International Civil Aviation Organization

CAEP/7-IP/24
25/1/07
English only

INFORMATION PAPER

COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION (CAEP)

SEVENTH MEETING

Montréal, 5 to 16 February 2007

Agenda Item 1: Review of proposals relating to aircraft engine emissions, including the amendment of Annex 16, Volume II
Agenda Item 3: Review of proposals relating to aircraft noise, including the amendment of Annex 16, Volume I
Agenda Item 4: Future Work

AVIATION ENVIRONMENTAL DESIGN TOOL (AEDT) PROGRESS

(Presented by the U.S. Representative)

SUMMARY

The U.S. Federal Aviation Administration Office of Environment and Energy (FAA/AEE), in collaboration with Transport Canada, is developing a comprehensive suite of software tools that will allow for thorough assessment of the environmental effects of aviation. The main goal of the effort is to develop a new, critically needed capability to assess the interdependencies between aviation-related noise, emissions, and associated environmental impact and cost valuations, including cost-benefit analyses. The Aviation Environmental Design Tool (AEDT) was formally introduced to the CAEP Steering Group at the November 2004, Bonn meeting. Since that time the Steering Group, FESG and WG2 have been kept informed of AEDT research and design developments. This paper serves to update the CAEP on the progress of the AEDT development and assessment effort.

1. AEDT INTRODUCTION

1.1 At CAEP/6 in 2004, participants recognized that effective mitigation requires consideration of interdependencies between noise and emissions and amongst emissions. CAEP/6 recommended, and ICAO's 35th Assembly subsequently adopted, three environmental goals: to limit or reduce noise exposure, local air quality emissions, and greenhouse gas emissions. Analytical tools and

supporting databases that could account for interdependencies amongst these goals and potentially optimize the environmental benefit of mitigation measures would greatly facilitate and enhance progress toward these goals.

1.2 In assessing the scope of future analytical tools, it is important to consider the potential decisions that policy makers are likely to face. The complexity of decisions has increased over time, as the remit of CAEP has gone from concentrating primarily on setting standards applied to aircraft, to providing policy advice on operational issues and consideration of potential market-based options to reduce the impact of aviation on the environment. In seeking to meet the ICAO goals to limit or reduce aviation environmental impacts, CAEP may consider more stringent environmental standards, new emissions standards, technological advancements, and elements of the balanced approach (CAEP-SG/20051-IP/12) in a future work program.

1.3 Existing aircraft noise and aviation emissions analytical tools used by CAEP cannot effectively assess interdependencies between noise and emissions, or analyze the cost-benefit of proposed actions. Accordingly, the Federal Aviation Administration's Office of Environment and Energy (FAA-AEE) is developing a comprehensive suite of software tools that will allow for thorough assessment of the environmental effects of aviation. Transport Canada is collaborating with the FAA in those elements of the development effort undertaken by the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) Center of Excellence. The main goal of the effort is to develop a new capability to assess the interdependencies between aviation-related noise and emissions effects, and to provide comprehensive impact and cost and benefit analyses of aviation environmental policy options. The FAA tool suite is illustrated in Figure 1. The building block of this suite of software tools that integrates existing noise and emissions models is the Aviation Environmental Design Tool (AEDT). The following describes the components highlighted in Figure 1.

Environmental Design Space (EDS) provides integrated analysis of noise, emissions and performance at the aircraft level. (See CAEP/7 Environmental Design Space information paper, CAEP/7-IP/23.)

Aviation Environmental Design Tool (AEDT) comprises the integration of existing or new aviation noise and emissions analytical modules to provide an integrated capability of assessing interrelationships between noise and emissions, and amongst emissions at the local and global levels. This paper focuses on AEDT.

Aviation environmental Portfolio Management Tool (APMT) interacts with AEDT, EDS, and economic modules to provide the common, transparent cost/benefit methodology needed to optimize aviation policy in harmony with environmental policy. (See CAEP/7 Aviation environmental Portfolio Management Tool information paper, CAEP/7-IP/25.) In Figure 1, APMT is represented in terms of its primary components: “Benefits Valuation,” “Partial Equilibrium,” and “Costs and Benefits.”

