.2.6 International Credibility

- Alternative demonstrates more openness to input from others (international research community).
- I am concerned with national credibility, then international credibility, therefore this will be the same for all alternatives.
- Both approaches equally credible.
- Going straight to simulation puts analysis techniques on-par with those used in Europe
- As a model that is simulation-based from the ground up, Alternative #2 can be expected to have more international credibility than the Datum approach.
- Full simulation modeling seen as more "internationally accepted".

H.1.2.7 Cost Implications

- Lower than Datum only because it leaves out all the intermediate steps in getting the End State, which is essentially the same as the Datum?
- However, leaving out some of these intermediate steps is not good, in my view. So this cost savings is really "less product for less money."
- Little or no leverage with AEDT development means that FAA R&D expenditures to date would have been wasted.
- You get what you pay for. Although this will be extensively more expensive, it would be strongly advancing the noise and air modeling capabilities in the U.S.
- Because of the staged approach, the datum gets to a multimodal design within the first year. Thus the costs are very predictable. Whereas the costs to move straight into the simulation realm will likely be higher. It may turn out that the costs to get to the end state in each case will be similar.
- If these two models were developed independently beginning right now then I believe simulation modeling would be cheaper. However, many funds have been expended on existing models'

development so ignoring these investments and building a model from scratch effectively wastes these monies.

- If the Datum end-state is achieved, the build sequence in the Datum would increase costs compared to a single build. However, the learning curve developed in the build sequence could reduce overall costs
- The Datum approach will likely have greater overall costs (because of all the intermediate steps). However, Alternative #2 will likely have higher up-front costs, and will likely involve greater risk. My judgment is that on balance, the total overall cost of each approach is about equal.

H.1.3 Datum vs. Alternative #3

Datum		Alternative #3
Current Preferred Design with Build Sequence	**vs.**	Federal Adoption of Commercial Software

H.1.3.1 Agency Acceptance

- Same very bad prospect for agency acceptance as for the Datum.
- (This alt's page A-1, Road Noise): FHWA has not approved SoundPLAN computations. I was part of FHWA's evaluation of SoundPLAN and am well aware of SoundPLAN's failure to match TNM results (and SoundPLAN's designer's refusal to change their code to make a match).
- In addition, the propagation method within SoundPLAN is inherently unable, in my opinion, to account for at least two essential aspects of highway-noise propagation.
- Cannot imagine regulatory agencies agreeing to depend upon a commercial entity.
- Coming from a Federal agency, this option provides a loss of control. This is not a turf issue, but rather a regulatory compliance issue. The FHWA TNM is incorporated by reference and therefore required by, 23 CFR 772. If FHWA endorses a commercial model as the primary model, then it would revise 23 CFR 772 through the Federal Register process. The other issue is the cost to the users. Currently FHWA provide TNM free of charge to it primary stakeholder, i.e. State DOTs.
- The risk is far too great here should the vendor go out of business, unless licensing could be arranged to include the source code.
- Volatility of solutions in a market-based dynamic equilibrium of Alt#3 is a distinct negative.
- Some will be reluctant to scrap ongoing projects, and yet others will be happy to.
- Agencies would be unlikely to rely on the market to dictate performance and costs - particularly costs to the users
- Alternative #3 would require all agencies to abandon their own noise/emissions models, and would mandate their user communities to purchase commercial software (and a foreign one at that). These are serious barriers to acceptance.

H.1.3.2 Technical Feasibility

- US-approved code in TNM (planned for Version 3) will not fit into the modular propagation routines within SoundPLAN and CadnaA. They will have to redesign their products substantially.
- Lack of US source data key factor.
- Lack of source data is pretty much a wash between the two.

- This is a difficult criterion to rate, as it is unclear what, if any, domain knowledge the software firm may or may not have. For this criteria, all the risk shifts to the software firm. To what degree the Government could influence development is completely unclear.
- Prioritization of problems of interest allows the selection of "winners" across the field by problem category. The integration step however is non-trivial and it is unclear where that responsibility would lie.
- It takes years and $millions to develop a federally accepted model, whereas the commercial software exists and only policy would need to change.
- With Alternative #3, there will be some tension between the commercial software developer and the agencies regarding direction of development. For example, a commercial software developer might not develop a fully-integrated product (i.e. the desired end state) if it deems that there is not enough of a demand for it to make a profit on that effort.

H.1.3.3 Analytical Proficiency

- US-approved code in TNM (planned for Version 3) will not fit into the modular propagation routines within SoundPLAN and CadnaA. They will have to redesign their products substantially. Same as Datum, more or less, but much worse than possible with AEDT (once supplemented by the DLLs that will emerge from current TNM 3.0 development).
- These models were not based on a simulation foundation, which is where we need to go. One would have to be developed. In essence these tools implement the procedures within tools like INM, TNM, etc. So, they essentially have a similar proficiency with what we have today, and comparable complexities to moving towards simulation, if this is even planned.
- Highly tailored solutions that make the system easy to use enhances Alt#3's proficiency. There would likely be compromises on the underlying fidelity/accuracy as there is a lack of fundamental research and long-term development in market-based system solutions.
- The datum's modular approach is based on domestic models, whereas modules available within a commercial software package will include algorithms both domestic and non-domestic.
- Alternative #3 could turn out better or worse or the datum, depending on how well the software developers can work with the regulatory agencies. On balance, I deem the analytical proficiencies scores equal.

H.1.3.4 Scalability

- [Alternative #3 more scalable] Based on a cursory look at the types of projects that have applied either SoundPlan or CadnaA.
- Both approaches should be equally scalable.
- Scalability depends a lot on the design of the base software. I will assume that the two approaches are equal in scalability.

H.1.3.5 Responsiveness

- Mainly because so much is out of the control of US agencies.
- Commercial developers could give up any time they wished. And I think they would do that "soon," once they truly understood how different the US would want matters, compared to the products they already have developed.

- While the alternative appears to more responsive technically, there is substantial risks that certain regulatory requirements would not be fulfilled if left to the determination of a commercial entity.
- Of course this will be better - we are dealing with commercial models where the companies will have huge financial gain as a direct result of their responsiveness.
- The risk is far too great here should the vendor go out of business, unless licensing could be arranged to include the source code.
- Again highly dependent on the category of stakeholder using the system. For those users very close to the development team and sponsoring agencies the Datum will be very responsive. However, for other commercial and consulting agencies using third party support tools Alt#3 will be more responsive at adopting standards and plug-n-play capabilities.
- Surely response to change through professional software development will be more efficient than existing government contracts processes.
- Highly dependent on the developer commitment and the market
- It is expected that a commercial software developer, placed in a competitive situation, might be more responsive.

H.1.3.6 International Credibility

- Example products seem to be widely used, especially in the EU states.
- Since these companies are from other countries, I am sure international credibility will be better - but since I am not concerned with international acceptability, it is the same. I am concerned with national acceptability.
- The U.S. would have little international credibility following this approach, as each module would be considered somewhat of a black box, unless licensing could be arranged to obtain the source code. The U.S. will not be in a position of global leadership with this approach.
- Similar to Responsiveness, the Credibility would probably track with the alignment of the stakeholder with the agency.
- Commercial software is already heavily used abroad.
- Transparency could be a problem with a commercial product if the developer protects his product. Presumably, the contract to develop the product would be re-competed every few years.
- Alternative #3 already used in a number of international jurisdictions.

H.1.3.7 Cost Implications

- My rating here is an average between: Rating of 1 for development costs. Rating of 5 for User's costs. SoundPLAN, for example, has a very steep learning curve, adding burden to its extremely high license fee.
- All government agencies are used to having zero license fees for current models. I seriously doubt that possibility for this alternative.
- Savings on future federal R&D funds is outweighed by high user fees and wasted expenditures on existing projects, such as AEDT.
- It will be much more expensive for the user. State DOTs would have to purchase their own, as well as every consultant the does this work for a State DOT. These costs could adversely hinder small, minority or women lead businesses.

- Substantial individual seat costs associated with these tools render this a non-viable option
- Both the recurring costs to the user base and the maintenance of accessibility to results inventories will be costly for both the agencies and commercial vendors.
- Cost is higher for the end-user, but the government will save developmental costs. So it depends on your perspective.
- Lower costs for DOT, but potentially high costs for users.
- Smaller development cost (to the government agencies) offset by higher user costs (purchase of licenses).

H.1.4 Datum vs. Alternative #4

Datum		Alternative #4
Current Preferred Design with Build Sequence	**vs.**	Build on EC IMAGINE Project

H.1.4.1 Agency Acceptance

- I cannot image the "foreign" methodologies surviving in this alternative, however.
- The 'Interim methods' idea is a good approach for the federal agencies to take, but dependency on foreign methods and entities would be hard for the agencies to swallow.
- I am not viewing foreign government models much differently than foreign commercial models in terms of acceptance by U.S. agencies.
- Use of foreign methods is not desired, and if source code can not be obtained this is a non-starter for the U.S. Government.
- If the stakeholder base is US the adoption of some methods and the framework would be difficult in Alt#4.
- If federal agencies can put hubris aside, they should recognize the enormous effort which has already been put into the EC approaches and be happy most of the legwork is already complete.
- Agencies would be reluctant to accept a European approach
- Alternative #4 would require all agencies (and their respective user communities) to accept this tool.

H.1.4.2 Technical Feasibility

- A propagation method that replaces a roadway with intermittent points cannot possibly compute correct roadway noise levels, due to two critical (and "show-stopping") limitations---which, however, are too complex to fit within this spreadsheet cell.
- EC IMAGINE seems to achieve technical harmonization in noise modeling areas that face Datum.
- [Alternative #4 less feasible] Since EC projects were only on noise, no air.
- It is not clear if a license could be negotiated to obtain the source code and the model does not include any air quality considerations. Not clear on modularity of design, etc.
- The IMAGINE end-state noise algorithms are ready and tested (advantage over Datum). Implementation of air quality will be of similar difficulty to that of the Datum.

- Despite using the results of the IMAGINE research work, Alternative #4 is more ambitious than the Datum approach, and is thus more risky.

H.1.4.3 Analytical Proficiency

- Smaller scale projects will need screening tools, which this alternative might incorporate (assumed yes).
- [Equally proficient] Based on the similar simulation end states.
- This would be a regional model, which is not good for FHWA projects. As indicated, single (and more localized) mode projects would need to use that agency's model. Since most of FHWA's projects would fall in the more localized category, the FHWA would need to maintain its TNM to keep it up to par and usable for these situations.
- Although simulation-based, does not include air quality considerations.
- No option for reduced fidelity modeling excludes very large portion of stakeholders in the user base.
- A complex model to use
- As a program that is designed from the start to be a comprehensive state-of-the-art simulation tool, Alternative #4 can be expected to provide better results.

H.1.4.4 Scalability

- Especially better than the Datum's End State.
- Retaining existing tools for small projects and reserving multimodal model for large projects is a good idea.
- Demonstrated, scalable capability.
- Information management system of Alt#4 reduces analyst workload so that larger problems can be more easily executed.
- IMAGINE algorithms were built with scalability in mind, and the "reference" and "engineering" models allow for variable detail.
- Alternative #4 has the potential for increased scalability due to its 'clean-sheet' design. However, this would require a disciplined development effort to ensure that the scalability potential is realized.

H.1.4.5 Responsiveness

- Without knowing the availability of the source code, it is not clear that this alternative is responsive.
- With modularity and first principles approaches being roughly equivalent between Datum and Alt#4 there do not seem to be any differentiator in Responsiveness.
- Getting concurrence for changes from multiple countries could be difficult, but the US does not necessarily need to do everything in parallel with Europe - just use what they've got as a springboard.
- Not certain that the source code would be made available. Would require coordination with foreign developers.

- Alternative #4 is more of a labor-intensive effort, especially in the short term. Because of this, there might be pressure to freeze the design as early as possible, and thus be less responsive to evolving needs.

H.1.4.6 International Credibility

- But this criterion is of no important, in my view.
- Collaboration with EC IMAGINE is a major plus.
- Collaboration with European developers should lead to a level of international credibility, but there will always be the question about U.S. domain knowledge working off of a European design. The U.S. will not be in a position of global leadership with this approach.
- While underlying algorithms have equivalent credibility internationally, the framework of Alt#4 seems to have better potential.
- Obviously… [Alternative #4 would be more credible because of EC IMAGINE collaboration.]
- Presumably, a product based on an approved EC model would be credible.
- As the product developed from the result of an EC research effort, Alternative #3 should have good international credibility.

H.1.4.7 Cost Implications

- Judged at higher cost because not clear what happens to AEDT project. If it continues at current pace, then simulation modeling becomes a new initiative requiring additional funding. Even if AEDT is retooled, some new funding is necessary for the simulation modeling effort that is not currently part of the AEDT development plan.
- FHWA would still need to fund TNM to keep it operational.
- Substantial additional costs needed to reach an end state with this approach -- although multimodal it does not include air quality considerations.
- Seems that development costs preference Alt#4 but user/analyst costs slightly favor Datum.
- Development costs are now spread across the globe - many users and developers should result in economies of scale. Any European investment will make costs for the US lower, but international bureaucracy will have its costs.
- Working with foreign developers would be difficult and time consuming.
- The Datum approach will likely have greater overall costs (because of all the intermediate steps). However, Alternative #2 will likely have higher up-front costs, and will likely involve greater risk. My judgment is that on balance, the total overall cost of each approach is about equal.

H.1.5 General Comments

Getting acceptance from the various Federal agencies will be a monumental task, and will be the life or death of whichever alternative is selected. I am grateful for being apart of this project's panel, however, I can only speak from the highway noise side of the equation.

- A few general comments: (1) Alternatives 3 and 4 just seem like non-starters to me, given the uncertainty associated with availability of source code; (2) I struggled with rating Alternative 1 - going back and adjusting it several times. I see a lot of the difference being driven by how this model gets funded (assuming it ever does).

H.2 Round 2 Comments

H.2.1 Datum vs. Alternative #1

Datum	vs.	**Alternative #1**
Progressive Build		Build on AEDT

H.2.1 Agency Acceptance

- Pure AEDT much much much worse than Datum, re agency acceptance, for lack of Datum's Builds 1 and 2---that is, post-processor for existing computer programs, and screening tools. And although these items could be added to Alt.1 that would just serve to convert Alt.1 partially into the Datum, itself. Screening tools could either (1) employ lower-precision algorithms, re the existing computer programs, or (2) act only as a pre-processor to feed "simplified GUI/spreadsheet input" directly to the official computer programs for calculation, with results passed to the post processor. I believe that method (2) would gain better agency acceptance, since it will be lower precision only because input is constrained to be simpler...and the various agencies could help determine how "simple" is still adequate when they are not funding the project. What about screening for marine-vessel noise and emissions? I would suggest adding Alt.1's tasks concerning (1) Rulemaking and (2) Data Clearinghouse to the Datum, as well. I'd also suggest not "combining" sound levels from differing modes, since noise impact differs significantly by mode for the same sound level. Decibel-adding sound levels into one composite noise-contour set ignore this inherent, subjective difference.
- With the active role of agencies in the progressive build, Datum is clearly superior.
- Starting from the existing tools will help with this [Datum].
- Some like better, others not as well, so this [Datum vs. Alt#1] is the same.
- This depends upon which agency, but I've answered it within the context of DOT as a whole, whereas it [Alt#1] would be 2 if FAA-centric.

H.2.2 Technical Feasibility

- The simulation model end state should be the long term goal. However, using the performance criteria description from page 16 of the first round scorebook, it is technically more challenging.
- Not clear to me that it [Alt#1] is more or less feasible.
- Need to think this through a bit more as the detailed design evolves, but currently both seem equally feasible.
- Pure AEDT would likely be more technically feasible than the Datum, because the Datum's simulation development will be difficult for ground sources (huge numbers of individual vehicles). Nevertheless, I like very much the scaled-down simulation effort now in the Datum. Other comments:
    - If we force the same noise-propagation algorithms onto every mode, we will either (1) greatly sacrifice the required precision for noise barriers along highways, or (2) burden aviation computations with algorithms grossly more complicated than needed.
        - I'd suggest dropping this self-imposed requirement. Including refraction via ray tracing will upset/undermine highway-noise propagation. Instead, I'd strongly recommend transforming the vertical geometry of each transept computation to account for refraction.

  - To increase technical feasibility of the Ground-Source screening tool in the Datum, I'd suggest digitized USGS maps as input, with automatic Terrain-Line generation, parallel to roadways and rail lines, at specified offset intervals from the road/rail.

- This [Alt#1] is proven and development has been worked out.

H.2.3 Analytical Proficiency

- Both designs will use AEDT framework for some time, but Datum is better because of the screening tools and the introduction of a multimodal model sooner.
- New datum goes farther towards simulation.
- The datum draws the best from the best, while balancing the needs of the agencies. It may not be the most efficient way of getting to the end state, but it provides more analytical proficiency quicker.
- Both will provide acceptable answers. AEDT sooner but the Datum could be better in the long term so again, [Datum and Alt#1 are] the same.
- Again, the simulation end state is a better long term goal.

H.2.4 Scalability

- AEDT aspects are about the same for both alternatives, but the Datum's simulation (with sufficient choice of input precision) provides much finer-tuned scalability.
- In addition, scalability might be improved in the Datum by utilizing a common terrain input method (digital USGS and/or digital highway-project contour maps), but allowing the user to determine the precision needed when approximating that digital terrain during computations. In highway-barrier design, the user could then choose very precise vertical and horizontal precision when very close to the highway, but lesser precision at larger distances.
- By design the datum is more robust and scalable.
- Datum includes screening tools and will eventually lead to simulation model; which significantly better than Alt#1.
- Starting fresh gives the edge to the Datum.

H.2.5 Responsiveness

- Pure AEDT much much much worse much than Datum, re responsiveness, for lack of Datum's Builds 1 and 2---that is, post-processor for existing computer programs, and screening tools.
- Datum includes screening tools and will eventually lead to simulation model; which significantly better than Alt#1.
- [Datum is more responsive] Since the datum appears to get to a multimodal capability sooner.
- As the datum draws the best from the best it is by definition more responsive.
- This really depends on the timeframe of consideration. AEDT is better in the short and mid term while the Datum, if all goes right, is better in the long term. So [Datum and Alt#1 are] the same.

H.2.6 International Credibility

- Pure AEDT ultimately might have less international credibility for lack of a simulation end state.
- Drawing form EC IMAGINE gives the advantage to Datum.

- Beyond the aviation sector, it's not clear how important this is (hence the low weighting), but inclusion of the best from the canned international packages makes the datum better.
- [Datum more credible] Since the datum starts from models that are more widely known
- AEDT has already been out there. Nothing to prove as the Datum would require.

H.2.7 Cost Implications

- Hard to determine which will cost more/less.
- Time will tell on this. It is very difficult to judge. If all the funding agencies are playing well together, there will be buy-in and the datum should cost less. However, there is risk that in an effort to keep "everyone" happy, the datum could cost more. Hence the neutral stance.
- Pure AEDT would cost less for lack of simulation. However, I do not believe that the resulting Value Score of 0.93 reflects my overall comparison of the two alternatives. If I were asked to provide an intuitive Value Score of Alt.1 re the Datum, I would estimate it to be somewhere around 0.5. Numerically, instead of dividing 1.85 by 2 to get the Value Score, I would like to divide 1.4 by 2.8, to get 0.5. That would require finer-grained options than were available for scoring---options such as:
    - Much Much Much worse, and
    - Only Very Slightly Lower.
- Costs are similar through the Build on AEDT stages, but development of a simulation model makes Datum more expensive.
- A lot of effort has gone into the AEDT development. So, many problems have already been worked out. This is why I think the Datum should begin with the AEDT not just take from.

H.2.8 General Comments

- On the impacts since, the air quality and climate modeling we do in APMT already is multimodal (this is required since atmospheric chemistry is non-linear; we need to put all inventories in before doing a calculation in CMAQ for example). I don't think you need to say anything about this, but just wanted to make sure you were aware that the impacts models for emissions are already set up to take full inventories (e.g. from NEI). Then they apply standard time fluctuations to them for different sources (e.g. daily and weekly cycles).
- When I think about things like the current CAEP NOx stringency analysis, I see a string of modeling tools starting with an FESG demand forecast (derived from a consultative process with input from Airbus and Boeing market projection models), going to one industry economic model (APMT-Economics), going to multiple international noise and emissions inventory estimators (AEDT, AERO2K), ending with one environmental impacts modeling effort (APMT-Impacts). Within this string, the two most influential model aspects in terms of changing the answer are arguably the demand forecast/economic modeling, and the environmental impacts modeling (all the inventory estimators give about the same answer plus/minus 10%). Like this modeling string, the plans described for Project 02-09, are heavy on inventory estimation, and light on the other two ends of the spectrum. So for example, getting movements data for aircraft, trains, autos, long-haul trucking, etc. that are consistent with a single economic forecast will be a challenging task (let alone how those movements and that forecast are influenced by policies) -- and different growth assumptions are likely to be very influential. But economics modeling and scenario generation are not discussed. Conversely, on the impacts side life may be a little easier because the air quality and climate models already incorporate all the emissions, but there are other influential aspects not given much attention in the write-up -- e.g. the extent to which the fuel-

side (especially alternative fuels, life cycle GHGs, etc.) will be addressed. Since we now have a low carbon fuel standard signed by Obama, I think we need to look ahead to how integrated environmental impact modeling might be done 5 years from now (e.g., will it include agricultural models or energy grid models?).

- This [a build sequence is predicated on giving the users and agencies the tool that they need within expandable system architecture] is the idea that I really wanted to keep. But starting with individual models with a combined GUI delays this resulting in more cost and time. The related issues and suggestions are as follows:
    - In some cases screening tools don't exist. Where they do they are often quite different. For example, FTA's screening tool is essentially a distance from the tracks. But in an intermodal plan, this doesn't really work since we should be looking at the combined effects of all modes in answers we provide. So the screening tool represents a significant amount of work to build unless it is not truly inter-modal.
    - It appears now that both Build 1 and Build 2 are to use existing models and then improve this approach in Build 2. Then we throw this out for Build 3 and start with AEDT expansion?
    - So why could we not just start by bringing the other models into the AEDT system by changing the AEDT GUI? In this way we don't throw away previous work but can still answer the questions you pose in the operational track and at the same time get a head start on the overall modal model. This advances us to Build 4 very rapidly.

APPENDIX I. CURRENT AIR QUALITY, DISPERSION, AND NOISE MODELS

This appendix describes noise and air quality current in use around the world. The models are grouped as follows:

- Air Quality Emissions and Dispersion Models (Sec. I.1);
- Noise Models (Sec. I.2); and
- Models that do Both Noise and Air Quality (Sec. I.3).

Forty-seven (47) models are described (29 classified as air quality, 15 classified as noise, and 3 classified as both). Tables are used to organize the descriptions according to a model evaluation protocol with the following topics:

1. Overall model scope
2. Algorithms (scientific merit)
3. System architecture
4. Database
5. Usability
6. Documentation
7. Validation and confidence in use
8. Outputs
9. Policy or requirements

I.1. Air Quality Emissions and Dispersion Models

Model:	ACAM (Air Conformity Applicability Model)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain and maintained by the Air Force.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emissions
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Aviation – air and ground (vehicles)
d. Screening or detailed (intended categorization)?	Intended for detailed analysis, but some screening can be accomplished by the details inherent in the input data.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	All emissions evaluations at Air Force basis including those related to NEPA can be conducted using ACAM.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	ICAO reference method using "certified" emission factors for military aircraft. Simple correlations and emissions modeling based on emission factors and activity data. Simple comparisons to General Conformity de minimis threshold levels.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Combination of simple and First order.
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Microsoft Access and flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single integrated exe
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	None

Model:	**ACAM (Air Conformity Applicability Model)**
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Military aircraft, GAVs, stationary sources
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Military aircraft emission factors, MOBILE6 emission factors, stationary source emission factors
c. Robustness of data (i.e., fidelity and resolution of data	Fidelity and resolution of the internal data is generally fixed, but flexibility of input data allows different levels of fidelity
d. Traceability (e.g., documented sources, acceptability, etc.)	All data are well-documented.
e. Publicly available	All data are publicly available
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Some work required, but data is generally available.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Some flexibility for aircraft operational and vehicle types (as well as for other sources)
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Software is currently well developed and mature.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate to high for emissions.
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Emissions in mass per time (e.g., metric tons per year)
b. If air quality, what pollutants are covered?	CO, NOx, SO2, VOC, PM10, and PM2.5
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	Generally considered required for Air Force bases, but can be substituted with EDMS as necessary.
b. Input restrictions (i.e., parameter limits)	Based each modules limit.

Model:	ACAM (Air Conformity Applicability Model)
c. Limitations on application (i.e., scenario limits)	Only air force bases and below mixing height

Model:	ALAQS-AV (Airport Local Air Quality Studies, ArcView Based)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. Eurocontrol (ian.fuller@eurocontrol.int).
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Both emissions and dispersion in a tool set.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Aircraft, airport sources, highway.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Primarily used in Europe and satisfies requirements of air quality regulations. Not known to be required for use by a governmental agency
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Use of program permits a 4-D emission inventory based on emission factors and time/location of use for equipment. Input by the use of temporal profiles allows emissions to be allocated by time. Use of aircraft vertical profiles, assignment of ground tracks, and GIS (ARCVIEW9.0) enhance the spatial delineation of the emissions. Model can use COPERT III for highway emission work (European specific). Dispersion can then be accomplished by using the Lagrangian model LASAT, the Gaussian model AERMOD, or a CFD model approach.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	This model is most closely related to theoretical although dispersion is done by other models and simplifications do occur.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Input is by entry to various screens.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Runs in Windows.
c. Software language (e.g., Fortran, C#.NET, etc.)	Proprietary software.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Use of modularized components permit emission inventories to be completed. The software then acts as a preprocessor for other dispersion models.

Model:	**ALAQS-AV (Airport Local Air Quality Studies, ArcView Based)**
e. Distributed computing? (yes or no)	No.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Can use input from INM for flight tracks.
g. Hardware/additional software requirements	Runs on PC.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Small number of stationary sources, aircraft, APUs, GSEs, and motor vehicles.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	EIs (made for European use) are available for all included sources. Flight profiles (SAE1845) included.
c. Robustness of data (i.e., fidelity and resolution of data	Robust. Data is very similar to that used in EDMS with the exception of the motor vehicles based on European vehicles.
d. Traceability (e.g., documented sources, acceptability, etc.)	Source EIs are fully documented as are flight profiles.
e. Publicly available	Must obtain from Eurocontrol.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	For complete use, data requires considerable effort.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid input but use of defaults is possible.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Has been validated and changed so assumed to be implementation ready.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Unknown, not readily available.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Unknown, not readily available.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Model has been validated and used successfully.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined metrics for both spatial and temporal input. Uses gridded emission inventory concept.
b. If air quality, what pollutants are covered?	CO, NOx, HC.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	

Model:	**ALAQS-AV (Airport Local Air Quality Studies, ArcView Based)**
9. Policy or requirements	
a. Is this a preferred or required model?	Not required by regulation.
b. Input restrictions (i.e., parameter limits)	No.
c. Limitations on application (i.e., scenario limits)	Designed specifically for airports

Model:	**ADMS – Airport (Atmospheric Dispersion Modeling System)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain for purchase.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion.
b. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	Aircraft, airport sources with rail capability.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required by regulations but provides output that satisfies European requirements.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion nested in a trajectory model.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretically based although some simplifications are made.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Formation of input file required.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Proprietary
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT	ArcGIS and EMIT emission model.

Model:	**ADMS – Airport (Atmospheric Dispersion Modeling System)**
linkage, etc.)	
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Handles multiple types of sources but does not include emission work.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	User input.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, purchase through CERC.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Fixed.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Extensive but easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	High reliability.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete user guide with examples and help support.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Hardcopy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High, designed for use in the vicinity of airports.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined for both temporal and spatial.
b. If air quality, what pollutants are covered?	Designed for conservative pollutants although a chemistry algorithm for the NOx cycle is included.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Not required by regulations.

Model:	ADMS – Airport (Atmospheric Dispersion Modeling System)
b. Input restrictions (i.e., parameter limits)	Physical limits on input.
c. Limitations on application (i.e., scenario limits)	Designed for use in the vicinity of airports.

Model:	LASAT (Lagrangian Simulation of Aerosol-Transport, Version 1.6)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. Unclear but Janicke Consulting has reported.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion. Lagrangian particle model.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Not source specific but used in the vicinity of airports for all airport sources.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required by regulations but complies with German Guideline VDI 3945 Part 3.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission dispersion based on Lagrangian particle model.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Primarily theoretical based but uses random walk theory as approximation to turbulence.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	User created ASCII files.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows.
c. Software language (e.g., Fortran, C#.NET, etc.)	Thought to be JAVA.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components.
e. Distributed computing? (yes or no)	No.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Used in ALAQS.
g. Hardware/additional software requirements	PC
4. Database	

Model:	**LASAT (Lagrangian Simulation of Aerosol-Transport, Version 1.6)**
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	None.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	No.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	From Easily Found to Considerable Effort depending upon desired results.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	User defined sources.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Unknown, assumed easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	High. Based on proven methods and has been validated.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Unknown.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Unknown.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Has been proven in direct use.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined.
b. If air quality, what pollutants are covered?	Conservative pollutants.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	Not required but conforms to German Guideline VDI 3945 Part 3.
b. Input restrictions (i.e., parameter limits)	Physical limits.
c. Limitations on application (i.e., scenario limits)	Not limited for airport sources.

Model:	**LASPORT (LASAT for Airport)**

Model:	LASPORT (LASAT for Airport)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. Janicke Consulting.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emission and dispersion model. Uses LASAT (Lagrangian Simulation of Aerosol Transport) for dispersion.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Airport, airport sources, highway.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required by regulations.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission modeling (with temporal/spatial allocation) and dispersion.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretical based although some approximations occur.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Creation of data ASCII input file.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows.
c. Software language (e.g., Fortran, C#.NET, etc.)	JAVA and ANSI-C.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components.
e. Distributed computing? (yes or no)	No.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	GIS files.
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Aircraft, some stationary sources, GSE, APU, highways.
b. What data is included? (e.g., NPD, EI, performance	EIs are included and default performance profiles.

Model:	LASPORT (LASAT for Airport)
profiles, etc.)	
c. Robustness of data (i.e., fidelity and resolution of data	High. Very similar to EDMS with European information.
d. Traceability (e.g., documented sources, acceptability, etc.)	Fully documented.
e. Publicly available	No.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort although default values may be used.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Defined input format.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Unknown, assumed easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	High, has undergone extensive evaluations.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Unknown.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Unknown.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High, validation efforts have occurred.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined both spatially and temporally.
b. If air quality, what pollutants are covered?	CO, HC, NOx, PM.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Not required by regulations.
b. Input restrictions (i.e., parameter limits)	Physical limits applied
c. Limitations on application (i.e., scenario limits)	Designed for use in the vicinity of airports.

Model:	AUSTAL2000 (Version 2.4.4)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Purchase through SELMAGIS for 3950 Euros.
b. Air quality or noise?	

Model:	AUSTAL2000 (Version 2.4.4)
a. Air quality: emissions or dispersion?	Dispersion based on Lagrangian particle model.
b. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	User defined sources.
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Micro to Mesoscale.
b. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	Official German Federal Environmental Agency Model.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emissions dispersion.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretical based with some simplifications.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	User derived ASCII file.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows.
c. Software language (e.g., Fortran, C#.NET, etc.)	Unknown but thought to be JAVA.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components.
e. Distributed computing? (yes or no)	No for purchased version although unknown in German government offices.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	SELMA GIS, ARCGIS, ARCMAP and CADNA-A.
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	None.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A

Model:	AUSTAL2000 (Version 2.4.4)
e. Publicly available	Yes, for purchase.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort but use of defaults could change to easily found.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Flexible.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Unknown, but thought to be easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	High. Has been thoroughly tested.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Paper user guide and help services.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Hard copy with call in help
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Has been thoroughly tested.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined.
b. If air quality, what pollutants are covered?	Conservative pollutants.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Official German Federal Environmental Agency Model.
b. Input restrictions (i.e., parameter limits)	Physical limitations.
c. Limitations on application (i.e., scenario limits)	User defined for sources so limitations are only in input parameters.

Model:	CMAQ (Community Multi-scale Air Quality, Version 4.7)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Download at CMAS.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Eulerian dispersion, various scales with chemical kinetic modeling possible.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Not for any one mode as it uses more of regional approach.

Model:	CMAQ (Community Multi-scale Air Quality, Version 4.7)
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Regional.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	No required use.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emissions dispersion with heavy chemistry interactions possible.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretically based with multiple approximations.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	ASCII files.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows or LINUX.
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with multiple preprocessors.
e. Distributed computing? (yes or no)	No.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	MM5 for meteorology.
g. Hardware/additional software requirements	PC and SUN systems.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Not source specific, regional scale dispersion modeling with chemistry.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Chemical kinetic data.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, free download.
5. Usability	
a. General data requirements (e.g., readily available,	Considerable effort.

Model:	**CMAQ (Community Multi-scale Air Quality, Version 4.7)**
easily found, considerable effort required, etc.)	
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	No. Rigid input.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	High. Implementation ready with many validations.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User guide in downloadable zip file. Multiple other help files available on various topics.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Computer zipfile of hardcopy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High, many users and many validations.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined very flexible time scales. Spatially can be reduced to User defined km sized grids.
b. If air quality, what pollutants are covered?	Can handle most pollutants that remain airborne.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Not required by regulation but has been heavily used in regional modeling analyses.
b. Input restrictions (i.e., parameter limits)	Kilometer sized grids. Most pollutants.
c. Limitations on application (i.e., scenario limits)	Very flexible upward spatial changes and very flexible time scales. Large grids do not support receptor location input.

Model:	**UAM V (Urban Airshed Model V)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Downloadable from SAI.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Regional Eulerian photochemical dispersion with chemistry modules. Work horse for ozone evaluations for a long time.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Not mode specific since regional model.

Model:	UAM V (Urban Airshed Model V)
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Regional with km sized grids.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Was model of choice in the past by EPA for regional ozone analysis.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission dispersion in regional grid boxes.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretically based.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	ASCII input files.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS.
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with multiple preprocessors.
e. Distributed computing? (yes or no)	Has been used in this way but not required.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	
g. Hardware/additional software requirements	PC (SUN and mainframe versions also).
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Not source dependent since regional model.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Kinetic chemistry relations.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, downloadable from SAI.
5. Usability	
a. General data requirements (e.g., readily available,	Considerable effort.

Model:	UAM V (Urban Airshed Model V)
easily found, considerable effort required, etc.)	
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid input for reactive pollutants.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	High. Multiple evaluations.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Downloadable pdf file user guide. Other help documents available on various topics.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Zip files of hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Multiple validations have occurred.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined but has lower limitations on time and space.
b. If air quality, what pollutants are covered?	Inert and reactive pollutants primarily HC, NOx and Ozone.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Was preferred by EPA in the past.
b. Input restrictions (i.e., parameter limits)	Kilometer sized grids and longer reaction times.
c. Limitations on application (i.e., scenario limits)	Primarily used for regional ozone analysis. Large grids do not permit receptor location approximations.

Model:	CAMx (Comprehensive Air quality Model with eXtensions, Version 4.5)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Download from Environ.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Photochemical Eulerian dispersion model.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Photochemical Eulerian dispersion model.
d. Screening or detailed (intended categorization)?	Detailed, although CAMx Screen is also available.
e. Scales of analysis	

Model:	**CAMx (Comprehensive Air quality Model with eXtensions, Version 4.5)**
a. Air quality (e.g., microscale, regional, national, etc.)	Regional.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required by regulations.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission dispersion in grid cells. Chemical reactions considered.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretically based with multiple approximations.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	User defined ASCII files and input binary files.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows.
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with pre and post processors available.
e. Distributed computing? (yes or no)	Yes, can be used in this fashion.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	PAVE, Surfer, Vis5D, and Grads.
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Not source specific due to regional nature.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Chemical kinetics.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, from Environ.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort required.
b. Input flexibility (e.g., different resolution of data, user-	Rigid input but for both reactive air pollutants (including toxics) and particulate

Model:	CAMx (Comprehensive Air quality Model with eXtensions, Version 4.5)
defined sources, etc.)	matter.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Very good. More validation may be needed.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User guide in PDF format.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF format of hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate, may need more validation.
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined but 1 hour minimum and large km sized girds.
b. If air quality, what pollutants are covered?	Inert and reactive air pollutants and particulate matter.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	No.
b. Input restrictions (i.e., parameter limits)	Large grids and at least one hour. Regional.
c. Limitations on application (i.e., scenario limits)	Large grids do not permit receptor location input.

Model:	REMSAD (REgional Modeling System for Aerosols and Deposition, Version 8)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Download from SAI.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Eulerian Dispersion.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Not mode specific as it is a macroscale model.
d. Screening or detailed (intended categorization)?	Originally intended as screening model but has evolved into a “one atmosphere” model.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national,	Regional to macroscale (national).

Model:	**REMSAD (REgional Modeling System for Aerosols and Deposition, Version 8)**
etc.)	
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required by regulation.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission dispersion in km size gridded cells.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Has evolved to theoretically based, but has major simplifications, especially simplified ozone chemistry.
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	User defined ASCII files.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components.
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Chemical kinetic information.
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, download from SAI.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort.
b. Input flexibility (e.g., different resolution of data, user-	Fixed input but can be used for different reactive species.

Model:	**REMSAD (REgional Modeling System for Aerosols and Deposition, Version 8)**
defined sources, etc.)	
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Good. More validation may be needed.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Downloadable user manual.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Computer file of hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate. More validation may be needed.
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Large time scales and spatial grids.
b. If air quality, what pollutants are covered?	Spatial and temporal distribution of toxic and particulate emissions including sulfur dioxide (SO2), oxides of nitrogen (NOx), volatile organic compounds (VOC), and ammonia (NH3) (both anthropogenic and non-anthropogenic).
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	No
b. Input restrictions (i.e., parameter limits)	Not for all gases but does do both wet and dry particulate matter deposition.
c. Limitations on application (i.e., scenario limits)	Very large areas so receptor location estimation not possible. A typical advective time step for coarse (50–80 km) grid spacing is 10–15 minutes, whereas time steps for fine grid spacing (10–30 km) are on the order of a few minutes.

Model:	**URBEMIS (URBan EMISsions, Version 9.2.4)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Downloadable from urbemis.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emission model for land use development projects.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway, off-road, and land uses including construction.

Model:	URBEMIS (URBan EMISsions, Version 9.2.4)
d. Screening or detailed (intended categorization)?	More screening than detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Regional emissions.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	No, although could be preferred in California.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission estimation with built in trip generation rates and emission factors for various land use activities.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation techniques used in model.
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Input to spreadsheet type environment.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows with Microsoft.Net.
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic running in Microsoft.Net.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single but now has add-ins as dlls.
e. Distributed computing? (yes or no)	Yes
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	EMFAC2007 and OFFROAD2007.
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Highway, off-road, and land uses including construction.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	EFs for land use and trip generation rates.
c. Robustness of data (i.e., fidelity and resolution of data	Good
d. Traceability (e.g., documented sources, acceptability, etc.)	Good
e. Publicly available	Yes, download from urbemiss.
5. Usability	
a. General data requirements (e.g., readily available,	Easily found.