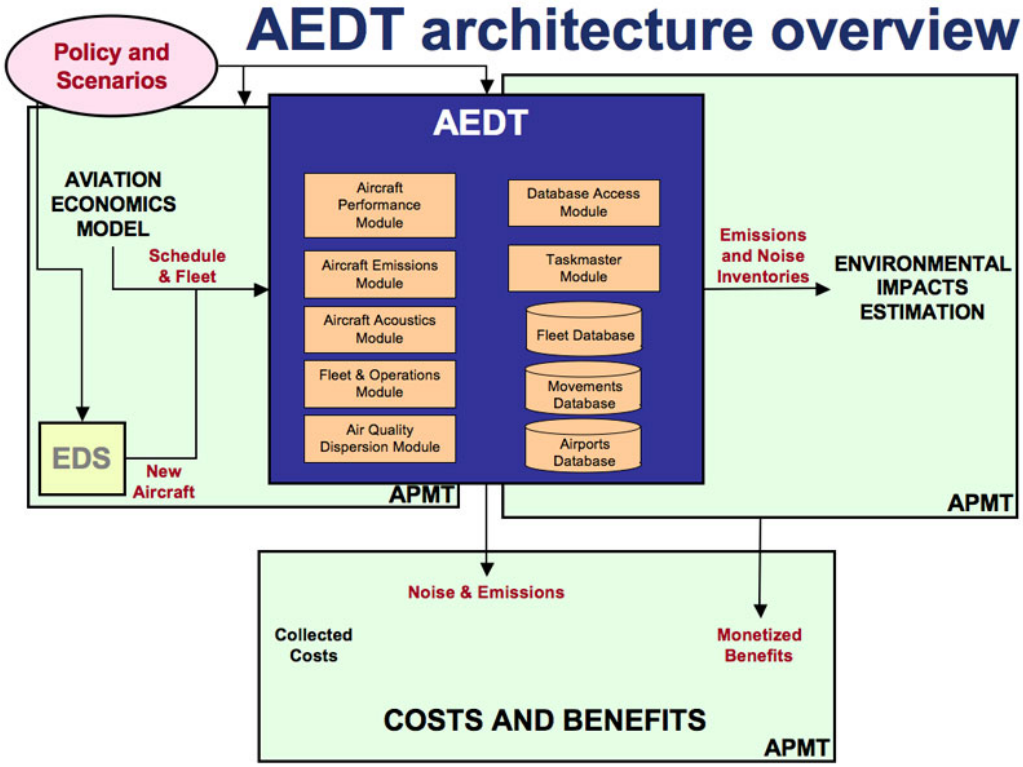

Figure 1. Schematic of the Components of the New Aviation Environmental Tool Suite

1.4 AEDT was first introduced to the CAEP Steering Group in 2004 in Bonn, Germany (CAEP-SG20041-WP/7) and then overviewed in more detail in CAEP-SG/20051-IP/12 and CAEP-SG/20063-IP/6. In response to the WG2/TG2/4 Ad Hoc Group's recommendation for methodological enhancements to landing-takeoff (LTO) emissions inventories documented in CAEP7-WG2-TG2/4-4-WP/10, FAA/AEE presented a summary of AEDT features in CAEP/7-WG2-TG2-6-WP/10[1]

1.5 This paper serves to update the CAEP on the progress of the AEDT development and assessment effort.

2. AEDT DESIGN

2.1 AEDT consists of an integrated set of common modules and databases used for conducting noise, emissions, and fuel burn analyses on a local (down to flight level), national, regional,

1 2004-07 - CAEP-SG/20041-WP/07, Progress Developing Analytical Tools to Address Interdependencies Among Environmental Impacts
2005-12 - CAEP-SG/20051-IP/12, Development of a Comprehensive Software Suite to Assess Aviation Environmental Effects
2006-10 - CAEP/7-WG2-TG2-6-WP/10, AEDT NOx Prototype 1: Preliminary Modelling Enhancements to CAEP/6-IP/13 NOX Stringency Analysis
2006-08 - CAEP/7-WG2-TG3-7-WP/8, AEDT Continuous Descent Approach (CDA) Demonstration
2006-01 - CAEP/7-WG2-TG2-7-IP/01, AEDT NOx Modelling Demonstration
2006-14 - CAEP/7-WG2-TG2-8-WP/14, Environmental Goals Assessment
2006-15 - CAEP/7-WG2-TG2-8-WP/13, Reduced Thrust Sample Problem