Model:	URBEMIS (URBan EMISsions, Version 9.2.4)
easily found, considerable effort required, etc.)	
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	User must define scenario so flexibility is limited.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Bugs have been reported so some issues probably still remain.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User guide (downloadable) and training videos available.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Downloadable hard copies and training videos.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate, only because of scenario limitations and reported bugs
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Emissions in California air basins and daily estimates.
b. If air quality, what pollutants are covered?	Reactive organic gases, NOx, CO, SO2, and PM10.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	No. But could be a requirement for California analysis.
b. Input restrictions (i.e., parameter limits)	Only for air basins in California and daily changes.
c. Limitations on application (i.e., scenario limits)	Made for use only in California and limited land use selections do not include airports.

Model:	TEXIN2-5 (TEXas Intersection, Version 2 with Mobile 5)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. But out of date so no one source.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion model meant for CO.
b. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	Highway intersections.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	

Model:	**TEXIN2-5 (TEXas Intersection, Version 2 with Mobile 5)**
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	No
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Dispersion based on Gaussian model. Also includes algorithms for traffic performance.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretically based (both dispersion and traffic).
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Development of ASCII files by user.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS.
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable.
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but MOBILE5 built in.
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Motor vehicles.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	EIs and traffic parameters.
c. Robustness of data (i.e., fidelity and resolution of data	Very good, but older.
d. Traceability (e.g., documented sources, acceptability, etc.)	Good
e. Publicly available	Yes, but old and no longer from any one source.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Easily found.
b. Input flexibility (e.g., different resolution of data, user-	Limited to intersections.

Model:	**TEXIN2-5 (TEXas Intersection, Version 2 with Mobile 5)**
defined sources, etc.)	
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Fair
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User guide and technical manual in hard copy.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate since more validation needed. Also has become dated.
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Only for intersections and one hour averages.
b. If air quality, what pollutants are covered?	Conservative pollutants, designed for CO.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	No
b. Input restrictions (i.e., parameter limits)	Only for intersections and one hour averages.
c. Limitations on application (i.e., scenario limits)	Intersection use only.

Model:	ROADWAY
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, but very old and no known source. Originally developed by GM.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Gaussian dispersion (line source).
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway free flow.
d. Screening or detailed (intended categorization)?	Screening for most cases.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	No. Very old (early 1970s).
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion, adapted as a line source.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Simple
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	ASCII
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None. Dispersion model only. However, interesting that plume rise from motor vehicles is included since it has been neglected in other models.
b. What data is included? (e.g., NPD, EI, performance	None

Model:	ROADWAY
profiles, etc.)	
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, but very old and no single source.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Little flexibility.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Implementation ready, no bugs.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User pamphlet.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Hard copy
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	Only for free flow line source such as highway traffic.
b. Moderate	
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Receptor located by user with restrictions. Generally one hour averages.
b. If air quality, what pollutants are covered?	Conservative pollutants, used primarily for CO.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	No
b. Input restrictions (i.e., parameter limits)	Receptor locations limited and need to generally be at 45 degree angle or greater to wind direction/highway direction.
c. Limitations on application (i.e., scenario limits)	Line source such as highway only.

Model:	**HIWAY**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, but very old was part of EPA UNAMAP series of models.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Gaussian dispersion (line source).
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway free flow.
d. Screening or detailed (intended categorization)?	Screening for most cases.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	No. Very old (early 1970s).
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion, adapted as a line source.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Simple
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	ASCII
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	Originally for mainframe but can port to PC.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None. Dispersion model only.
b. What data is included? (e.g., NPD, EI, performance	None

Model:	**HIWAY**
profiles, etc.)	
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, but very old and no single source. Can get old mainframe computer tapes of UNAMAP series.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Little flexibility.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Implementation ready, no bugs.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User pamphlet.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	Only for free flow line source such as highway traffic.
b. Moderate	
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Receptor located by user with restrictions. Generally one hour averages.
b. If air quality, what pollutants are covered?	Conservative pollutants, used primarily for CO.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	No
b. Input restrictions (i.e., parameter limits)	Receptor locations limited and need to generally be at 45 degree angle or greater to wind direction/highway direction.
c. Limitations on application (i.e., scenario limits)	Line sources such as highway only.

Model:	**CTDMPLUS (Complex Terrain Dispersion Model PLUS Algorithms for Unstable Situations)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, EPA download.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Gaussian dispersion in complex terrain. Intended for point sources.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Non-modal, dispersion only.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	An EPA preferred model in assessments such as NEPA.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian point source dispersion with algorithms for complex terrain and unstable conditions. A skewed bi-Gaussian distribution used in unstable cases.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Theoretically-based with simplifications.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	ASCII files defined by user.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS although was run on mainframe as well.
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with preprocessors. Terrain data preparation processor used to format raw terrain data.
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Preprocessors
g. Hardware/additional software requirements	PC (mainframe in past).
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None. Dispersion only.
b. What data is included? (e.g., NPD, EI, performance	None other than dispersion algorithms.

Model:	**CTDMPLUS (Complex Terrain Dispersion Model PLUS Algorithms for Unstable Situations)**
profiles, etc.)	
c. Robustness of data (i.e., fidelity and resolution of data	N/A
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A
e. Publicly available	Yes, EPA download.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	If defined source, readily available.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid format but flexible for terrain, weather and source emission rate.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Very good. Often used so validated.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Downloadable PDF user manual for main kernel program, meteorological preprocessor and terrain preprocessor.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF of hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Often used.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	User defined receptor locations and time periods. One hour or more most often used.
b. If air quality, what pollutants are covered?	Conservative pollutants.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	This is a preferred model for complex terrain by EPA. Preferred EPA model.
b. Input restrictions (i.e., parameter limits)	Physical limits on input.
c. Limitations on application (i.e., scenario limits)	Designed for point source with limits flexibility for other uses.

Model:	**NONROAD2005**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. EPA download.

Model:	NONROAD2005
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emission inventory model for a large array of off road sources including diesel engines and airport/aircraft sources.
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Off-road sources, large database.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Best used on regional basis, but use on microscale basis possible.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Recommended model due to regulations involving portions of data base.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Base emission factor with corrections for multiple parameters for a large number of off road equipment.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Actually more than first order approximation but has many simplifications.
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	ASCII files built but GUI has been designed for system.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS.
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable.
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	A very large number of off road sources including diesel and aircraft. Sources are broken down into multiple components for breakout.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Emission factors and estimation processes.
c. Robustness of data (i.e., fidelity and resolution of data	Very good, multiple validations.

Model:	NONROAD2005
d. Traceability (e.g., documented sources, acceptability, etc.)	Very good documentation.
e. Publicly available	Yes, downloadable from EPA.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort, sources must be quantified and characterized.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Flexibility in selection of off road service but limited flexibility for other parameters.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve but not extremely difficult.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Multiple iterations and changes have resulted in excellent reliability.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete. Strong user guide and multiple technical references.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Downloadable PDF files.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	Strong validation.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Best for long time periods such as year. Not spatially oriented.
b. If air quality, what pollutants are covered?	HC (including evaporative) , CO, NOx , PM, SO2, CO2
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	This model is recommended and has been used for conformity and SIP preparation.
b. Input restrictions (i.e., parameter limits)	Limits on input relating to sources and time periods.
c. Limitations on application (i.e., scenario limits)	Designed for longer term applications such as yearly.

Model:	OFFROAD2007
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, through CARB
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emission model for off road sources of 94 equipment types including GSEs.

Model:	OFFROAD2007
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Multiple off road sources.
d. Screening or detailed (intended categorization)?	Detailed.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Emission model best for regional.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Preferred in California.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emission estimation process with emission factors.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Actually more that first order approximation but called first order since many simplifications required.
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Building of input files but has GUI.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows with Microsoft .NET Framework 2.0.
c. Software language (e.g., Fortran, C#.NET, etc.)	
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Three main modules: population, activity, and emissions factor.
e. Distributed computing? (yes or no)	Yes
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	PC
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	94 off road sources including GSE for airport operations.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Emission factors, numbers of equipment, adjustments to base emission factor.
c. Robustness of data (i.e., fidelity and resolution of data	Very good. Well tested.
d. Traceability (e.g., documented sources, acceptability, etc.)	Very good
e. Publicly available	Yes, Through CARB

Model:	**OFFROAD2007**
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Considerable effort in quantification and typing of sources needed.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Flexible but has very defined source mechanisms.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Steep learning curve but not difficult.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Very good. Well tested.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User brochure with additional helps.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Downloadable files in Word format.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	Considerable use.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Not spatially oriented best for longer time periods typical of emission inventories.
b. If air quality, what pollutants are covered?	TOG,CO, NOx PM, CO2, SO2, N2O, CH4
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Recommended in California.
b. Input restrictions (i.e., parameter limits)	Temporarily for longer periods.
c. Limitations on application (i.e., scenario limits)	Defined source categories sometimes hard to apply.

Model:	**CALINE3**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Developed by CALTRANS and maintained/promulgated by EPA.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed

Model:	CALINE3
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes, used for regulatory studies
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion from finite length links
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but intended to use the direct outputs from models like MOBILE6.2
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	No data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A since all data are inputs
e. Publicly available	N/A since all data are inputs
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available

Model:	CALINE3
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively cryptic keys and switches in text file
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Well tested and free of bugs
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High confidence based on volume of validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally only stable compounds like CO, but depends on what the user is willing to accept.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	This is a required model
b. Input restrictions (i.e., parameter limits)	None except based on scope of model
c. Limitations on application (i.e., scenario limits)	Only for microscale applications

Model:	CALINE4
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Developed by CALTRANS and maintained/promulgated by EPA.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion
b. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national,	Microscale

Model:	CALINE4
etc.)	
b. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes, used for regulatory studies generally in California only
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion from finite length links and modal emissions
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but intended to use the direct outputs from models like EMFAC2007 and MOBILE6.2
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	No data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A since all data are inputs
e. Publicly available	N/A since all data are inputs
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible

Model:	CALINE4
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively cryptic keys and switches in text file
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Well tested and free of bugs
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High confidence based on volume of validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally only stable compounds like CO, but depends on what the user is willing to accept.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	This is a required model for California
b. Input restrictions (i.e., parameter limits)	None except based on scope of model
c. Limitations on application (i.e., scenario limits)	Only for microscale applications

Model:	CAL3QHC (CALINE3 with Queuing and Hot spot Calculations)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained by EPA
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion
b. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes, used for regulatory studies

Model:	CAL3QHC (CALINE3 with Queuing and Hot spot Calculations)
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion from finite length links and queuing theory
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but intended to use the direct outputs from models like MOBILE6.2
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	No data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A since all data are inputs
e. Publicly available	N/A since all data are inputs
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively cryptic keys and switches in text file
d. Reliability (e.g., software bugs, technical errors,	Well tested and free of bugs

Model:	**CAL3QHC (CALINE3 with Queuing and Hot spot Calculations)**
implementation issues, etc.)	
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High confidence based on volume of validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally only stable compounds like CO, but depends on what the user is willing to accept.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	This is a required model
b. Input restrictions (i.e., parameter limits)	None except based on scope of model
c. Limitations on application (i.e., scenario limits)	Only for microscale applications

Model:	**CALPUFF**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained Earth Tech
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Potentially all since it is a generic dispersion model
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale and regional
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes, used for regulatory studies on a case by case basis
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion based on point, line, area, and volume sources. Also, contains detailed modeling of atmospheric effects. Can be used to model visibility. All of

Model:	CALPUFF
	these modeling can be accomplished under a time-varying environment.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Flat ASCII files and GUI
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran and Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single executable
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but intended to use the direct outputs from models like EMFAC2007 and MOBILE6.2
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	None. This is a generic dispersion model
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	No data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A since all data are inputs
e. Publicly available	N/A since all data are inputs
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available, but some time-varying data may be difficult to obtain. Will depend on the needs of the user.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format for input. CALPUFF is flexible to model various sources including both stationary and moving.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand GUI.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Well tested and free of bugs
6. Documentation	

Model:	CALPUFF
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High confidence based on volume of validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally only stable compounds like CO, but pseudo-first-order chemical mechanisms for SO2, SO4, NOx, HNO3, and NO3. Depends on the assumptions the user is willing to make.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	This is an alternate model that can be used on a case by case basis.
b. Input restrictions (i.e., parameter limits)	None
c. Limitations on application (i.e., scenario limits)	Generally none, but need to consider reactivity of pollutants modeled and range of dispersion.

Model:	CMEM (Comprehensive Modal Emissions Model)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained by UC Riverside and requires a fee to purchase.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Currently no
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Regressed equations to take into account various vehicle characteristics, operational, and environmental variables.

Model:	CMEM (Comprehensive Modal Emissions Model)
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	MS Access database files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	VB Script
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Various modules with a single database query GUI
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only (currently only light duty vehicles)
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Fleet characteristics, operational, and environmental effects data
c. Robustness of data (i.e., fidelity and resolution of data	Internal data is generally high resolution. Input data such as speed, age, type, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	Well documented
e. Publicly available	Internal databases available with purchased software
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Most are readily available, but others may require considerable effort depending on fidelity requirements of the user
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand GUI.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Some software bugs
6. Documentation	

Model:	CMEM (Comprehensive Modal Emissions Model)
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic, not on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High confidence based on initial validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Grams per second, Grams per vehicle-hour, grams per vehicle-mile
b. If air quality, what pollutants are covered?	CO, THC, NOx, CO2
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Currently no
b. Input restrictions (i.e., parameter limits)	None
c. Limitations on application (i.e., scenario limits)	Only for light-duty, on-road vehicles

Model:	EMFAC2007
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained by CARB.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Initially intended for regional and national, but can be used for microscale as well
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes, but mainly in California
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Regressed equations to take into account various California-specific vehicle characteristics, operational, and environmental variables.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	

Model:	EMFAC2007
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Flat ASCII files and GUI
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe with various libraries underneath
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but the outputs can be directly used by some other tools
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Fleet characteristics (age, type, etc.), operational (hot, cold, speed, etc.), and atmospheric data correlated to basic emission rates
c. Robustness of data (i.e., fidelity and resolution of data	Internal data is generally high resolution. Input data such speed, age, type, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	Well documented
e. Publicly available	Most datasets are publicly available
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Most are readily available, but others may require considerable effort depending on fidelity requirements of the user
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand GUI
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Well developed and issues resolved
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line,	Electronic and on-line

Model:	EMFAC2007
etc.)	
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High based on validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Grams per vehicle-hour, grams per vehicle-mile
b. If air quality, what pollutants are covered?	CO, CO2, NOx, SOx, THC (and various components), PM10, PM2.5, Pb
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Required in California
b. Input restrictions (i.e., parameter limits)	None
c. Limitations on application (i.e., scenario limits)	Only for on-road vehicles covered by the model

Model:	EMIT (Easy Mobile Inventory Tool)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Not in public domain. Maintained by FHWA
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Initially intended for regional and national, but can be used for microscale as well
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	MOBILE6.2 emissions
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical

Model:	EMIT (Easy Mobile Inventory Tool)
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Through GUI
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe with MOBILE6.2 underneath
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but the outputs can be directly used by some other tools
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	All those associated with MOBILE6.2 such as fleet characteristics (age, type, etc.), operational (hot, cold, speed, etc.), and atmospheric data correlated to basic emission rates
c. Robustness of data (i.e., fidelity and resolution of data	Internal data is generally high resolution. Input data such speed, age, type, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	Data are for MOBILE6.2 and well documented
e. Publicly available	Most datasets are publicly available
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Most are readily available, but others may require considerable effort depending on fidelity requirements of the user
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand GUI
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Likely some bugs in GUI
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic
7. Validation and confidence use	

Model:	EMIT (Easy Mobile Inventory Tool)
Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High based on the user of MOBILE6.2
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Same as MOBILE6.2: Grams per vehicle-hour, grams per vehicle-mile
b. If air quality, what pollutants are covered?	Same as MOBILE6.2: CO, CO2, NOx, SOx, THC (and various components), PM10, PM2.5
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	Required based on use of MOBILE6.2
b. Input restrictions (i.e., parameter limits)	None
c. Limitations on application (i.e., scenario limits)	Only for on-road vehicles covered by MOBILE6.2

Model:	FLINT (FLorida INTersection Model)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Not in public domain. Maintained by FDOT and University of Central Florida.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion model
b. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not currently used for regulatory studies
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian dispersion from PAL2 and vehicle queuing algorithm
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with	

Model:	FLINT (FLorida INTersection Model)
individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	GUI and Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe with model underneath (e.g., PAL2)
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but intended to use the direct outputs from models like MOBILE6.2
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	No data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A since all data are inputs
e. Publicly available	N/A since all data are inputs
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand GUI
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	GUI has some bugs
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Some technical papers but no user’s guide
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic, not on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	

Model:	FLINT (FLorida INTersection Model)
b. Moderate	Moderate to high based on initial validation work
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally only stable compounds like CO, but depends on what the user is willing to accept.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	No
b. Input restrictions (i.e., parameter limits)	None except based on scope of model
c. Limitations on application (i.e., scenario limits)	Only for microscale applications

Model:	HYROAD
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained by SAIC
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion and emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	In certain cases as an option
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	AERMOD dispersion, NETSIM traffic simulation, MOBILE6.2 emissions
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	

Model:	HYROAD
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	GUI and Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe with modularized components in serial fashion
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	No data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	N/A since all data are inputs
e. Publicly available	N/A since all data are inputs
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand GUI
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	GUI has some bugs
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate to high based on initial validation work
c. High	
8. Outputs	

Model:	**HYROAD**
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally only stable compounds like CO, but depends on what the user is willing to accept.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Alternative model
b. Input restrictions (i.e., parameter limits)	None except based on scope of model
c. Limitations on application (i.e., scenario limits)	Only for microscale applications

Model:	**MOBILE6.2**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained by EPA
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Initially intended for regional and national, but can be used for microscale as well
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Yes
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Regressed equations to take into account various vehicle characteristics, operational, and environmental variables.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux,	MS-DOS

Model:	MOBILE6.2
etc.)	
c. Software language (e.g., Fortran, C#.NET, etc.)	Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe with various libraries underneath
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No, but the outputs can be directly used by some other tools
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Fleet characteristics (age, type, etc.), operational (hot, cold, speed, etc.), and atmospheric data correlated to basic emission rates
c. Robustness of data (i.e., fidelity and resolution of data	Internal data is generally high resolution. Input data such speed, age, type, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	Well documented
e. Publicly available	Most datasets are publicly available
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Most are readily available, but others may require considerable effort depending on fidelity requirements of the user
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Hard to understand codes, cryptic switches, and steep learning curve
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Well developed and issues resolved
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High based on validation work
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual	Grams per vehicle-hour, grams per vehicle-mile

Model:	**MOBILE6.2**
average, etc.)	
b. If air quality, what pollutants are covered?	CO, CO2, NOx, SOx, THC (and various components), PM10, PM2.5
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Required
b. Input restrictions (i.e., parameter limits)	None
c. Limitations on application (i.e., scenario limits)	Only for on-road vehicles covered by the model

Model:	**MOVES**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	In public domain. Maintained by EPA
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	All levels
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Currently no, but planned
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Regressed equations to take into account various vehicle characteristics, operational, and environmental variables.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	MySQL database files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Java
d. Software structure (e.g., single exe, modularized	Various modules with a single GUI

Model:	MOVES
components, preprocessors, etc.)	
e. Distributed computing? (yes or no)	Yes
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	Added processors may be necessary for efficient runs of detailed scenarios
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Fleet characteristics, operational, and environmental effects data
c. Robustness of data (i.e., fidelity and resolution of data	Internal data is generally high resolution. Input data such speed, age, type, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	Well documented, and supporting documents continuing to be developed
e. Publicly available	Yes
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Most are readily available, but others may require considerable effort depending on fidelity requirements of the user
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Easy to understand database GU
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Some software bugs
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate to high based on initial validation work
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Grams per vehicle-hour, grams per vehicle-mile
b. If air quality, what pollutants are covered?	Currently just greenhouse gases (e.g., CO2, CH4, etc.) but criteria pollutants (CO, NOx, etc.) planned

Model:	MOVES
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	[redacted]
9. Policy or requirements	
a. Is this a preferred or required model?	Currently no
b. Input restrictions (i.e., parameter limits)	None
c. Limitations on application (i.e., scenario limits)	None

Model:	TRAQSIM (Traffic Air Quality Simulation Model)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Currently not in public domain. Maintained by Wyle.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Dispersion and emissions model
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Highway
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Microscale
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Currently, no
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Gaussian puff dispersion, CMEM modal emissions, and traffic simulation using NETSIM core algorithms
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretical
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	GUI and Flat ASCII files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe with modularized components that are fully integrated
e. Distributed computing? (yes or no)	No

Model:	**TRAQSIM (Traffic Air Quality Simulation Model)**
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	None
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Vehicular sources only
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Pre-run CMEM modal emissions data
c. Robustness of data (i.e., fidelity and resolution of data	Emission factors, speed, etc, can be general or specific
d. Traceability (e.g., documented sources, acceptability, etc.)	CMEM data is fully documented
e. Publicly available	CMEM and its data is publicly available
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Readily available
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Rigid data format, but resolution of data is flexible
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand GUI
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	GUI has some bugs
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic, not on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate to high based on initial validation work
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	ppm
b. If air quality, what pollutants are covered?	Generally an only stable compound like CO, but depends on what the user is willing to accept.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	

Model:	TRAQSIM (Traffic Air Quality Simulation Model)
a. Is this a preferred or required model?	Currently no
b. Input restrictions (i.e., parameter limits)	None except based on scope of model
c. Limitations on application (i.e., scenario limits)	Only for microscale applications

I.2. Aviation Noise Models

Model:	AAM (Advanced Acoustic Model) (NMSim + RNM)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	▪ NMSim 3.0 is the public version (some functionality is not available in the public version). NMSim and RNM were developed by Wyle Laboratories. ▪ AAM 1.0 has been submitted to SERDP and availability to the public at this point (Fall 2008) is unlikely ▪ Updates and transition from NoiseMap are happening now.
b. Air quality or noise?	▪ Noise
a. Noise: SI, SPL, or other?	▪ SPL (spectrum and overall level time histories)
c. Mode (highway, rail, water, air)	▪ NMSim: Aircraft (fixed-wing and helicopters), highway and rail ▪ Simulation models support any noise source provided the data exists in sphere format
d. Screening or detailed (intended categorization)?	▪ Detailed
e. Scales of analysis	
a. Noise (free field, long range propagation)	Far-field noise analysis including audibility, terrain, 1-D weather, ground effects (reflections and impedance)
f. Regulatory use (e.g., NEPA assessments, etc.)?	▪ NMSim: The NPS has adopted the model as its preferred standard noise model. ▪ AAM: Will be used by The Department of Defense for noise analysis in conjunction with NoiseMap until proper data is available for all analyses in AAM
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	3D directivity and all vehicle dynamics are taken into account in a detailed trajectory input including yaw, pitch, roll, thrust vector angle, thrust, speed, time, x, y, z, etc.

<table>
<tr><td>Model:</td><td>AAM (Advanced Acoustic Model) (NMSim + RNM)</td></tr>
<tr><td></td><td>

Component	Description
A_{spread}	Geometrical spherical spreading (point source).
A_{atm}	ANSI/ISO atmospheric absorption standard [**4**].
A_{grnd}	Ground reflection and attenuation losses, caused by the ground and the resultant interaction between direct and reflected acoustic rays. The calculations are based on the work by Chessel [**5**] with corrections noted by Daigle, et. al. [**6**].
A_{topo}	Topographic attenuation, caused by the reflections and absorption that occurs from barriers formed by the terrain, based on work by Rasmussen [**7**] and Maekawa [**8**].
A_{weath}	Weather attenuation or amplification, caused by the weather profile that exists between the source and the receiver.

4. Acoustical Society of America National Standard, *American National Standard Method for Calculation of the Absorption of Sound by the Atmosphere,* ANSI S1.26 (R2004).

5. Chessell, C., *Propagation of Noise Along a Finite Impedance Boundary,* J. Acoust. Soc. Am., 62, 825-834, 1977.

6. Daigle, G., Embleton, T., Piercy, J., *Some Comments on the Literature of Propagation Near Boundaries of Finite Acoustical Impedance,* J. Acoust. Soc. Am., 66(3), 918-919, 1979.

7. Rasmussen, K., *The Effect of Terrain Profile on Sound Propagation Outdoors,* Danish Acoustical Institute Technical Report 111, January 1984.

8. Maekawa, Z., *Noise Reduction by Screens,* Appl. Acoust., 157-173 (1968).

Non-linearity can be approximated based off a table of source-dependent nonlinear coefficients calculated apriori using Pressure vs. Time wave files and a generalized form of the Burgers equation</td></tr>
<tr><td colspan="2">b. Which category does the model fall into:</td></tr>
<tr><td>a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)</td><td></td></tr>
<tr><td>b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)</td><td></td></tr>
<tr><td>c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)</td><td>Source data spheres are based on measurements and principles of linear acoustics which allow for “reverse” propagation back to the source based on local weather conditions.</td></tr>
<tr><td colspan="2">3. System architecture</td></tr>
</table>

Model:	AAM (Advanced Acoustic Model) (NMSim + RNM)
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	▪ NMSim: Outputs at specific points of interest and grids in ESRI's ASCII and NMGF file formats. ▪ AAM: Output data provided in ASCII files, TecPlot *.plt files, and/or NMPlot *.grd files based on user's desires.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	▪ NMSim: 32 bit Windows ▪ AAM: Windows and Linux
c. Software language (e.g., Fortran, C#.NET, etc.)	▪ NMSim: Visual Fortran ▪ AAM: Fortran
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	▪ NMSim: A full NMSim case can have as many as seven input files. Of these possible input files, only an Elevation File, a Trajectory File, and a Noise Source file are required. ▪ AAM: single EXE with components such as trajectory builder, elevation file builder, 3D visualizer provided as separate EXE's. Sphere input is in the form of NETCDF binaries, ELV files are binary, and an ASCII file is required with a Keyword structure with options, commands, grid definitions, etc.
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	▪ NMSim: Recommended hardware: o 500 MHz Pentium (or equivalent) based computer o 256 Megabytes of RAM o 1024x768, 24-bit color display. ▪ NMSim: Minimum hardware: o 200 MHz o 128 MB RAM o 800x600 with 16-bit color o If color rendering and animations are not required, color depth can be 8 bits. ▪ AAM: Same as NMSim
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	▪ NMSim: Air Tour Fixed Wing Sources, Air Tour Helicopter Sources, Ground Sources, INM Converted Sources, Military Sources ▪ Source data is subject to permission for release by the DoD or, in RNM's case, NASA ▪ AAM data currently limited to AV8-b, F-15, F-16 (GE engine), F-16 (PW engine), F-18A/C, F-22, and F-35A (soon to be updated with Fall 2008 Edwards AFB measurement data) ▪ Preliminary techniques exist to convert NoiseMap data into AAM data, but validity has yet to be proven

Model:	AAM (Advanced Acoustic Model) (NMSim + RNM)
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	▪ NMSim: ▪ Air Tour Fixed Wing Sources o Based on measurements made by FAA during Grand Canyon Model Validation project. Noise sources do not vary with given parameters such as speed or throttle setting. ▪ Air Tour Helicopter Sources o Based on measurements made by FAA during Grand Canyon Model Validation project. Noise sources do not vary with given parameters such as speed or throttle setting. Not as complex as RNM sources ▪ Ground Sources o Cars, buses, trucks, motorcycles and trains. Automobiles sources based on speed. Train source based on incline of track. ▪ INM Converted Sources o Based on INM spectral classes and INM's ground attenuation algorithms (which determine directivity pattern). Vary with given throttle setting. (Data not very refined.) ▪ Military Sources o Developed by Wyle Laboratories from USAF flight test recordings. (Most accurate of sources.)
c. Robustness of data (i.e., fidelity and resolution of data	Resolution is variable, but current sources exhibit 5 degree longitudinal spacing and 15 degree lateral spacing on a sphere containing third-octave band data at each point. Nose and tail data is "smeared" to eliminate singularities, and lower hemisphere is mirrored on the top of the sphere as an approximation to handle very large roll angles. Lateral directivity is limited by the microphone array when measured, but generally is of high-fidelity out to 45 degrees from below the aircraft and the data from 30-45 degrees is averaged and repeated up to 90 degrees (where the wings are)
d. Traceability (e.g., documented sources, acceptability, etc.)	No formal acceptance plan is in place. POI results generated from AAM compared to original microphone data are agreeable, however.
e. Publicly available	No
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Data is generated by the Acoustic Repropagation Technique (ART) and considerable effort is required to take measurements and create spheres. However, suite of executables includes one called Bullwink.exe capable of taking an ASCII file and turning it into a NETCDF sphere, which could circumvent the ART process if the data was available
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	▪ NMSim: User can define total grid size and grid resolution ▪ Noise spheres may contain broadband, narrowband, or pure tone data. ▪ Angular resolution on noise sphere is variable

Model:	AAM (Advanced Acoustic Model) (NMSim + RNM)
	▪ Elevation data grid is variable
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	AAM in single-track mode is generally used for research purposes and a host of cryptic switches and keywords are available if the user wishes to climb a steep learning curve and bury himself with output data. All keywords are explained in the AAM manual if one so chooses to look However, AAM in multi-track mode will be integrated with BaseOps and the user will not have to do much out of the ordinary, making AAM more accessible to the average user
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Software is reliable, provided inputs are created properlly and all the ends meet. This can be somewhat difficult for a very detailed analysis, though.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	AAM User's guide and Technical Manual are available upon request from Wyle
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF, Word, and hardcopies available
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	▪ NMSim: Evaluation of model performed at Grand Canyon National Park by National Park Service and FAA in 1999. ▪ Field validation by Department of Defense and Department of Interior. ▪ AAM / RNM propagation algorithms have been accepted by the DoD and NASA
a. Valid only in special cases	
b. Moderate	
c. High	Accuracy of results depends on availability of properly measured and generated data spheres. As with any noise model, comparing results with measurements will be heavily caveated by meteorological conditions
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	▪ NMSim: Flat-weighted max, A-weighted max, Leq, Ldn, Time-above ambient, Time-audible ▪ AAM results provide, if not explicitly, the implicit capability for literally any and all metrics to be calculated based off spectral time histories
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	▪ NMSim: Gives spectral noise level for 1/3 octave bands for frequencies from 50 Hz to 10 kHz ▪ AAM generally used from 10 Hz to 10 kHz in third octave bands. The model is flexible, however, and can handle narrowband data and pure-tone data as well
9. Policy or requirements	
a. Is this a preferred or required model?	Likely will be required for use with highly directional fighter jets for military noise evaluations
b. Input restrictions (i.e., parameter limits)	Currently input data is contingent on proper measurements, but steps are being taken to provide input for legacy aircraft where immediate measurement is not a

Model:	AAM (Advanced Acoustic Model) (NMSim + RNM)
	reasonable option
c. Limitations on application (i.e., scenario limits)	

Model:	CNM (Community Noise Model)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, but new users no longer provided model
b. Air quality or noise?	Noise.
a. Air quality: emission or dispersion?	N/A
b. Noise: SI, SPL, or other?	SPL, A-weighted (L_{Aeq1hr}, L_{dn})
c. Mode (highway, rail, water, air)	Highway, rail, community sources, limited air.
d. Screening or detailed (intended categorization)?	Detailed true simulation model
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	N/A
b. Noise (free field, long range propagation)	Free field with increased error occurring over 2000 feet.
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required model in US.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Applied ray acoustics. Reference Energy Mean Emission Levels are adjusted for each time step and vehicle operational mode and type. Then propagation considering geometric spreading, ground effects, diffraction, vegetation, and atmospheric absorption is considered. Many of the algorithms based on ISO9613. Reports in A-weighted values.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Closest to theoretical-based although first order approximation techniques are applied as well.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Requires input through GUI and forms a working database. Output reported in GUI and hard copy tables.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 95/98/ME/NT4/2000/XP.
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic..
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with central core executable program and DLL files.

Model:	CNM (Community Noise Model)
e. Distributed computing? (yes or no)	No. Not as designed.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No direct linkage.
g. Hardware/additional software requirements	IBM compatible PC with Pentium processor and above recommended.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	5 motor vehicle types (Autos, medium trucks, heavy trucks, buses, and motorcycles.), multiple rail engines and trailing cars, compressors, overflights, rail yard activities, user defined sources.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Reference Energy Mean Emission Levels for all 5 vehicle types by speed and mode (cruise, deceleration, acceleration, idle) which is updated for each time step.
c. Robustness of data (i.e., fidelity and resolution of data	Use of USDOT motor vehicle REMELS (as used in TNM), reported rail values and overflights. Measurements used for validation.
d. Traceability (e.g., documented sources, acceptability, etc.)	Data reported in document: user manual and Journal of the TRB.
e. Publicly available	Yes. Although no longer distributed.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Highway data including roadway/path/receiver geometry, traffic volumes/speeds/vehicle type, ground type. Rail movements, track locations, crossing locations. Community noise source types and locations.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Little flexibility in input data. Metric/English. Creation of user-defined sources accepted.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Straight forward graphical or spreadsheet entry.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Verified by multiple users in multiple countries but more needed on rail and community sources. Use of TNM REMELs make predictions reliable and added deceleration REMELs added to flexibility of use.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete with user guide (MacDonald, J, R.Wayson, Community Noise Model User's Guide, University of Central Florida..
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic copy on disk with model.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	More validation would be desirable, on acoustic and vehicle movement.
a. Valid only in special cases	
b. Moderate	
c. High	High. Validation indicates good results for areas in the immediate vicinity of highway. Especially good in the vicinity of intersections.

Model:	**CNM (Community Noise Model)**
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	L_{Aeq1hr}, L_{dn}, statistical metrics.
b. If air quality, what pollutants are covered?	N/A
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	A-weight reported.
9. Policy or requirements	
a. Is this a preferred or required model?	No.
b. Input restrictions (i.e., parameter limits)	Limited to use for normal urban sources (continuous sources).
c. Limitations on application (i.e., scenario limits)	In close proximity to highway.

Model:	**CREATE (Chicago Rail Efficiency and Transportation Efficiency)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes (developed by HMMH). It can be downloaded at: <http://www.fra.dot.gov/us/content/253>
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Road, rail
d. Screening or detailed (intended categorization)?	Screening
e. Scales of analysis	
a. Noise (free field, long range propagation)	Free field.
f. Regulatory use (e.g., NEPA assessments, etc.)?	The CREATE model is based on the Federal Transit Administration General Transit Noise Assessment.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Moving noise sources are modeled as line sources and propagation is assumed to take place over soft ground, resulting in an attenuation rate of 4.5 dB per doubling of distance. A speed coefficient is defined to represent the variability of SEL of a pass-by as a function of vehicle speed. Stationary noise sources are modeled as point sources and propagation is assumed to take place over soft ground, resulting in an attenuation rate of 7.5 dB per doubling of distance. Track noise sources add a predetermined constant number of decibels to the level Intervening rows of buildings add a 4.5 dB attenuation for the first row and 1.5 dB for each additional row (up to 5 rows and no more than 10 dB).
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Simple
b. First order approximation (e.g., partial vehicle	

Model:	CREATE (Chicago Rail Efficiency and Transportation Efficiency)
data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Program is spreadsheet, inputs and outputs in XLS file
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Operating system that supports MS Excel
c. Software language (e.g., Fortran, C#.NET, etc.)	Spreadsheet
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single spreadsheet
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	MS Excel
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Moving and stationary rail and road sources: • Moving Noise Sources: o Electric and diesel commuter locomotives o Commuter passenger cars o Light-rail transit (LRT) powered cars o Automated-guideway transit (AGT) cars (steel-wheeled and rubber-tired) o Monorail o Magnetic-levitation (Maglev) trains o Freight locomotives o Freight cars (typical and empty hopper) o Automobiles o Buses (city and commuter) o Commuter buses o Moving Noise Sources: • Stationary Noise Sources: o Track crossovers (switches, turnouts, crossing diamonds) o Rail yards or shops o Layover tracks o Bus storage yards o Bus operating facilities o Bus transit centers

Model:	CREATE (Chicago Rail Efficiency and Transportation Efficiency)
	o Parking garages o Park and ride lots Also includes option to include track noise sources such as: o Percentage of wheel flats for rail cars o Jointed track o Embedded track o Aerial structure
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Reference SELs at 50 feet, speed coefficients, reference speeds, etc.
c. Robustness of data (i.e., fidelity and resolution of data	Average, conservative values are used with approximations as needed.
d. Traceability (e.g., documented sources, acceptability, etc.)	Values are listed but not fully traceable.
e. Publicly available	Yes, included with spreadsheet
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Input data related to source: ▪ Source type, number of trains per hour for rail-related sources, number of vehicles per hour for road-related sources, number of locomotives or cars per train, duration of trains for track crossovers, and speed of vehicles. Input data related to receptor: ▪ Land-use type (FTA Category 1,2,3), distance to noise sources, presence of noise barrier, and intervening building rows.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Not very flexible--choose from predetermined options.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Simple spreadsheet
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Reliability assumed to be high because CREATE is not an intricate program.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User's guide at: <http://www.fra.dot.gov/us/content/253>
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF online
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	While the model has been extensively used, actual validation does not seem to have occurred.
a. Valid only in special cases	
b. Moderate	
c. High	
8. Outputs	

Model:	CREATE (Chicago Rail Efficiency and Transportation Efficiency)
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Hourly-equivalent (Leq) or day-night (Ldn) noise levels.
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Overall spectrum.
9. Policy or requirements	
a. Is this a preferred or required model?	Preferred.
b. Input restrictions (i.e., parameter limits)	Input up to 8 different types of noise sources.
c. Limitations on application (i.e., scenario limits)	Simple scenarios only with restrictions such as single height barriers, barrier parallel to tracks, and simple topography.

Model:	Florida Rail Model
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, available from Florida DOT.
b. Air quality or noise?	Noise.
a. Air quality: emission or dispersion?	N/A
b. Noise: SI, SPL, or other?	SPL, A-weighted (L_{Aeq1hr}, L_{dn})
c. Mode (highway, rail, water, air)	Rail with limited community sources.
d. Screening or detailed (intended categorization)?	Detailed true simulation model
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	N/A
b. Noise (free field, long range propagation)	Free field with increased error occurring over 2000 feet.
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not required model in US but results are consistent with FTA simplistic spreadsheet..
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Applied ray acoustics. Reference Energy Mean Emission Levels are adjusted for each time step and vehicle operational mode and type. Then propagation considering geometric spreading, ground effects, diffraction, vegetation, and atmospheric absorption is considered. Many of the algorithms based on ISO9613. Reports in A-weighted values.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Closest to theoretical-based although first order approximation techniques are applied as well.

Model:	Florida Rail Model
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Requires input through GUI and forms a working database. Output reported in GUI and hard copy tables.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 95/98/ME/NT4/2000/XP.
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic..
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with central core executable program and DLL files.
e. Distributed computing? (yes or no)	No. Not as designed.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No direct linkage.
g. Hardware/additional software requirements	IBM compatible PC with Pentium processor and above recommended.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Multiple rail engines and trailing cars including high speed rail and some rail yard activities. User defined sources as line, area, or point also possible..
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Reference Energy Mean Emission Levels for all cars and engines and is updated for each time step.
c. Robustness of data (i.e., fidelity and resolution of data	Values derived from multiple sources as reported in the literature. Measurements used for validation.
d. Traceability (e.g., documented sources, acceptability, etc.)	Data reported in document: user manual and Journal of the TRB.
e. Publicly available	Yes. Request through Florida DOT.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Rail movements, track locations, crossing locations, number of horn blasts.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Little flexibility in input data. Metric/English. Creation of user-defined sources accepted.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Straight forward graphical or spreadsheet entry.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Verified by multiple measurements at various locations. Comparison to FTA spreadsheet (simple cases only available in spreadsheet) shows consistency.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete with user guide (MacDonald, J, R.Wayson, Community Noise Model User's Guide, Florida Dept. of Transportation..
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic copy on disk with model.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	

Model:	**Florida Rail Model**
More validation would be desirable.	
a. Valid only in special cases	
b. Moderate	Moderate. Validation indicates good results for areas in the immediate vicinity of rail activities but more validation really needed.
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	L_{Aeq1hr}, L_{dn}.
b. If air quality, what pollutants are covered?	N/A
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	A-weight reported.
9. Policy or requirements	
a. Is this a preferred or required model?	No.
b. Input restrictions (i.e., parameter limits)	Limited to use in rail activities and user defined sources.
c. Limitations on application (i.e., scenario limits)	In close proximity to rail activities.