and global scale. Sections 2.3 through 2.11 outline the common modules and databases. Model scenario inputs have also been updated for consistency. The existing tools that provide the foundation for AEDT include the Integrated Noise Model (INM – local noise analysis), the Emissions and Dispersion Modeling System (EDMS – local emissions analysis), the Model for Assessing Global Exposure from Noise of Transport Airplanes (MAGENTA – global noise analysis) and the System for assessing Aviation's Global Emissions (SAGE – global emissions analysis). Figure 2 provides an historical overview as to how these legacy tools are being integrated into AEDT. Consistent with the historic public release versions of the local noise and emissions tools, FAA plans to release a single, integrated version of the local analysis capabilities in 2010 (AEDT-Local). FAA will also maintain a single, integrated version of the global analysis capabilities, for use in support of CAEP and other initiatives (AEDT-Global).

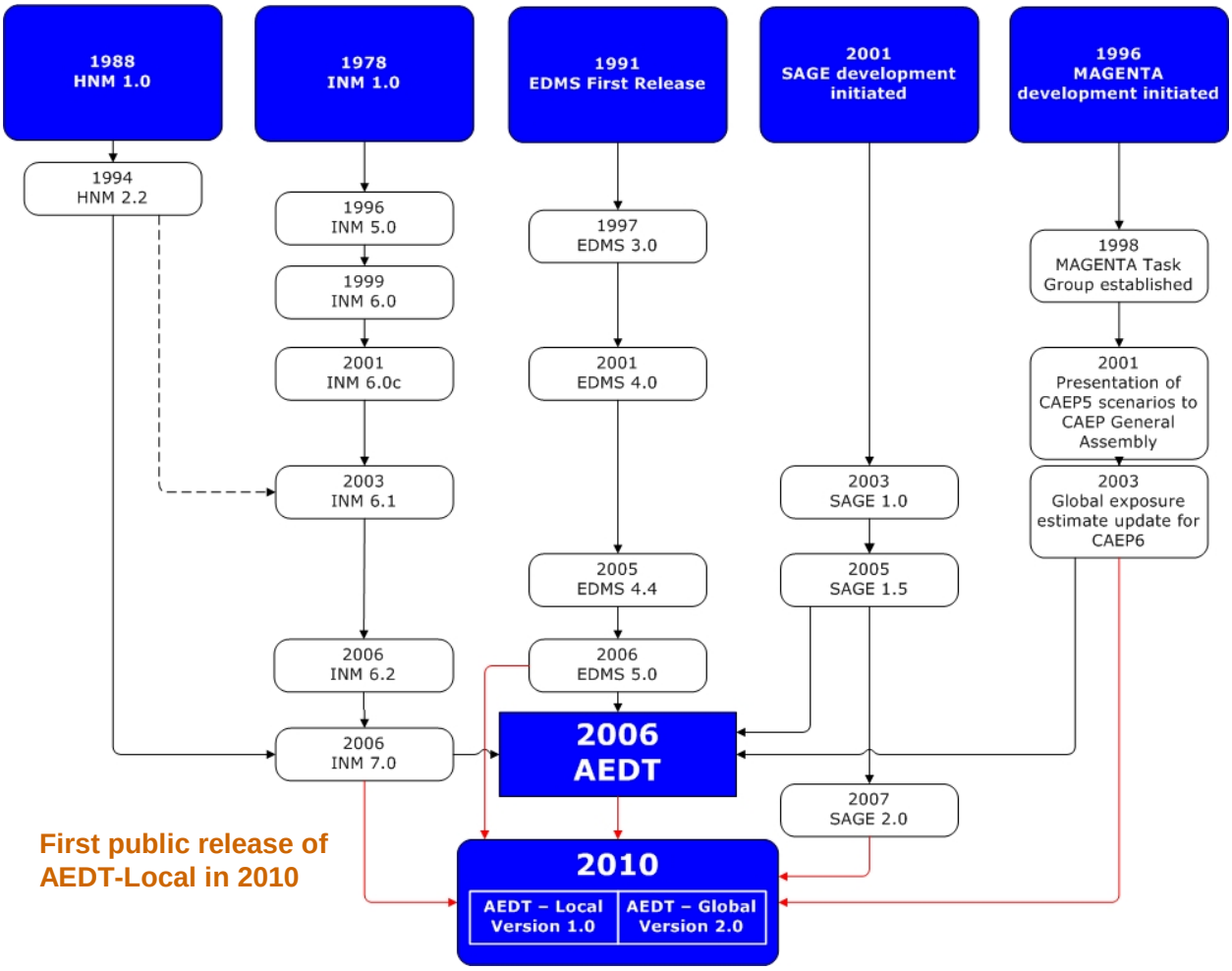

Figure 2. AEDT Module Development History

2.2 AEDT will help users to better address complex aviation environmental issues in a comprehensive, consistent, and more efficient manner. The legacy tools have developed independently over time, supporting individual areas of environmental analysis. While individual tool developments have gained knowledge from each other (e.g., SAGE historically made use of the INM – SAE-AIR-1845 – aircraft performance data), there have been few common computational modules and databases.

2.3 AEDT represents a significant step forward in that common computational modules and databases will be used in the computation of both noise and emissions for local and global analyses. The

modules and databases are being developed under a single system architecture that emphasizes the flexibility and scalability of AEDT. The major common modules and databases are described below.