Model:	**HICNOM (Highway Construction Noise Computer Program)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Sponsored by the U.S. Department of Transportation Federal Highway Administration. Developed by Vanderbilt Transportation Research, Vanderbilt University.
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SI and SPL
c. Mode (highway, rail, water, air)	Highway Construction Noise
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	▪ Sources in HICNOM can have point, line or area geometries. Geometrical spreading, ground attenuation and barrier effects are incorporated. The 8-hour equivalent sound level is a function of the energy-averaged emission level over some time period measured at a reference distance, the number of hours the equipment is in operation, the excess attenuation rate, and the distance between the source and receiver. The energy averaged emission can be calculated as the Lmax (max level during the operating cycle of the equipment) and the difference between the max and the equivalent sound level values over the duty cycle. Calculations are made to represent equipment with a production rate associated with it where its production is being

Model:	HICNOM (Highway Construction Noise Computer Program)
	coordinated with that of another piece of equipment with a production rate. ▪ HICNOM uses an analogous method to that of FHWA Highway Traffic Noise Prediction Model (as of 1982) for both the haul and non-haul line source calculations. ▪ Area sources are defined by segments defining a centerline of the area and a width of the area at the specified segment points. The segments are analyzed separately and combined for the total level calculation. The excess attenuation for an area source is calculated by dividing the source into strips and calculating separately for each strip. ▪ Barrier effects for point sources are calculated according to Maekawa's formulation for screens. Barrier effects for line sources are calculated according to the Kurze and Anderson formulation in which the effect of shielding is integrated for point sources along the line. Barrier effects for area sources are calculated for each strip separately, applying the line source method. Only one barrier per source-receiver geometry is incorporated. ▪ Source height and frequency data are not used apart for barrier effect calculations.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	▪ Data is inputted through HINPUT, which asks the user for the inputs it needs. HICNOM then performs the acoustical calculations and produces the results. ▪ A results report is automatically printed after the program is run. An input data file report can be requested by the user with a TYPE or PRINT command made external to the program.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	
c. Software language (e.g., Fortran, C#.NET, etc.)	FORTRAN IV
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	The HICNOM code structure makes use of several subroutines.
e. Distributed computing? (yes or no)	Assumed no.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	

Model:	HICNOM (Highway Construction Noise Computer Program)
g. Hardware/additional software requirements	
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Database includes 53 different types of equipment. The source type and model number are used to select a particular piece of equipment.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	▪ Data for point, line, and area sources. ▪ Categories of data that may be contained in the database include: Lmax, (dBA), Delta (dBA), Cycle Time (hrs), Capacity (cu. yds.), Acoustic Height (ft.), Acoustic Frequency (Hz), Reference Speed (mph), Slope, Critical Speed (mph).
c. Robustness of data (i.e., fidelity and resolution of data	
d. Traceability (e.g., documented sources, acceptability, etc.)	Most of the data in the model was gathered for the program's development, but some was obtained from a review of the literature.
e. Publicly available	Available in Volume 5 of the FHWA Highway Construction Noise Handbook, probably for price.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	User must provide the number and coordinates of receivers, the excess attenuation rate from the source to each receiver, names and model numbers of equipment used, coordinates of points defining positions and geometries, the number and coordinates of barriers, and, potentially, the speed and hourly volume for haul operations, the type of turn-arounds for loops on haul roads, source activity data, and the noise level and operational data for user-defined equipment.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Allows for user-defined sources. These can be permanently entered into the database.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	User responds to data entry prompts by the program.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User's Manual
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	A pdf was prepared for this research, at a price. Hardcopies exist.
7. Validation and confidence use ▪ Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate. Measurements were made at three construction sites for Interstate 440 in Nashville, Tennessee and compared to predictions for model validation. Results of differences between measured and predicted levels were 2.7, 2.7, and 2.5 dB, with the model always underpredicting levels. Conclusion was that model

Model:	**HICNOM (Highway Construction Noise Computer Program)**
	is accurate to the degree that input data assumptions are accurate.
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Predicts 8-hour equivalent sound levels (Leq(8h)) and the sound level and intensity contributions of each source.
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Overall spectrum, A-weighted. Uses representative frequencies for each source when calculating barrier effects.
9. Policy or requirements	
a. Is this a preferred or required model?	
b. Input restrictions (i.e., parameter limits)	HICNOM can use up to 10 point sources, up to 6 line sources (defined by up to 10 points each), up to 5 area sources (defined by up to 10 centerline points and widths each), and up to 3 barriers (defined by up to 5 top edge points each).
c. Limitations on application (i.e., scenario limits)	Up to 10 receiver locations.

Model:	**Horn Model**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes. Available at Federal Railroad Administration's <http://www.fra.dot.gov/us/content/254>
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Train horn
d. Screening or detailed (intended categorization)?	Screening
e. Scales of analysis	
a. Noise (free field, long range propagation)	Free field
f. Regulatory use (e.g., NEPA assessments, etc.)?	Evaluation of horn noise by FRA
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	▪ Moving noise sources are modeled as line sources and propagation is assumed to take place over soft ground, resulting in an attenuation rate of 4.5 dB per doubling of distance (3 dB from divergence and 1.5 dB from ground effect). ▪ Atmospheric effects are not incorporated. ▪ Shielding from rows of buildings add a 3 dB attenuation for the first row (assumed to be at 200 feet from the tracks) and 1.5 dB for each additional row (assumed to be at 400, 600, 800, and 1000 feet from the tracks).
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Simple
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	

Model:	Horn Model
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Program is spreadsheet, inputs and outputs in XLS file
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Operating system that supports MS Excel
c. Software language (e.g., Fortran, C#.NET, etc.)	Spreadsheet
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single spreadsheet
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	MS Excel
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Train horn
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	User inputs Horn Lmax (dBA) @ 100 feet
c. Robustness of data (i.e., fidelity and resolution of data	Based on field measurements but average values used.
d. Traceability (e.g., documented sources, acceptability, etc.)	Field measurements at grade crossings from many railroads were used as the basis for the source reference. The reference level for the source is modeled as constant from 1/4 of a mile to 1/8 of a mile from the crossing and increases linearly from 1/8 of a mile to crossing. (This is because data shows the horn is sounded more continuously and more loudly as the train approaches the crossing.)
e. Publicly available	Yes
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	User must input parameters: ▪ Noise situation (horns existing and future, horns in future only, no horns existing and future) ▪ Horn Lmax (dBA) @ 100 feet ▪ Horn location on locomotive (National Average: 50% front, 50% middle, all front mounted, all middle mounted, or used defined) ▪ Non Train Noise Environment (Urban, suburban, rural, or used defined Ldn) ▪ Shielding (Dense Urban, Light Urban, Dense Suburban, Light Suburban, Rural, No Shielding) ▪ Length of Impact Area (1/4 mile, 20 seconds, 15 seconds) ▪ Existing and future train speed (mph) ▪ Number of existing and future trains in one direction

Model:	**Horn Model**
	▪ Existing and future number of day trains (7am-10pm) ▪ Existing and future number of night trains (10pm-7am) ▪ Existing and future average number of cars ▪ Existing and future average number of locomotives
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	User defines Lmax of the source
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Simple spreadsheet
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Reliability assumed to be high because the Horn Model is not an intricate program.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Webpage on Horn Noise Questions and Answers: <http://www.fra.dot.gov/us/content/1173> Instructions sheet in spreadsheet
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Webpage online
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	Has been used in multiple document but actual validation not listed. The original data taken from average of field measured data.
a. Valid only in special cases	
b. Moderate	
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	▪ Existing and future 65 Ldn contour at crossing (in feet) ▪ Existing and future 65 Ldn contour at 1/2 zone length (in feet) ▪ Zone and 1/2 zone length (in feet) ▪ Impact and severe impact distance at crossing (in feet) ▪ Impact and sever impact distance at 1/2 zone length (in feet)
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Overall spectrum, A-weighted
9. Policy or requirements	
a. Is this a preferred or required model?	Preferred by FRA.
b. Input restrictions (i.e., parameter limits)	Specified source with average values. General ground effects, shielding and divergence taken into account from input parameters. Limited to ¼ mile of crossing.
c. Limitations on application (i.e., scenario limits)	For use only of specific source.

Model:	HSRNOISE (High-Speed Rail Initial Noise Evaluation)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes (developed by HMMH). Available on the Federal Railroad Administration website. It can be downloaded at: <http://www.fra.dot.gov/us/content/167>
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Rail
d. Screening or detailed (intended categorization)?	Screening
e. Scales of analysis	
a. Noise (free field, long range propagation)	
f. Regulatory use (e.g., NEPA assessments, etc.)?	HSRNOISE uses the methods of Chapter 4 of the "High-Speed Ground Transportation Noise and Vibration Impact Assessment (FRA,1998).
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Simple equations are applied and corrections are made to reference levels provided for the three types of high-speed rail sources. Corrections are applied for attenuation of noise with distance and geometry, and shielding by intervening rows of buildings.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Simple
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Program is spreadsheet, inputs and outputs in XLS file
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Operating system that supports MS Excel
c. Software language (e.g., Fortran, C#.NET, etc.)	Spreadsheet
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single spreadsheet
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	MS Excel
4. Database	
a. What sources are included? (e.g., number and types of	▪ Train types: electric, fossil fueled, maglev

Model:	HSRNOISE (High-Speed Rail Initial Noise Evaluation)
vehicles, stationary source, etc.)	▪ Track Geometries: tracks at grade, tracks in shallow cut, tracks in deep trench/cut, tracks on aerial structure, tracks on embankment, noise barrier.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	▪ For each combination of train type and speed regime, the Reference SEL, Speed Coefficient, Reference Speed, Reference Length, and Transition Speed are provided. ▪ For each combination of track geometry and speed regimes, a shielding correction is provided.
c. Robustness of data (i.e., fidelity and resolution of data	
d. Traceability (e.g., documented sources, acceptability, etc.)	
e. Publicly available	Yes, included with spreadsheet.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	User inputs Land Use Category (Outdoor Quiet, Residences, or Institutional) of receiver, Receiver Data including distance to the track center line, and number of intervening building rows, and Train Data including train type (pick from list), speed, length of each power car, length of each passenger car, number of power cars in consist, number of passenger cars in consist, track geometry (pick from list), number of daytime trains, and number of nighttime trains.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Not very flexible--choose from predetermined options.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Simple spreadsheet
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Reliability assumed to be high because HSRNOISE is not an intricate program.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Description of HSRNOISE spreadsheet is provided as the first sheet of the spreadsheet. It outlines the purpose, implementation, and interpretation of the model.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Sheet within spreadsheet.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Ldn, daytime Leq, nighttime Leq, or peak hour Leq.

Model:	HSRNOISE (High-Speed Rail Initial Noise Evaluation)
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Overall spectrum, A-weighted.
9. Policy or requirements	
a. Is this a preferred or required model?	
b. Input restrictions (i.e., parameter limits)	One type of high-speed rail source.
c. Limitations on application (i.e., scenario limits)	One receiver.

Model:	IMMI 6.3.1
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. It is a product of the German company, Wölfel Meßsysteme. There are 3 versions of IMMI: Standard, Plus, and Premium.
b. Air quality or noise?	Air quality and noise
a. Air quality: emission or dispersion?	Dispersion (for gaseous and odorous pollutants and dust) and emission.
b. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Road, rail, air, industrial and recreational noise
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Maps can be calculated for projects of any scale
b. Noise (free field, long range propagation)	Maps can be calculated for projects of any scale
f. Regulatory use (e.g., NEPA assessments, etc.)?	IMMI complies with national and international (ISO/EU) noise calculation standards and with Austrian and German air pollution calculation standards.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	IMMI includes over 20 different noise calculation methods and 3 air dispersion modeling methods. Noise modeling effects such as reflections, diffraction, ground effect, geometric divergence, atmospheric absorption, and meteorological corrections are calculated according to the chosen calculation method. Road: o EU Interim Method: XP S 31-133/NMPB and Guide du Bruit o National methods: CRTN (UK), XP S 31-133 (France), RMW-SRMII (Netherlands), TemaNord 1996:525 (Nordic), StL-86 (Switzerland), RVS 3.02 (Austria), RLS-90 (Germany). Rail: o EU Interim Method: RMR-SRM II-1996 o National methods: CRN (UK), XP S 31-133 (France), RMR-SRM II (Netherlands), TemaNord 1996:524 (Nordic), SEMIBEL (Switzerland), ÖNorm S 5011 (Austria), SCHALL 03 (Germany) Industrial:

Model:	IMMI 6.3.1
	o EU Interim Method: ISO 9613-2 o National methods: Nordic Standard (Nordic), VDI 2714/2720/2571 (Germany), ISO 9613-1 & 9613-2 (International), BS 5228 (UK), ÖAL 28 (Austria) Aircraft: o EU Interim Method: ECAC.CEAC Doc. 29 1997 and Segmentation o National methods: ÖAL 24 (Austria), AzB/AzB-L (Germany), DIN 45684 IMMI uses a Gaussian air dispersion model, based on the German TA-Luft, Annex C of 1986. Point, line, and area sources are used for air pollution. IMMI can be equipped with the Lagrangian air dispersion model (using the external calculation module AUSTAL2000). Statistical meteorological data such as wind speed, wind direction, and stability classes are used for calculations The meteorological correction for long-term noise levels is calculated according to ISO 1996-2, where required. Average indoor levels are calculated according to a Sabine formula spreadsheet.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	▪ Measured spectra can be imported from text files or clipboard. ▪ Noise maps can be exported to bitmaps and EMF vector graphics, DXF graphics formats, numeric text files, numeric dBase files, text and binary float raster data interface to ArcGIS applications (e.g. ArcView Spatial Analyst). ▪ Numerical results can be exported to text, EXCEL, WORD, and RTF.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 32-bit
c. Software language (e.g., Fortran, C#.NET, etc.)	
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	
e. Distributed computing? (yes or no)	Yes, with the AUDINOM option, IMMI accommodates distributed computing among several computers or within multi-core computers. A full license is

Model:	IMMI 6.3.1
	required for the "master" computer and one or several client licenses are required for the "slave" computers.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	GoogleEarth interface. Data interface with ArcView/ArcGIS (SHP) and MapInfo (MID/MIF).
g. Hardware/additional software requirements	
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	IMMI includes a database of predefined airplanes and helicopters and allows user-defined aircraft. It also includes emission, transmission, and reflection spectra. Choices of databases exist for industrial, rail, building machinery, and recreation noise.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	An Austro-German aircraft noise emission database, which is associated with the data-acquisition system for airports, is included with IMMI.
c. Robustness of data (i.e., fidelity and resolution of data	IMMI can calculate complete error statistics including confidence intervals, standard deviation and average, maximum and minimum error. A forecast feature can estimate the accuracy of results, in compliance with the latest release of DIN 45687 (quality assurance of noise mapping software packages). Air quality errors for concentration and deposition can be displayed graphically.
d. Traceability (e.g., documented sources, acceptability, etc.)	Databases include: ▪ VDI 2571 (Industrial) and ÖAL 28 (Industrial and Rail) ▪ VDI 3770 (Recreational activities) ▪ Noise emission from building machinery HLUG, Heft 2 ▪ Saxonian study of noise from recreational activities ▪ ÖAL 33 for gastronomy (assumed to be restaurants) ▪ Sound forum for noise from industrial machinery
e. Publicly available	
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	User can define grid mesh size, noise emission spectra and transmission loss databases. Spectra can be imported from and exported to Excel.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	▪ IMMI includes a 3D viewer with which the user can display noise maps, overlay noise maps, record AVI videos, define fixed flight paths, etc. ▪ 3D schemes can be drawn on-screen with the mouse. ▪ IMMI can display 2D horizontal and vertical grids with noise contours
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	English Reference Manual, 2 volumes, over 600 pages. In addition, IMMI provides an online help system, manuals for aircraft noise, ESRI shape file and MapInfo MID/MIF data exchange interfaces, and air pollution calculation, and a

Model:	IMMI 6.3.1
	free service period and maintenance contracts covering hotline support and updates.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	Rasmussen claims it was "tested against all available test cases for the existing calculation methods." IMMI is certified for German aircraft noise calculation.
a. Valid only in special cases	
b. Moderate	
c. High	High
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	**Noise:** L_{eq}, L_{day}, $L_{evening}$, L_{night}, L_{den}, L_{Amax}, L_{10} and other sound or statistical indicators can be calculated depending on the calculation method employed. **Air Quality**: Average and 50-99 percentiles of concentration and deposition can be calculated for gases and dust. Percentage of hours of a year with odor perception can be calculated for odors.
b. If air quality, what pollutants are covered?	Using the Lagrangian air dispersion model, up to 45 pollutants are covered.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Calculation in 1/3-octave bands for industrial noise. Calculation in octave bands for other source types if required by the calculation method.
9. Policy or requirements	
a. Is this a preferred or required model?	Not required.
b. Input restrictions (i.e., parameter limits)	No limitation on the number of elements.
c. Limitations on application (i.e., scenario limits)	IMMI can use up to 25 orders of reflection. IMMI Standard can use up to 400,000 terrain nodes, 8001 by 8001 grid points, and 200 obstacles (each of which can have up to 500 nodes, allowing up to 99,800 horizontal diffracting edges). IMMI Plus can use up to 400,000 terrain nodes, 8001 by 8001 grid points, and 1000 obstacles (each of which can have up to 500 nodes, allowing up to 499,000 horizontal diffracting edges). IMMI Premium can use up to 4,000,000 terrain nodes, 40,001 by 40,001 grid points. Only the available RAM limits the number of obstacles.

Model:	**INM (Integrated Noise Model)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Available for purchase ($300) to public. Developed and maintained by: ▪ FAA Office of Environment and Energy (AEE-100)--project management ▪ ATAC Corporation--system integration, user interface, and flight model ▪ Volpe National Transportation Systems Center (VNTSC)--noise model
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Air
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Noise (free field, long range propagation)	The scope of analysis is the terminal area. INM standard profiles start at 6,000 feet above the airport for approaches and end at 10,000 feet above the airport for departures. INM standard aircraft do not exist above these altitudes; consequently, no noise is produced. Sound exposure levels are calculated from NPD tables which range from 200 feet to 25000 feet. Extrapolation is performed beyond 25000 feet. Below 200 feet, 10Log is used for exposure-base noise metrics and 20Log is used for maximum noise metrics.
f. Regulatory use (e.g., NEPA assessments, etc.)?	Used for FAR Part 150 noise compatibility planning, FAR Part 161 approval of airport noise restrictions and, as stipulated by FAA Order 1050.1E, environmental assessments and environmental impact statements.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Segmentation model incorporates spherical spreading, atmospheric absorption, terrain shielding, lateral attenuation, and ground effects. It is based on standards documents: ▪ SAE-AIR-1845: "Procedure for the Calculation of Airplane Noise in the Vicinity of Airports" ▪ SAE-AIR-5662: "Method for Predicting Lateral Attenuation of Airplane Noise" ▪ SAE-ARP-866A: "Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity" ▪ ECAC Doc 29: "Report on Standard Method of Computing Noise Contours around Civil Airports" ▪ ICAO Circular 205: "Recommended Method for Computing Noise Contours Around Airports" ▪ HNM 2.2 integrated into INM, including additional adjustments applicable only to helicopters such as source noise due to advancing tip Mach Number, Lateral Directivity, static directivity, and static operation duration.
a. Which category does the model fall into:	

Model:	INM (Integrated Noise Model)
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Input files: DXF, Polyline TXT, Census 2000, and Radar Track CSV files, Census Tiger/Line data, 3CD/TX terrain data, GridFloat and DEM terrain data The format of most INM input and output files is dBase IV (DBF file extension)
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 2000 or XP
c. Software language (e.g., Fortran, C#.NET, etc.)	C++
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components
e. Distributed computing? (yes or no)	Yes. Has multi-threaded run mode that can make use of a PC's multiple cores by dividing calculations between cores to run in parallel for a given scenario.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	3-tier Study/Scenario/Case input data structure that will be easier to integrate into AEDT
g. Hardware/additional software requirements	PC with minimum Pentium III processor hardware configuration 1.0-Gb RAM
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	3 aircraft types: Civil Airplanes, Military Airplanes, and Helicopters (over 250 fixed-wing aircraft includes commercial aircraft, military aircraft, small turboprop, and piston aircraft, 19 different helicopters)
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	NPD and performance data. Helicopter NPDs classified by operational mode (organized in categories of dynamic or static modes) rather than thrust/power setting. They come in sets of three for dynamic operational modes to represent the asymmetric directivity of helicopter noise, corresponding to noise levels directly below the helicopter and at angles of approximately 45 degrees to the left and right of the centerline.
c. Robustness of data (i.e., fidelity and resolution of data	Data complies with specifications and formats of SAE AIR 1845 and endorsed by ECAC
d. Traceability (e.g., documented sources, acceptability,	Data from most of the larger modern aircraft models is supplied by the

Model:	INM (Integrated Noise Model)
etc.)	manufacturers and was acquired during noise certification tests carried out under internationally standardized procedures regulated by national certification agencies. Data from other aircraft was acquired from other sources like controlled tests carried out by national noise modeling agencies in various countries. The database specifies the source of the data and, possibly, more detailed information about the processes applied to derive the data for each listed aircraft.
e. Publicly available	NPD and performance data are available for free from Eurocontrol's Aircraft Noise and Performance (ANP) database at <http://www.aircraftnoisemodel.org>
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Standard info on airport/heliport (e.g. runway position, airport elevation, etc.), terrain data file if terrain is to be used in noise computation, aircraft information (e.g. flight operation type, flight path, etc.), observer information (e.g. regular grid, location points, or irregular grid), noise metric information (e.g. metric identifier (DNL, SEL, etc.), low and high cutoff contour level (dB or minutes), etc.). Helicopter flight paths are not defined with flight tracks like fixed-wing aircraft. Data for helicopter procedure steps include: horizontal coordinate relative to an origin, altitude of the helicopter above the helipad, helicopter true airspeed at the point, helicopter operational mode, and time spent at the location for static operational modes.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	▪ User can define own flight profiles, aircraft source noise data, and basic aircraft data. ▪ User can specify grid resolution.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	▪ Menu of functions allows user to manage study, input data, run model and display results. ▪ Interactive data entry in input windows ▪ Interactive ground track data entry in graphics window ▪ Option to import data from specially formatted text files ▪ Direct edit of DBF input files in spreadsheet or database management program permitted. ▪ Output charts, graphics, and tables displayed
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Reliable. Any problems are resolved by the caretakers cited above.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User's guide, technical manual
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	CD-ROM with electronic copies of the User's Guide and Technical Manual, one paper User's Guide included with purchase
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	

Model:	INM (Integrated Noise Model)
a. Valid only in special cases	
b. Moderate	Moderate
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	A-Weighted Noise Metrics ▪ SEL (A-Weighted Sound Exposure Level), ▪ DNL (Day Night Average Sound Level), ▪ CNEL (Community Noise Equivalent Level), ▪ LAEQ (Equivalent Sound Level), ▪ DDOSE (Change in Exposure), ▪ LAMAX (A-Weighted Maximum Sound Level), ▪ TALA and %TALA (Time-Above and Percent Time-Above), ▪ TAUD and %TAUD (Time Audible and Percent Time Audible), C-Weighted Noise Metrics ▪ CEXP (C-Weighted Sound Exposure Level), ▪ LCMAX (C-Weighted Maximum Sound Level), ▪ TALC and %TALC (Time-Above and Percent Time-Above), Tone-Corrected Preceived Noise Metrics ▪ EPNL (Effective Perceived Noise Level), ▪ NEF (Noise Exposure Forecast), ▪ WECPNL (Weighted Equivalent Continuous Perceived Noise Level), ▪ PNLTM (Tone-Corrected Maximum Perceived Noise Level), ▪ TAPNL and %TAPNL (Time-Above and Percentage Time-Above)
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Displays overall spectrum. However, 1/3 octave band spectrums with frequencies of 50 to 10,000 Hz are used to calculate levels.
9. Policy or requirements	
a. Is this a preferred or required model?	Required model per 14 CFR Part 150, 14 CFR Part 161, and FAA Order 1050.1E.
b. Input restrictions (i.e., parameter limits)	No limit with respect to airport layout or size, number of operations, or fleet mix, although INM's database is not as extensive for smaller aircraft.
c. Limitations on application (i.e., scenario limits)	INM is for use around single airports. NIRS is used for large-scale areas with multiple airports. INM designed to use average input data to estimate long-term average noise levels. It is not meant for single-event noise prediction.

Model:	Lima™
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. It is the product of the German company Stapelfeldt Ingenieurgesellschaft.
b. Air quality or noise?	Air pollution and noise
a. Air quality: emission or dispersion?	Emission and dispersion
b. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Road, rail, aircraft, industrial, sports, leisure, water traffic
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Maps can be calculated for projects of any scale
b. Noise (free field, long range propagation)	Maps can be calculated for projects of any scale
f. Regulatory use (e.g., NEPA assessments, etc.)?	
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Lima can use the noise calculation methods presented in any of the following standards and guidelines (as specified by the Mapping Software Catalogue spreadsheet): ▪ Road Noise: RLS 90, VBUS, DIN 18005, RVS_3.02/RVS, NMPB/XPS31-133, CRTN, ISO9613, UT2.1-302 ▪ Rail Noise: Schall 03, VBUSCH, DIN 18005, AKUSTIK 04, TRANSRAPID, ÖAL 30/ÖNORM_S_5011, CRN, RLM2/SRM2, ISO9613, MSZ2904 XPS/FER ▪ Aircraft Noise: AzB, VBUF, AzB-L, DIN 45684, LBF, ECAC DOC 29 ▪ Industrial Noise: VDI2714, VDI2720, VDI2571, ISO9613-2, ÖAL 28, DAL 32, Harmonoise, MSZ15036, DIN18005, VBUI, BS5228 Lima can include reflections up to the 10th order and sideways diffraction. Air pollution from road traffic or industrial sources can be calculated using the German regulation MLuS92, using VDI 3782, solving the 3D equation of compressible gas flow for up to 400 by 400 by 20 nodes using the program developed by Prof. Dr.-Ing. Schenk, Halle), or using the Canyon Plume Box (CPB) model with the program developed by IVU, Berlin.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation
c. Theoretically-based (e.g., vehicle-specific with individual	

Model:	Lima™
characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Geometry inputs are done by digitizer, mouse, keyboard or data import. LimA has import tools for ARC INFO, ARC VIEW, SICAD SD, ALK GIAP, ATKIS, MAP INFO, ATLAS GIS, GRANIS, CITRA, EZSI, MOSS, DXF. Mouse input supported by PCX- or TIFF-maps, optionally. Can also import DXF, XML, VISUM, INM result, TNM result, MOSS, and B&K Measurement data. (Mapping software Catalogue spreadsheet) HPGL/HPGL-2 or POSTSCRIPT can be used for graphic output. Module data exchange can use ASCII text files.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	MS-DOS, Windows, Windows 9x, Windows NT, UNIX
c. Software language (e.g., Fortran, C#.NET, etc.)	FORTRAN
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components
e. Distributed computing? (yes or no)	Comment made in Mapping Software Catalogue spreadsheet implies that there is.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Can be combined with SAIL II in order to use scanned maps for digitizing and result presentation. Lima can be embedded in GIS using LimAarc (as stated in the Mapping Software Catalogue spreadsheet)
g. Hardware/additional software requirements	
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	11 different types of emitter such as road traffic, railway traffic, industrial noise, sports, etc.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	
c. Robustness of data (i.e., fidelity and resolution of data	
d. Traceability (e.g., documented sources, acceptability, etc.)	
e. Publicly available	
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	▪ Geometric data can be imported and LimA will automatically close any gaps in data derived from aerial surveys. ▪ Objects that can be included are: o Natural obstacles (contour lines, punctual altitude information, break edges (quarries, etc.), embankments, gridnet altitude information, woods) o Artificial obstacles (screens, areas of average attenuation, cantilever roofs, buildings, roofs, bridges)

Model:	**Lima™**
	o Emitting objects (punctual emission source, line emission source, area emission source, vertical area emission source, moveable point source) o Special objects (traffic lights, areas of restriction for maximum noise level, graphic symbols, survey points, economic areas, planning zones)
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	One approach available in LIMA for aircraft noise allows the definition of point sources with time dependent intensity, directivity pattern, positioning, and width and height of flight corridors.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Entering geometry input is done by digitizer, mouse, keyboard, or data import. 3D visualization, 10 forms of tabular result documentation and a variety of forms of graphic outputs.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	
7. Validation and confidence use ▪ Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Benchmarked with all published official test cases (as stated in the Mapping Software Catalogue spreadsheet)
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Lden, Lnight, Leq 24 based on Lday, evening and night, L10, LASmax, LAZ, LAX, SEL for aircraft noise and moving point sources, total annoyance.
b. If air quality, what pollutants are covered?	
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Calculated in average frequency or octave bands.
9. Policy or requirements	
a. Is this a preferred or required model?	Not required.
b. Input restrictions (i.e., parameter limits)	No software-imposed limitation on number of elements
c. Limitations on application (i.e., scenario limits)	Number of emitting elements and obstacles is limited by computer memory. A standard configuration of approximately 250,000 line elements can be used 32 MB RAM. Noise levels can be calculated for grids of 32,000 by 32,000 points.

Model:	NIRS (Noise Integrated Routing System)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	NIRS is the FAA's standard regional noise model and can be purchased from the distributor, Metron Aviation. NIRS Screening Tool (NST) may only be used by FAA employees
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Air
d. Screening or detailed (intended categorization)?	Detailed. Another tool, the NIRS Screening Tool (NST), is used for simple air traffic changes, such as aircraft route, aircraft altitude, aircraft mix, number of operations, time of day or operational procedures, at altitudes above 3,000 feet over noise sensitive areas.
e. Scales of analysis	
a. Noise (free field, long range propagation)	Long range propagation. NIRS was designed to be used over broad areas with multiple airports.
f. Regulatory use (e.g., NEPA assessments, etc.)?	As stipulated in FAA Order 1050.1E, NIRS is to be used when noise is assessed in areas larger than the immediate vicinity of an airport, when multiple airports are involved, or when actions being considered are at altitudes above 3,000 feet AGL. NIRS is then used to determine noise impacts at altitudes up to 10,000 feet AGL. NIRS is also one of the models used to assess the significance of proposed changes affecting the level of aviation noise.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	NIRS is based on the same noise computation algorithms as INM.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	NIRS organizes applications as projects, which contain all input files, output files, reports, and graphics. NIRS organizes projects in a directory/file structure with the project files being a mix of ASCII and XML text, binary, and JPEG/GIF.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	▪ Linux RedHat 9.0 or greater, an equivalent Linux distribution, or Microsoft Windows XP SP2 or greater
c. Software language (e.g., Fortran, C#.NET, etc.)	▪ Java & C++

Model:	NIRS (Noise Integrated Routing System)
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	▪ Multi executable, project level management ▪ Single Java executable wrapping several C++ executables with access to a dozen or so data files.
e. Distributed computing? (yes or no)	▪ Yes
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	▪ Intended to work with other Air Traffic modeling systems that provide information on source of routes, events, and Air Traffic procedures (e.g. altitude restrictions) ▪ Can import SDAT traffic files and TIGER population files. ▪ Capabilities to be integrated with AEDT
g. Hardware/additional software requirements	▪ PC compatible computer ▪ 512 MB RAM ▪ 4 MB to install software ▪ 100-2000 MB or more of disk space for projects, depending on project size.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Same as INM: 3 aircraft types: Civil Airplanes, Military Airplanes, and Helicopters
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Same as INM: NPD, performance profile data
c. Robustness of data (i.e., fidelity and resolution of data	Same as INM: Data complies with specifications and formats of SAE AIR 1845 and endorsed by E
d. Traceability (e.g., documented sources, acceptability, etc.)	Same as INM: Data from most of the larger modern aircraft models is supplied by the manufacturers and was acquired during noise certification tests carried out under internationally standardized procedures regulated by national certification agencies. Data from other aircraft was acquired from other sources like controlled tests carried out by national noise modeling agencies in various countries. The database specifies the source of the data and, possibly, more detailed informatio about the processes applied to derive the data for each listed aircraft.
e. Publicly available	Same as INM: NPD and performance data are available for free from ICAO's Aircraft Noise and Performance (ANP) database at <http://www.aircraftnoisemodel.org/>
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Inputs include: runway data, population census data, grid data, scenarios or design alternatives, airspace routes, traffic files.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	User can define a flight track in three-dimensions or use "standard" profiles that are consistent with the airspace design. NIRS can mix traffic from different operational configurations to appropriately represent average annual airspace and runway use
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	From the main window interface, the user can: build and organize a study, error check all inputs and outputs, perform noise computation, analyze impacts and

Model:	NIRS (Noise Integrated Routing System)
	trace their causes, format the output for reports and graphics that can be used in Word, Excel or Powerpoint.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Same as INM
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Thompson, T, et al., Noise Integrated Routing System User's Guide -Version 7.0, Metron Aviation, Inc., October 2008. Available with distribution of software.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Similar to INM: A detailed validation and verification process comparing INM and NIRS results is performed for each release of NIRS.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	NIRS produces population impact and change-of-exposure reports and graphics and can determine which traffic elements are causing significant noise impacts. Change-of-exposure tables and maps use the criteria of plus or minus 1.5 dB for DNL greater than 65, plus or minus 3 dB for DNL between 60 and 65 dB and plus or minus 5 dB for DNL between 45 and 60 dB. Additionally, NIRS can output noise maps for population and grids over all 16 INM metrics.
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Same as INM: Displays overall spectrum. However, 1/3 octave band spectrums with frequencies of 50 to 10,000 Hz are used to calculate levels.
9. Policy or requirements	
a. Is this a preferred or required model?	Required.
b. Input restrictions (i.e., parameter limits)	Realistic input parameters should be acceptable and produce reasonable results
c. Limitations on application (i.e., scenario limits)	NIRS is meant to be a large-scale model involving multiple airports as opposed to INM, which is meant to be used for noise assessments around a single airport

Model:	**NOISEMAP**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	The basic version of NOISEMAP can be freely downloaded at www.wasmerconsulting.com,Äîbaseops.htm. <http://www.wasmerconsulting.com/baseops.htm.> and used and distributed as acknowledgement-ware meaning that Wasmer Consulting must be acknowledged as the author. The Air Force Research Laboratory (AFRL/RHCB) oversees its development and maintenance.
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Air
d. Screening or detailed (intended categorization)?	Detailed analysis for Environmental Impact Statements
e. Scales of analysis	
a. Noise (free field, long range propagation)	Far field noise propagated long distances with rudimentary terrain effects
f. Regulatory use (e.g., microscale, regional, national, etc.)	The noise contours produced are used by base planners for on-base sitting and to advise local communities through the Air Installation Compatible Use Zone (AICUZ) program, encouraging development that protects airbase operational mission requirements.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation)	▪ Whereas INM flight tracks are point-to-point tracks, NOISEMAP flight tracks are represented as vectors. ▪ NMAP is the NOISEMAP component that propagates the sound and calculates the noise contours. ▪ 2 ground impedances: hard (effective flow resistivity = 1,000,000 kNs/m^4) or soft (effective flow resistivity = 200 kNs/m^4) ▪ Can use hard ground, soft ground, or a combination of the two. ▪ Terrain can be flat, a valley, or a hill (wedge or wall). Based off approximation Maekawa and Rasmussen algorithms for shielding and diffraction effects. Integrated models such as INM and Noise map cannot handle anisotropic effects such as weather and terrain properly. ▪ Monthly average temperature, relative humidity and atmospheric pressure used to calculate atmospheric absorption.
a. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with	First order approximation

Model:	NOISEMAP
average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	▪ Cases stored in BASEOPS file. Can also edit flight operations in Excel spreadsheet (XML). ▪ 2 files to compute noise exposure from aircraft operating on multiple flight tracks: o RUN files: contain specifications for execution of noise model o OPX files: contain descriptions of flight and run-up events ▪ OPX files (and most other files) in NMAP 7 are ASCII ▪ Display background maps can be stored as: o ARC/INFO Shapefile (SHP) o Digital Line Graph (DLG) o AutoCAD Data Exchange Format (DXF) o Georeferenced Bitmap (BMP, TIF, JPG, PNG) o Compressed ARC Digitized Rater Graphics (CADRG)
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows XP or Vista
c. Software language (e.g., Fortran, C#.NET, etc.)	FORTRAN? (NMAP is in FORTRAN)
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	3 Fundamental components: BASEOPS (input), NMAP (modeling), and NMPLOT (output).
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Can use RNM instead of NMAP to calculate noise from helicopters if RNM is installed. INM cases can be imported, but should be carefully checked to make sure no changes in the case where caused by importing. BaseOps exports noise level contours to a ARC/INFO Shapefile Noise level contours can be imported into a third-party Geographic Information System (GIS) as most GIS's can import shapefiles.
g. Hardware/additional software requirements	Processor--1.0 GHz Pentium Memory--512 MB Monitor--64,000 colors (i.e. 16-bit color), resolution of 1024x768 Hard Drive Space--50 MB
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Large number of aircraft preprogrammed in with different engine options. Number of variations on 4 types of flight tracks: arrival, departure, closed pattern,

Model:	NOISEMAP
	and interfacility All reference noise data normalized to airspeed of 160 knots and sea level conditions.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Major data files are: ▪ Flight01.dat: database of flyover spectral sound power levels for many aircraft, power settings, and airspeeds. ▪ INM10SEL.dat: dataset of SEL versus distance for several INM aircraft. ▪ Static01.dat: database of static spectral sound power levels for many aircraft and power settings for runups. Data appears to be in the form of NPD curves Hemisphere files for new aircraft in RNM can be used
c. Robustness of data (i.e., fidelity and resolution of data	Flight Data is provided as integrated metrics and a spectrum for the angle of maximum noise relative to the aircraft. Static runup data is provided on a circle around the vehicle as a function of third octave band – generally 50 to 5,000 Hz
d. Traceability (e.g., documented sources, acceptability, etc.)	Has been accepted as the standard for environmental impact statements for military bases for the past few decades
e. Publicly available	Available with NOISEMAP, which is publicly available
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Standard inputs including information like flight track, engine, engine power setting, etc. RNM aircraft may require additional information like yaw angle, angle of attack, roll angles, and nacelle angle. If actual flight profile is unknown, a standard flight profile for the aircraft may be selected from a library in BaseOps
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	▪ User can create higher resolution contours with finer grid spacing around an area of interest. ▪ Runways, flight tracks, flight profiles, etc. all have editable options. ▪ If desired aircraft not included in standard aircraft library, user can define an aircraft substitution, using an aircraft in the library as an equivalent proxy. ▪ Different scenarios can be defined in a single case allowing, for example, a different number of flight profile operations or static profiles. When case is run, noise data calculated for each scenario. ▪ User can save own flight profiles to the standard profile library.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	▪ BaseOps is used for inputs. It has 3 panes: list, text, and map. ▪ List pane has object type selector (to choose object type like runways, flight tracks, etc.) and object list (which displays all objects of the selected type). ▪ Text pane displays properties of object selected in list pane and allows editing of those properties. ▪ Map pane displays graphical representation of the object selected in list pane with which user can interact. User can draw flight tracks over map.
d. Reliability (e.g., software bugs, technical errors,	▪ NMAP 7.0 implements runway displacement incorrectly, shifting the entire