2.4 All AEDT computational modules now use a single unified airports database. The common database has been assembled via both the merging of legacy model databases and the collection of additional data sources, done collaboratively with the EUROCONTROL Experimental Centre. Other data sources beyond those encompassed by the legacy models include Digital Aeronautical Flight Information Files (DAFIF), National Airspace System Resource (NASR), NAV Canada "Canada and North Atlantic Terminal and Enroute Data," and the ICAO Airports Database (http://www.icao.int/index.html). Figure 3 illustrates the merging of the individual data sources into the AEDT airports database.

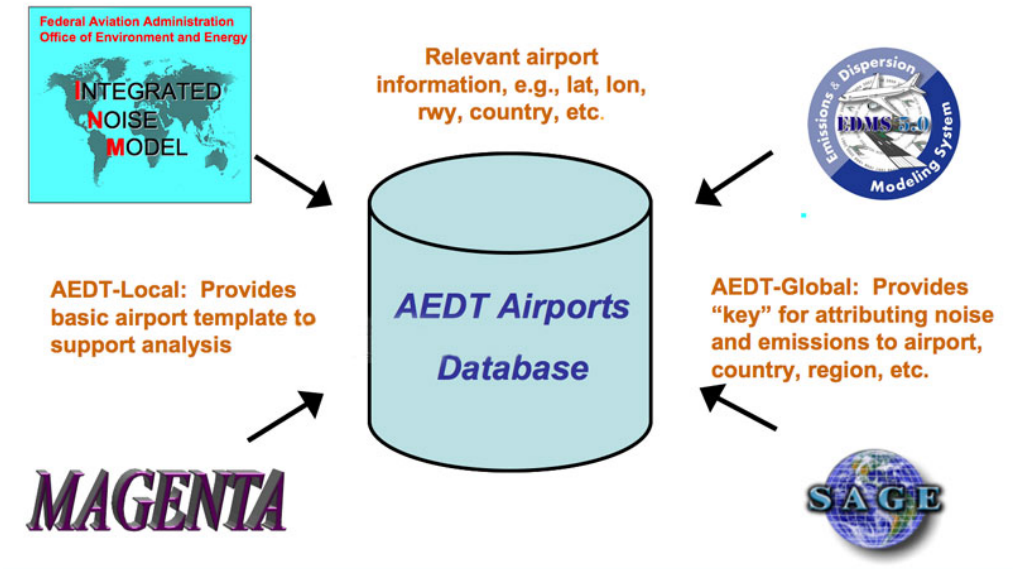

Figure 3. AEDT Airports Database Data Sources

2.5 A global movements database has been assembled for use in generating high fidelity inventories of noise and emissions. This database allows for the modeling of scenarios that range from a single flight to airport, country, ICAO region, and global levels. Data sources primarily include the U.S. Enhanced Traffic Management System (ETMS) and the International Official Airline Guide (IOAG). ETMS data include both schedule and flight track data, whereas the IOAG only includes schedule information. Data from EUROCONTROL's Enhanced Tactical Flow Management System (ETFMS) have also been added to the global movements database. The addition of these data allows for greater overall flight track data coverage, and validation and verification of flight track and schedule data using the combined ETMS and ETFMS data sets. With these two data sets combined, AEDT will provide between 75% and 80% coverage of global commercial aviation. Radar data from other sources are also being added to the database, as they become available. CAEP issued State letter AN 1/17-03/86 in August 2003, which initiated an effort for CAEP/7-WG2-TG2-8-WP/8 to gather information on CNS/ATM systems initiatives and air traffic movements in other regions of the world. In April 2006, a follow-up State letter AN1/17-IND/06/4 was issued to targeted member states. Currently, additional air traffic movement data have been received from Australia, Brazil, China, Japan, South Africa, the Middle East (primarily Oman and the UAE) and Morocco.