Model:	NOISEMAP
implementation issues, etc.)	flight track down the runway instead of shifting the flight profile points along the flight track. ▪ Typical INM cases will include information that BaseOps can't import. Therefore, imported cases must be carefully checked. ▪ Computation time can increase by an order of magnitude when using topography option.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User's guides for BaseOps, NMAP, and NMPlot are all available within the download for the NOISEMAP program.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	The user's guides for BaseOps and NMPlot are available in the Help menus of the programs. The NMAP user's guide is available as a Word document in the NMAP folder. The BaseOps and NMPlot user's guides can also be downloaded as a PDF or Plain Text file from <http://www.wasmerconsulting.com/baseops.htm> and <http://wasmerconsulting.com/nmplot.htm>, respectively. The NMAP User's guide can be downloaded from the Defense Technical Information Center at <http://oai.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA406645>.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate. Topography and surface noise models, developed under a joint NATO research project, were validated with measurements made in Narvik Norway
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, one hour average, annual average, etc.)	CNEL, DNL, LEQ, NEF, WECPNL Days can be split into day and night or day, evening and night.
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Displays overall spectrum. However, Noisefile Flight Data in FLIGHT01.dat contains data as mean SPL levels in dB for frequency bands 10 through 40. Noisefile Static Data in STATIC01.dat contains data SPL levels for 19 angles from 0 to 180 degrees for frequency bands 10 through 40.
9. Policy or requirements	
a. Is this a preferred or required model?	It is required to use Noisemap as the program in use to model noise exposure near military air bases caused by flights and engine runups.
b. Input restrictions (i.e., parameter limits)	Realistic input parameters should be acceptable and produce reasonable results
c. Limitations on application (i.e., scenario limits)	Meant to calculate many different scenarios involving noise calculations surrounding military air bases

Model:	**RCNM (Roadway Construction Noise Model)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, it is the Federal Highway Administration's (FHWA) national model and can be downloaded at: http://www.fhwa.dot.gov/environment/noise/cnstr_ns.htm
b. Air quality or noise?	Noise
a. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Construction
d. Screening or detailed (intended categorization)?	Screening
e. Scales of analysis	
a. Noise (free field, long range propagation)	Intended for use in the vicinity of construction site (say, within 500 ft). Lmax levels measured from specific types of equipment are used in conjunction with geometrical spreading and user-determined shielding effects and usage factors (% time equipment is used at full power during a construction operation) to determined a received sound level at a user-defined distance from the construction equipment.
f. Regulatory use (e.g., NEPA assessments, etc.)?	Construction noise must be considered under regulations, RCNM is not required to be used on a federal level, but some states or cities are adopting use of RCNM in their noise specifications for construction projects.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	The RCNM algorithms are based on the primary equation from the CA/T Construction Noise Control Specification 721.560. ▪ Lmax is calculated as the appropriate Lmax value for a specific piece of equipment at a distance of 50 feet minus 20log of the actual distance from the receiver to the source divided by 50 feet, minus a shielding term, which is the insertion loss of any barriers or mitigation. ▪ Leq is calculated as the calculated Lmax value plus 10log of the time-averaging equipment usage factor (the percentage of time during an operation that a piece of equipment is used at full power) ▪ L10 is calculated as the Leq plus a 3 dBA adjustment factor which was empirically derived by comparing CA/T construction noise data. ▪ The total sound levels are logarithmic sums of the individual equipment sound level values, except for the Total Lmax, which is the maximum among the individual equipment Lmax values. ▪ Some simplified shielding factors for use in the RCNM are presented in Appendix A of the User's Guide.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Simple
b. First order approximation (e.g., partial vehicle	

Model:	RCNM (Roadway Construction Noise Model)
data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Results are presented in a read-only spreadsheet Input information and results can be exported to a comma separated value (CSV) or text (TXT) file. Results can be saved for one or all receptors in the case.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 98 or newer.
c. Software language (e.g., Fortran, C#.NET, etc.)	Visual Basic 6
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Single exe
e. Distributed computing? (yes or no)	No
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	No
g. Hardware/additional software requirements	192 MB or more RAM 1024x768 pixels or greater display setting Adobe Acrobat 4.0 or newer
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	57 different equipment sources with noise emissions and acoustical usage factors.
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Acoustical Use Factor [%], Spec (specifications) Lmax @50 ft [dBA], Actual Measurement Lmax @50 ft [dBA]
c. Robustness of data (i.e., fidelity and resolution of data	Database from hundreds of pieces of equipment measured on CA/T project.
d. Traceability (e.g., documented sources, acceptability, etc.)	RCNM uses the data spreadsheet developed as a part of the Central Artery/Tunnel (CA/T) project (in Boston) noise control program. The spreadsheet originated from noise level work by the Environmental Protection Agency (EPA) and an Empire State Electric Energy Research Corp. Guide. The number of samples averaged together to computer the "Actual" emission level is given in the spreadsheet.
e. Publicly available	Yes. The spreadsheet is provided in the User's guide and the data is available in the program.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	User must inputs receptor data, type of equipment, distance to receptor, and any estimated shielding. If comparison with noise limit is desired, user can input the noise limit criteria or use default settings.
b. Input flexibility (e.g., different resolution of data, user-	User can specify whether equipment is an impact device, the usage factor, and the

Model:	RCNM (Roadway Construction Noise Model)
defined sources, etc.)	Lmax level (spec or actual measurement) if desired inputs are different than default values.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	The RCNM consists of one main display with sections for inputs and results in which the user employs command buttons and pull-down menus to adjust input data and descriptions
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Reliability assumed to be high because RCNM is not an intricate program.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User's guide at: <http://www.catseyeservices.com/Handbooks/cd/references/083-Construction%20Noise%20Model_UserGuide.pdf
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF online. A copy also downloads with the program.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	RCNM has not gone through a formal validation process, however, the CA/T spreadsheet, upon which RCNM is based, was used throughout the CA/T project, and results were shown to be good within 500 ft of the construction. The limitations are based on: 1) RCNM does not account for ground conditions and weather effects, 2) L10 predictions are only as good as the assumed usage factors, and 3) the shielding effects are only as good as the user estimates them.
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Lmax, Leq, and L10, Daytime Lmax, Leq, and L10 Exceedance, Evening Lmax, Leq, and L10 Exceedance, and Nighttime Lmax, Leq, and L10 Exceedance. (Exceedance metrics involve the difference between the sound level quantity and the sound level quantity limit.)
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Overall spectrum, A-weighted
9. Policy or requirements	
a. Is this a preferred or required model?	RCNM is not required to be used on Federal-aid projects; however this model is a screening tool that can be used for the prediction of construction noise during the various stages of project development and construction. For a more complex analysis HICNOM may be more appropriate.
b. Input restrictions (i.e., parameter limits)	Up to 20 pieces of equipment (either unique or repeated) can be analyzed at a time.
c. Limitations on application (i.e., scenario limits)	Receptors may be placed at any distance form construction activities. Only one receptor can be processed at a time Up to 100 receptors can be included in one case

Model:	TNM (Traffic Noise Model)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Yes, but purchase required through McTrans. (http://mctrans.ce.ufl.edu/store/description.asp?itemID=417)
b. Air quality or noise?	Noise.
a. Air quality: emission or dispersion?	N/A
b. Noise: SI, SPL, or other?	SPL, A-weighted (L_{Aeq1hr}, L_{dn}, L_{den})
c. Mode (highway, rail, water, air)	Highway.
d. Screening or detailed (intended categorization)?	Detailed. However, simplified lookup table available in computer or paper format.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	N/A
b. Noise (free field, long range propagation)	Free field with increased error occurring over 2000 feet.
f. Regulatory use (e.g., NEPA assessments, etc.)?	Required (or model with similar acoustic algorithms) by 23CFR772.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Applied ray acoustics. Reference Energy Mean Emission Levels are adjusted for propagation considering geometric spreading, ground effects, diffraction, vegetation, and atmospheric absorption. In a subroutine, absorption of hard surfaces can also be evaluated. Works in one-third octave bands but reports in A-weighted values.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Closest to theoretical-based although first order approximation techniques are applied as well.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Requires input through GUI and forms a working database. Output can be generated in ASCII files but GUI required.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 95/98/ME/NT4/2000/XP.
c. Software language (e.g., Fortran, C#.NET, etc.)	Proprietary modular software with executable core program.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized components with central core executable program and DLL files.
e. Distributed computing? (yes or no)	No. Not as designed.
f. Connectivity with other tools (e.g., AEDT-APMT	No direct linkage.

Model:	TNM (Traffic Noise Model)
linkage, etc.)	
g. Hardware/additional software requirements	IBM compatible PC with Pentium processor and above recommended. Can be used with digitizing table.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	5 motor vehicle types (Autos, medium trucks, heavy trucks, buses, and motorcycles.)
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Reference Energy Mean Emission Levels for all 5 vehicle types by speed and mode (cruise and acceleration).
c. Robustness of data (i.e., fidelity and resolution of data	Database from over 6000 measurements in 9 states.
d. Traceability (e.g., documented sources, acceptability, etc.)	Data reported in document: Fleming, G.G, A. Rapoza, C. Lee, Development of National Reference Energy Mean Emission Levels for the FHWA Traffic Noise Model, Report No. FHWA-PD-96-093, Volpe National Transportation Systems Center, Cambridge, MA, 1994.
e. Publicly available	Yes. Although program must be purchased.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Highway data including roadway/path/receiver geometry, traffic volumes/speeds/vehicle type, ground type.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Little flexibility in input data. Metric/English. Creation of user-defined vehicles possible but not trivial.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Straight forward graphical or spreadsheet entry.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Minor problems in Version 2.5, including some diffraction problems for various objects, incorrect calculation of L_{den}, and some geometry problems.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete with user guide (Anderson, G.S., C.S.Y. Lee, G.G. Fleming, and C.W. Menge, FHWA Traffic Noise Model , Version 1.0, User's Guide, FHWA-PD-96-009, U.S. DOT, Washington, D.C., Jan. 1998) and technical guide (Menge, C.W., C.F. Rossano, G.S. Anderson, and C.J. Bajdek, FHWA Traffic Noise Model , Version 1.0, Technical Manual, FHWA-PD-96-010, U.S. DOT, Washington, D.C., Feb. 1998.) Updates for later versions posted to internet.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Hard copy.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High. Validation indicates good results for areas in the immediate vicinity of highway.

Model:	**TNM (Traffic Noise Model)**
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	L_{Aeq1hr}, L_{dn}, L_{den}.
b. If air quality, what pollutants are covered?	N/A
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	A-weight reported (computed from octave bands).
9. Policy or requirements	
a. Is this a preferred or required model?	Required by 23CFR772 or equivalent.
b. Input restrictions (i.e., parameter limits)	Limited to use in urban highway environments.
c. Limitations on application (i.e., scenario limits)	In close proximity to highway.

I.3. Models that do Both Noise and Air Quality

Model:	AEDT/EDMS (Aviation Environmental Design Tool – Emissions and Dispersion Model System Component)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Not in public domain. FAA/AEE is caretaker.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Both
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Aviation – air and ground (vehicles)
d. Screening or detailed (intended categorization)?	Intended for detailed analysis, but some screening can be accomplished by the details inherent in the input data.
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Currently, microscale to regional.
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	All emissions and air quality evaluations at airports including those related to NEPA.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	BFFM2, BADA, AERMOD, MOBILE
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	Combination of all three. Simple for some emission factors (e.g., stationary sources), first-order for GAV emissions, and theoretically-based for BFFM2 and BADA.
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Currently uses dbf files but will use SQL database under AEDT.
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Currently Windows, but potential for others under AEDT depending on how modules are used.
c. Software language (e.g., Fortran, C#.NET, etc.)	Currently based on Visual C++ but will be C# .NET under AEDT. EPA modules are Fortran.
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Various exes in various stages of aggregation under an integrated environment with the GUI. Under AEDT, it will be highly modularized.
e. Distributed computing? (yes or no)	Not currently, but expected under AEDT
f. Connectivity with other tools (e.g., AEDT-APMT	Built in connections to EPA models and will have APMT linkage under AEDT.

Model:	AEDT/EDMS (Aviation Environmental Design Tool – Emissions and Dispersion Model System Component)
linkage, etc.)	
g. Hardware/additional software requirements	Will run on any windows machine but will need high-end machine for detailed modeling.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Aircraft, GAVs, GSEs, APUs, Stationary sources (e.g., power plants, paining, degreasing, etc.).
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Aircraft performance, aircraft emissions, aircraft-engine matches, MOBILE6.2 emission factor.
c. Robustness of data (i.e., fidelity and resolution of data	Segment-level resolution for aircraft emissions allows different aggregation levels. Also, flexibility in how aircraft movements' information can be input. The MOBILE data is pre-developed and cannot be readily changed, but MOBILE can be run externally to generate new data.
d. Traceability (e.g., documented sources, acceptability, etc.)	All data are well-documented.
e. Publicly available	All data are publicly available except for the BADA data which requires permission from Eurocontrol. Future developments under AEDT may not require the use of BADA.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Some work required, but data is generally available.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Some flexibility for aircraft movements data input and ability to generate vehicle emission factors externally.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Relatively easy to understand.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Software is currently well developed and mature. New software under AEDT may need to be refined.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	Moderate to high for emissions. Currently unclear for atmospheric concentrations since there have been very little validation work using measured data for airport sources.
c. High	
8. Outputs	

Model:	**AEDT/EDMS (Aviation Environmental Design Tool – Emissions and Dispersion Model System Component)**
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Emissions are in mass per time (e.g., metric tons per year) and concentrations are in µg/m3.
b. If air quality, what pollutants are covered?	CO2, CO, THC, NMHC, VOC, TOG, NOx, SOx, PM2.5, PM10, and 395 speciated hydrocarbons.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	This is the FAA required model.
b. Input restrictions (i.e., parameter limits)	Based each modules limits.
c. Limitations on application (i.e., scenario limits)	Only airports and below mixing height.

Model:	AEDT/SAGE (- System for Assessing Global Emissions Component)
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	Not in public domain and FAA/AEE is caretaker.
b. Air quality or noise?	
a. Air quality: emissions or dispersion?	Only aircraft emissions
b. Noise: SI, SPL, or other?	[redacted]
c. Mode (highway, rail, water, air)	Aviation – air only
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	National and global
b. Noise (free field, long range propagation)	[redacted]
f. Regulatory use (e.g., NEPA assessments, etc.)?	Not for regulation, but for national policy
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	Emissions (BFFM2), Aircraft performance (BADA), and delay (WWWLMINET)
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	Mostly theoretical but some mix of others as well.
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	SQL database
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	C#.NET
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modularized DLLs, preprocessors, etc.
e. Distributed computing? (yes or no)	Yes
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Some linkage with APMT planned under AEDT
g. Hardware/additional software requirements	Needs server with multiple processors for efficient computations. Large hard drive spaces needed.
4. Database	

Model:	**AEDT/SAGE (- System for Assessing Global Emissions Component)**
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	Aircraft
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	ICAO emissions, BADA performance, SAE 1845, airport locations and weather, airport capacity, fleet mappings
c. Robustness of data (i.e., fidelity and resolution of data	Some flexibility based on specificity of data (e.g., average or specific airport taxi times)
d. Traceability (e.g., documented sources, acceptability, etc.)	All data and sources are well documented
e. Publicly available	All data are based on publicly available sources with the exception of BADA, WWLMINET data, and BACK Aviation fleet data.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Most are readily available, but others like BADA require permission.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Different resolution of data for some modules are allow (e.g., taxi data)
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Limited or no UI at this point, but one is being planned as a web-interface under AEDT.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	Mature software with little or no bugs.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Complete
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Electronic and on-line
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	High confidence based on uncertainty and validation assessments
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Emissions in mass units (e.g.,. kg, Gg, Tg, etc.)
b. If air quality, what pollutants are covered?	NOx, CO, HC, CO2, H2O, and SOx
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	No, but the only model used by FAA within the model's scope.
b. Input restrictions (i.e., parameter limits)	Inputs based on FAA approval

Model:	AEDT/SAGE (- System for Assessing Global Emissions Component)
c. Limitations on application (i.e., scenario limits)	Inputs based on FAA approval

Model:	**AEDT/INM (- Integrated Noise Model Component)**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	The AEDT Development Team: John A. Volpe National Transportation Systems Center, ATAC Corp., CSSI Inc., Wyle Laboratories.
b. Air quality or noise?	
a. Noise: SI, SPL, or other?	
c. Mode (highway, rail, water, air)	
d. Screening or detailed (intended categorization)?	
e. Scales of analysis	
a. Noise (free field, long range propagation)	Local and global
f. Regulatory use (e.g., NEPA assessments, etc.)?	Assume will take the regulatory role held by INM, and other included tools
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	AEDT will be based on the Integrated Noise Model (INM: local noise), the Emissions and Dispersion Modeling System (EDMS: local emissions), the Model for Assessing Global Exposure from Noise of Transport Airplanes (MAGENTA: global noise), and the System for Assessing Aviation's Global Emissions (SAGE: global emissions).
a. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	
c. Software language (e.g., Fortran, C#.NET, etc.)	C#.NET
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Modular
e. Distributed computing? (yes or no)	
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Connectivity with the Environmental Design Space (EDS) and the Aviation Environmental Portfolio Management Tool (APMT).

Model:	**AEDT/INM (- Integrated Noise Model Component)**
	The EDS will be used to estimate source noise, exhaust emissions, performance, and economic parameters for new aircraft in planning stages under different technological scenarios. The APMT will use integrated analyses to assess and communicate environmental effects, interrelationships, and economic consequences, linking the environmental predictions of AEDT with comprehensive economic analysis capabilities.
g. Hardware/additional software requirements	
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	
c. Robustness of data (i.e., fidelity and resolution of data	
d. Traceability (e.g., documented sources, acceptability, etc.)	
e. Publicly available	
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	Separate GUIs for local and global portions of AEDT. Local portion will merge INM and EDMS and try to maintain consistency with the existing INM and EDMS features. Global portion will merge MAGENTA and SAGE into MASAGE.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	To be determined after AEDT Version 1.0 is released.
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Architecture and ADD (ADD plays part of Technical Manual, expressing mathematical and logical concepts within software module). Maybe others when AEDT released.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	
a. Valid only in special cases	
b. Moderate	
c. High	
8. Outputs	

Model:	**AEDT/INM (- Integrated Noise Model Component)**
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	
b. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	
9. Policy or requirements	
a. Is this a preferred or required model?	Assume will take the regulatory role held by INM, and other tools. Therefore, it would be required.
b. Input restrictions (i.e., parameter limits)	
c. Limitations on application (i.e., scenario limits)	

Model:	**CadnaA**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. It is the product of the German company, DataKustik. A free Demo Version can be downloaded at: <http://www.datakustik.com/en/service-support/demo-versions/>
b. Air quality or noise?	Noise and, with Option APL (an available extension), air pollution emission and immission.
a. Air quality: emission or dispersion?	Emission and dispersion.
b. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Industrial, road and rail, air
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	Maps can be calculated for projects of any scale
b. Noise (free field, long range propagation)	Maps can be calculated for projects of any scale
f. Regulatory use (e.g., NEPA assessments, etc.)?	CadnaA complies with regulations in Austria, Switzerland, United Kingdom, France, Scandinavia, and with the calculation methods of the EC-directive 2002/49/EC (Environmental Noise Directive).
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	CadnaA can use the noise calculation methods presented in any of the following standards and guidelines: o Industrial Noise: - ISO 9613 incl. VBUI and meteorology according to CONCAWE (International, EC-Interim) - VDI 2714, VDI 2720 (Germany) - DIN 18005 (Germany) - ÖAL Richtlinie Nr. 28 (Austria) - BS 5228 (United Kingdom) - General Prediction Method (Scandinavia) - Ljud från vindkraftverk (Sweden) - Harmonoise, P2P calculation model, preliminary version (International) o Road Noise - NMPB-Routes-96 (France, EC-Interim) - RLS-90, VBUS (Germany) - DIN 18005 (Germany) - RVS 04.02.11 (Austria) - STL 86 (Switzerland) - SonRoad (Switzerland) - CRTN (United Kingdom) - TemaNord 1996:525 (Scandinavia)

Model:	CadnaA
	- Czech Method (Czech Republic) o Railway Noise - RMR, SRM II (Netherlands, EC-Interim) - Schall03, Schall Transrapid, VBUSch (Germany) - Schall03 new, draft (Germany) - DIN 18005 (Germany) - ONR 305011 (Austria) - Semibel (Switzerland) - NMPB-Fer (France) - CRN (United Kingdom) - TemaNord 1996:524 (Scandinavia) - FTA/FRA (USA) o Aircraft Noise - ECAC Doc. 29, 2nd edition 1997 (International, EC-Interim) - DIN 45684 (Germany) - AzB (Germany) - AzB-MIL (Germany) - LAI-Landeplatzleitlinie (Germany) - AzB 2007, draft (Germany) It uses the air pollution dispersion model, AUSTAL2000, which is a Lagrange particle model that processes time-dependent emissions from road and industrial sources and takes terrain and buildings, wind fields and atmospheric stability into account.
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	First order approximation
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	Inputs can be imported in the following forms: ▪ Atlas GIS, former GIS-software by ESRI (until 2001) ▪ ArcView, shape-file from ArcView/ArcInfo-GIS-software (by ESRI) ▪ ASCII grid, ASCII-format for grid point data ▪ ASCII poly, ASCII-format for open or closed polygon-lines ▪ AutoCad-DXF, AutoCad export format for object geometry (by Autodesk Inc.)

Model:	CadnaA
	▪ Building height points, ASCII-format for building height points ▪ EDBS, format used by the German ordnance surveys ▪ GML, format used by the UK Ordnance Survey ▪ GYpSiNOISE, data interchange format CadnaA-GIS ▪ LimA, format used by LimA software ▪ MapInfo, format used by MapInfo (by MapInfo Corp.) ▪ MITHRA, format used by MITHRA software ▪ NTF, UK National Transfer Format ▪ QSI, data interchange format according to DIN 45687 and ÖAL 36 ▪ Sicad, GIS-software by AED-SICAD AG ▪ SLIP, format used by SLIP road noise software ▪ SOSI, format used by SOSI software (® Ordnance Survey Norwegen) ▪ SoundPLAN, format used by SoundPLAN software ▪ Stratis, program system for road design & civil eng. (by RIB Software AG) ▪ T-Mobil, format used by Deutsche Telekom MobilNet GmbH ▪ Winput-DGM, ASCII-format by the Bavarian Ordnance Survey, Munich Outputs can be exported to the following forms: ▪ ArcView Grid, used by ArcView/ArcInfo-GIS-software (by ESRI) ▪ ArcView Shape, used by ArcView/ArcInfo-GIS-software (by ESRI) ▪ AutoCad DXF, AutoCad format for object geometry (by Autodesk Inc.) ▪ Building height points, ASCII-format for building height points ▪ Google Earth, Keyhole Markup Language (KML) ▪ GYpSiNOISE, data interchange format CadnaA-GIS ▪ IMMIS Luft, format used by IMMIS software ▪ LimA, format used by LimA software ▪ QSI, data interchange format according to DIN 45687 and ÖAL 36 ▪ Rich text format, document file format ▪ Text files ▪ X-file
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows
c. Software language (e.g., Fortran, C#.NET, etc.)	C/C++
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	Different "Option" extensions are available for purchase
e. Distributed computing? (yes or no)	Yes. CadnaA can use up to 32 parallel processors for multithreading If multiple licenses are available, PCSP (Program Controlled Segmented Processing) can be used to support distributed computing on several processors and/or computers.

Model:	**CadnaA**
	If only one license is available, Option CALC (an available extension) can allow all computers in a network to use the CadnaA-processing kernel without the user-interface.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Can import flight traffic data via ODBC-connection (Open Database Connectivity)
g. Hardware/additional software requirements	A 64-bit version of CadnaA exists and requires a processor with a 64-bit extension and 64-bit Windows operating system. 4 GB or more memory is recommended.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	11 groups of aircraft, road traffic sources, about 150 modules for technical sound sources for industrial noise (with Option SET, an available extension)
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	For aircraft noise, predefined aircraft sorted according to their type and weight class into groups considered to have similar noise emission For road air pollution in Option APL, emission factors are obtained from a joint publication by the German, Swiss, and Austrian Environmental Protection Agencies (HBEFA Handbuch Emissionsfaktoren des Strassenverkehrs 2.1 - Manual for Emissions Factors of Road Traffic, February 2004). For Industrial Noise, with Option SET, sound power spectra can be generated based on technical parameters of a source (e.g. electric power, volume flow, or rpm) for about 150 predefined modules for technical sound sources like electric and combustion engines, pumps, etc.
c. Robustness of data (i.e., fidelity and resolution of data	Air pollution dispersion calculations have high resolution and incorporate buildings and terrain.
d. Traceability (e.g., documented sources, acceptability, etc.)	
e. Publicly available	
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	Complexity of required data depends on complexity of model. If generating a digital town, need geometry and object data for the roads, buildings and terrain. This type of data can be imported from files of different formats to generate the final digital town model.
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	Noise levels can be calculated at specified receiver positions, on horizontal or vertical grids, or on grids enveloping building facades.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	The CadnaA main window has a Menu bar, a Toolbar that provides one-click access to menu commands or features, a Toolbox that allows the user to insert objects or trigger actions by clicking an object icon in the Toolbox and inserting it directly into the main screen, and the main screen where the graphical plot of the environment being considered is displayed. 3D visualization possible in separate window

Model:	CadnaA
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	Information on the website: <http://www.datakustik.com/en/products/cadnaa/> is extensive. There is also a CadnaA help file that comes with the program.
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	Online.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	Validation was performed at a test airport and accuracy of the calculation was proven by the German Environmental Protection Agency (Umweltbundesamt UBA).
a. Valid only in special cases	
b. Moderate	Moderate
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	L_{den} and L_{night}
b. If air quality, what pollutants are covered?	PM_{10} fine particles, NO_2, NO_X, SO_2, benzene
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Overall spectrum (Lin, A, B, C, or D weighting can be used)
9. Policy or requirements	
a. Is this a preferred or required model?	Not required.
b. Input restrictions (i.e., parameter limits)	Very high software-based limit. Therefore, practically no limit to project size by software. Most often, limiting factor is memory size of hardware. In the standard model of CadnaA, a maximum of 1000 buildings and 1000 barriers can be used. With the Option XL, there is no limit.
c. Limitations on application (i.e., scenario limits)	

Model:	**SoundPLAN**
1. Overall Model Scope	
a. In public domain? If not, who is caretaker?	No. It is the product of the German company Braunstein + Berndt GmbH.
b. Air quality or noise?	Air quality and noise
a. Air quality: emission or dispersion?	Dispersion. Emission source rates are user-defined.
b. Noise: SI, SPL, or other?	SPL
c. Mode (highway, rail, water, air)	Road, rail, industrial (and sports and leisure facilities), air
d. Screening or detailed (intended categorization)?	Detailed
e. Scales of analysis	
a. Air quality (e.g., microscale, regional, national, etc.)	MISKAM, SoundPLAN's air pollution model has a small pollutant simulation scope, accommodating studies that range out to a couple hundred meters.
b. Noise (free field, long range propagation)	Maps can be calculated for projects ranging from small to "huge."
f. Regulatory use (e.g., NEPA assessments, etc.)?	SoundPLAN implements calculations in accordance with regulations and national standards of many different countries. The user may pick which standard they wish SoundPLAN to use.
2. Algorithms (scientific merit)	
a. What algorithms are used? (e.g., sound propagation, emissions dispersion, vehicle performance, etc.)	SoundPLAN can use the noise calculation methods presented in any of the following standards and guidelines: ▪ Road Noise: RLS 90, DIN 18005, Calculation of Road Traffic Noise (CoRTN), Statens Planverk 48, Federal Highway Model (FHWA), NMPB o (The above were explicitly stated in the SoundPLAN Manual. In the Mapping software Catalogue_VersAPR08.xls spreadsheet, Rasmussen claims that the VBUS, NMR-96, Nord2000, and RVS 3.02 standards are also included in SoundPLAN.) ▪ Rail Noise: SCHALL-03, Transrapid, DIN 18005 with emission calculation railway, Calculation of Rail Noise CRN 99, Ö-Norm S 5011, RMR 2002, SEMIBEL, Nordic Prediction Method for Train Noise NMT 98, Nordic Rail Prediction Method Kilde Report 130, Japan Narrow Gauge Railways, ÖAL 30 o (The above were explicitly stated in the SoundPLAN Manual. In the Mapping software Catalogue_VersAPR08.xls spreadsheet, Rasmussen claims that the VBUSch and Nord2000 standards are also included in SoundPLAN.) o Industry Noise: VDI 2714, VDI 2720, ISO 9613, General Prediction Method, CONCAWE o Aircraft Noise:, AzB, AzB (free), AzB-L (revision from 1997), DIN 45643 strict, DIN 45643 (free), ÖAL 24, ECAC Doc 29 o Parking Lot Noise: DIN 18005, RLS 90, Bavarian Parking Lot Study o Indoor Noise: VDI 3760E, The Indoor Factory Noise Module

Model:	**SoundPLAN**
	Calculation Method For pollution dispersion calculations, SoundPLAN provides both a Gauss model according to TA-Luft for pollutant dispersion from smoke stacks and the MISKAM model, which is more accurate for smaller scale dispersion calculations. ▪ MISKAM is a "three dimensional non-hydrostatic flow and dispersion model for local prognosis of wind distribution and pollutant concentration in areas ranging from roads to city districts." It can model flow around buildings (treated as rectangle cubes), is "built on the complete 3 dimensional motion equations for simulation of the wind field and the advection-diffuse-equations for the dispersion of density neutral substances," and fulfills the German VDI 3782 /8. Air absorption can be calculated with the following standards ▪ ANSI 126 ▪ ISO 3891 ▪ ISO 9613 Part 1
b. Which category does the model fall into:	
a. Simple (e.g., averaging methods based on assumptions, simple multipliers, etc.)	
b. First order approximation (e.g., partial vehicle data and propagation simplifications supplemented with average information)	Between first order and theoretically-based.
c. Theoretically-based (e.g., vehicle-specific with individual characteristics and theoretical propagation implemented)	
3. System architecture	
a. Input/output data structure (e.g., flat ASCII files, SQL database, etc.)	For data entry: A scanned map input must be a bitmap (.bmp), DXF data must be based on AutoCAD DXF Version 12/13. SoundPLAN can also import data uses CARD/1, Stratis, ASCII, or ESRI Shape file as input. Results are stored as .res files. A results table can be exported as an ASCII file, an Excel file, or WMF files
b. Operating system (e.g., MS-DOS, Windows, Linux, etc.)	Windows 98, Windows NT 4.0, Windows 2000, or Windows XP (website indicates Windows 95 and ME as well, but not updated recently)
c. Software language (e.g., Fortran, C#.NET, etc.)	
d. Software structure (e.g., single exe, modularized components, preprocessors, etc.)	▪ SoundPLAN software is installed from the CD and a floppy disk containing license information, user name and address. ▪ Program updates are EXE files. ▪ SoundPLAN is a modular program consisting of multiple programs geared

Model:	SoundPLAN
	for specific functions and allowing multitasking within and between projects. ▪ Each project is stored in its own folder. ▪ Geo-Files (.geo), the smallest storage unit, contain information on elevation, coordinates, and attributes of objects. ▪ Situations (.sit) contain a list of the Geo-Files that are included in the Situation. ▪ Digital Ground Models (DGM) can be generated and used as the basis of the elevation model for digitizing new objects. ▪ Graphics templates can be stored for personalized layouts to be used in any new project.
e. Distributed computing? (yes or no)	Yes.
f. Connectivity with other tools (e.g., AEDT-APMT linkage, etc.)	Data can be imported with the ArcView interface
g. Hardware/additional software requirements	Recommended: ▪ PC Pentium 1 GigaHertz or higher ▪ Graphics Card with resolution of minimum 1024 x 768, 256 colors, 16 or 32 MB memory, for 3D-Graphics you need a graphics card with OpenGL drivers and at least 32 MB memory ▪ RAM memory >=256 MB ▪ Hard disk 20 GigaByte ▪ 17" monitor ▪ WinTab compatible Digitizer (WinTab drivers are available for nearly all current digitizers) ▪ All windows compatible printers and plotters can be used.
4. Database	
a. What sources are included? (e.g., number and types of vehicles, stationary source, etc.)	As stated in the manual regarding SoundPLAN's "library," it allows: "Access to the emission-, absorption-, transmissions- and mitigation library, the definitions of 2D- and 3D-directivity as well as day histograms, wind statistics, pollution component library(MISKAM) and the assessment library. The library comes with limited data and is ready to host your project and global data."
b. What data is included? (e.g., NPD, EI, performance profiles, etc.)	Many of the standards SoundPLAN uses in noise calculations specify source characteristics: ▪ Road Noise: RLS90 assumes road source at 0.5 m height above the middle of the two outer lanes, the emission level is the level measured 25 m from the center of the road, 4 m above ground and can be entered or calculated with SoundPLAN's "pocket calculator," for example. ▪ Railway Noise: SoundPLAN stores train types and properties and calculates emission data according to, for example, the standard Schall03. ▪ Aircraft Noise: Emission data is kept in "On,Rn" tables (in octave bands)

Model:	SoundPLAN
	for different aircraft classes for a set reference distance and direction factor (to include directivity). ▪ Industrial Noise: Sources are included as point, line or area sources. SoundPLAN includes a "system library" with emission data for different sources that can be copied to the "project libraries." ▪ Parking Lot Noise: SoundPLAN includes parking lots as area sources, modeled with different standards.
c. Robustness of data (i.e., fidelity and resolution of data	
d. Traceability (e.g., documented sources, acceptability, etc.)	Much of the source data and algorithms used in SoundPLAN come from standards and guidelines listed above.
e. Publicly available	Emission data use by SoundPLAN can be viewed in SoundPLAN.
5. Usability	
a. General data requirements (e.g., readily available, easily found, considerable effort required, etc.)	▪ Road Noise: The emission level for a road segment and can be calculated (based on number of vehicles, speed, etc.) or directly entered. User also enters the posted speed for cars and trucks in [km/hr]. The percentage of heavy vehicles and traffic load at night can be calculated from a table that was based on long time traffic observations, or entered by the user. The road type can be entered to result in corrections to sound levels. ▪ Rail Noise: User defines the description of the rail line, the track number, direction, and status. Number of trains day/night for each train type, train type addition and break type percentage (disk versus wheel), train speed, train length. For multiple reflection calculations (in railway canyon), user defines height of walls of canyon, width of canyon, and average reflection losses. ▪ Industrial Noise: User chooses between calculations of noise in only the mean frequency (which must be entered) or full spectra. SoundPLAN needs to know the sound power output for 24 hours (because industrial sources often do not operate 24 hours a day). ▪ Aircraft Noise: Airport geometry and runway setup must be included in the SoundPLAN model. User picks from routes, aircraft classes and operations data in definition sheets. User can input glide paths or use a preprogrammed path. User must differentiate between operations during the day and night so appropriate penalties can be assessed. ▪ Indoor Noise: User defines average room height, scattering object density, and absorption of floor, ceiling, scattering objects and facades. ▪ 2D or 3D directivity of sources can be entered. ▪ Objects can be entered by selecting the object type from a list, entering the coordinates and checking or entering elevation information and any object properties. ▪ For air quality calculations, user must specify meteorological conditions (vertical temperature gradient, wind statistics, etc.) and the emission rate of

Model:	SoundPLAN
	pollutants (per km of road per day in kg).
b. Input flexibility (e.g., different resolution of data, user-defined sources, etc.)	▪ SoundPLAN offers many opportunities for a user to define or redefine element and source properties. For example a user can define his/her own source emission levels, 2D or 3D source emission directivity adjustments, heights of floors in buildings, road surface (by providing a user-specified addition to the sound level), etc. ▪ The user can also define calculation settings such as grid size or height above ground for a grid noise map calculation. ▪ With the Cartography module, the user can define his/her own graphics object type, influencing the object's appearance in the graphics modules.
c. UI complexity (e.g., easy to understand, cryptic switches, steep learning curve, etc.)	▪ SoundPLAN can produce calculations for a single point receiver, grid noise map, cross-sectional noise map, facade noise map, and city noise map, to display different soundscape information. ▪ The "SoundPLAN-Manager" allows access to all modules of the program: Library, Geo-Database, Calculation Core, Documentation (results data), Spreadsheet (presentation of results), Expert Industry (analysis of source and receiver interactions, source contributions, etc.), Long Straight Road (rough screening calculations), City Noise Screening (rough screening calculations), Aircraft Noise Definition, and Socket Server (for distributed computing) ▪ The graphical user interface tells the user which Geo-File is being viewed, what object is selected, etc. as well as showing a large picture (viewport) of the area being considered. ▪ SoundPLAN's 3D-Graphics can be used to display any map in 3D. The 3D-Graphics model data check displays all data as used for calculations, while the 3D-Graphics animation shows further objects and allows the user to "drive" through an area on an existing road or railroad. The animation can be saved as an AVI file.
d. Reliability (e.g., software bugs, technical errors, implementation issues, etc.)	
6. Documentation	
a. Completeness (e.g., user's guide, technical manual, architecture, ADD, etc.)	User's Manual, SoundPLAN on-Line Help (information on current problems, updated every SoundPLAN version)
b. Format (e.g., series of notes, hardcopies only, on-line, etc.)	PDF and online. Manual available in printed form.
7. Validation and confidence use Based on the breadth of validation and uncertainty assessments conducted to date and the merits of the methods used, what level of trust is there in the model to produce accurate results:	Rasmussen claims: "Benchmarks have been performed on the published sets of official test cases defined in or for regulations. Additional documentation according to the Nordtest method NT ACOU 107 will be available end of 2006." The pollution model, MISKAM has been tested in wind tunnel experiments, with simulations and with measurements. However, SoundPLAN warns that MISKAM "cannot be regarded as a black box but rather a tool that requires considerable

Model:	SoundPLAN
	amount of thought and work. Uncritical acceptance of the results shall be avoided."
a. Valid only in special cases	
b. Moderate	Moderate to High
c. High	
8. Outputs	
a. What are the metrics both spatially and temporally (e.g., Leq(1 hr), DNL, ug/m^3, ppm, one hour average, annual average, etc.)	Leq (for day or night), Lmax, Lden, L10 (for UK road noise), Exceeding levels (for day and night)
b. If air quality, what pollutants are covered?	CO, HC, C6H6, NOx, Pb, SO2, PM. Additional pollutants can be defined for industrial sources.
c. If noise, frequency components (i.e., octave bands) or overall spectrum (i.e., A-weighted)	Octave or third-octave bands. Often A-weighted, however linear, B, C or D filters can also be set.
9. Policy or requirements	
a. Is this a preferred or required model?	Not required.
b. Input restrictions (i.e., parameter limits)	Some source emissions are restricted to a maximum level Restrictions apply when designing walls Restrictions apply for the shape and characteristics of the inside of buildings when using the Indoor Factory Noise Module.
c. Limitations on application (i.e., scenario limits)	None specified.

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