2.6 A fleet database has been developed that contains all aircraft noise, emissions, and performance characteristics required for integrated environmental analyses. This includes the aircraft

matching tables required to reconcile aircraft definitions for both noise and emissions analyses. The database, directly linked to ICAO's Campbell Hill database, comprehensively covers the world fleet, including jet and propeller-driven aircraft. The database does not contain characteristics for future technology aircraft.

2.7 A gate-to-gate aircraft performance module has been developed that enables the use of consistent aircraft state and trajectory information. The methodology is based primarily on the Society of Automotive Engineers Procedure for the Calculation of Airplane Noise in the Vicinity of Airports (SAE-AIR-1845) and the European Civil Aviation Conference (ECAC) Document 29 in the terminal area, and EUROCONTROL's Base of Aircraft Data (BADA) for the remainder of the flight regime. The module enables segment-by-segment calculation of aircraft fuel burn, emissions, and noise. The single performance module essentially harmonizes and merges the existing performance modules in the legacy tools; Figure 4 illustrates the merging of the existing modules.

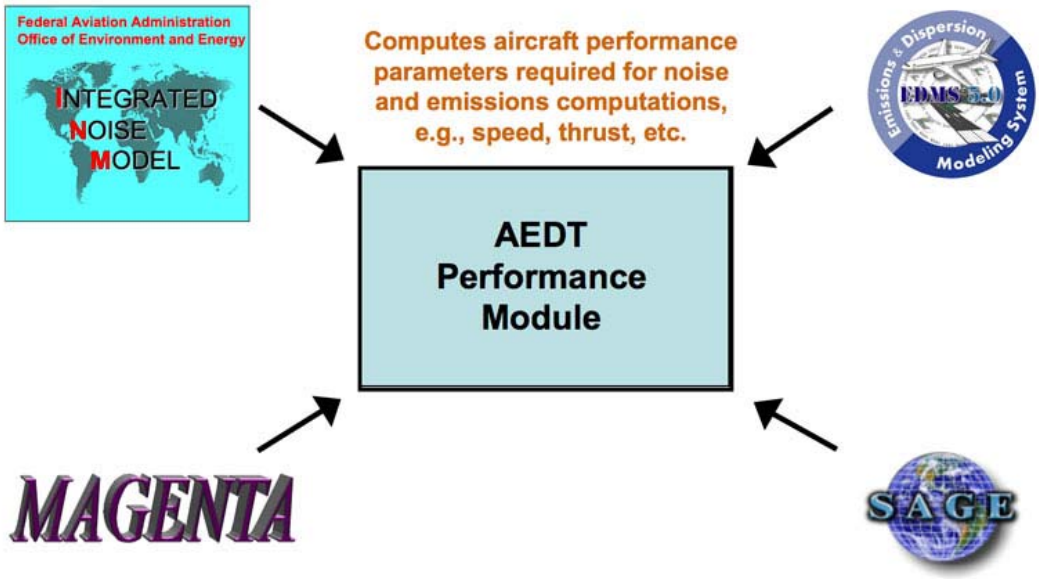

Figure 4. AEDT Aircraft Performance Module Sources

2.8 A fleet and operations module (FOM), based on the CAEP-accepted MAGENTA forecasting engine developed for CAEP/5 and CAEP/6, is also incorporated within AEDT. This module generates a future aircraft fleet using the generic fleet forecast, retirement algorithms and database of replacement aircraft, all provided by CAEP. The standalone module represents the same capabilities as those used previously by MAGENTA, streamlined per AEDT architecture standards.

2.9 An aircraft acoustics computational module based on the INM's capabilities has been developed for AEDT. This single module, which was previously common to both INM and MAGENTA and is consistent with both SAE-AIR-1845 and ECAC Document 29, is the backbone of all AEDT noise computations.

2.10 An aircraft emissions module has been developed to predict emissions for all modes of operations, including LTO and cruise. The module employs Boeing Fuel Flow Method 2 (BFFM2) to model CO, HC, and NOx. Fuel-based factors are used to model CO_2, H_2O, and SO_X, while PM is modeled using the U.S. FAA's first order approximation (FOA) version 2, which will soon be replaced

with version 3, as it was recently endorsed by WG3. Additionally, AEDT provides the capability to model emissions from all airport sources, including aircraft, ground support equipment, on-road vehicles, and stationary sources.

2.11 An air quality dispersion module, based on legacy capabilities within EDMS, will also be extracted and integrated within a standalone AEDT module. Specifically, the module is based on the U.S. Environmental Protection Agency's (USEPA) regulatory dispersion model, AERMOD. This airport-level dispersion is accomplished through the use of Gaussian dispersion calculations with a detailed characterization of the local weather.

3. AEDT ASSESSMENT

3.1 AEDT is undergoing comprehensive assessment at both the module and system levels. As documented in the CAEP/7 APMT information paper, a formal, module-level parametric sensitivity study and uncertainty assessment is being undertaken.

3.2 Significant efforts are also ongoing in coordination with the Society of Automotive Engineers (SAE) Aircraft Noise Committee (A-21) to assess specific modules and algorithms, including the aircraft noise, emissions, and performance modules. Additionally, exercises such as the sample problems described below aide in the assessment of the overall system.

4. AEDT SAMPLE PROBLEMS

4.1 Three rounds of a NOx demonstration analysis were undertaken using AEDT. Documented in CAEP/7-WG2-TG2-6-WP/10 and CAEP/7-WG2-TG2-7-IP/01, the analyses replicated the methodologies employed in support of the CAEP/6 Economic Analysis of NOx Emissions Stringency Options (CAEP/6-IP/13) in the AEDT system. Three rounds of increasingly complex analysis were undertaken as the effort was the first comprehensive application of AEDT, including its common modules and databases.

4.2 A similar demonstration of AEDT's modeling capability, as it pertains to operational assessment, was demonstrated in CAEP/7-WG2-TG2-6-WP/06 and CAEP/7-WG2-TG3-7-WP/08. These papers document analysis of continuous descent arrivals (CDA). This analysis is slightly more complex than the NOx demonstration due to the use of more specialized data analysis and modeling techniques. The CDA demonstration represents the first application of AEDT to a policy-based operational assessment. Since it considers noise, emissions, and fuel burn, it also provides a first look at interdependencies.

4.3 AEDT, along with other models, was also utilized to analyze the effects of reduced thrust takeoffs. Documented in CAEP/7-WG2-TG2-8-WP/13, this demonstration analysis particularly addressed integrated noise and emissions analysis. (See related CAEP/7 working paper on capability demonstrators for the U.S. Tool Suite, CAEP/7-WP/52.)

5. AEDT APPLICATIONS

5.1 As part of the CAEP/7 work program, AEDT was used to report on progress to meeting three environmental goals: limit or reduce the number of people impacted by noise, limit or reduce the impact of aviation emissions on local air quality, and limit or reduce the impact of aviation greenhouse

gas emissions on the global climate. (See associated CAEP/7 paper on goals assessment, CAEP/7-WP/18.)

5.2 In support of the goals assessment, AEDT was used to compute noise, emissions and fuel burn for baseline years 2000 through 2005 and forecasted years 2010, 2015, 2020, and 2025.

5.3 An updated goals assessment will be conducted as part of the CAEP/8 work program.

6. SCHEDULE

6.1 AEDT technical development is progressing on schedule. Draft versions of an overall system architecture document, as well as module interface control and algorithm description documents and database description documents, have been developed. As appropriate, common modules and databases are being integrated into the legacy models. Efforts are under way to develop common modules to handle all data access, as well as overall system work flow and logic. AEDT will be available to conduct analyses in support of CAEP/8 at the end of calendar year 2007.

7. REVIEW OF AEDT BY CAEP

7.1 As part of the CAEP/7 work program, Working Group 2 was charged with conducting an evaluation of candidate models to be considered for use as part of the CAEP/8 work program. AEDT is being considered as part of the evaluation process, which is expected to continue into the CAEP/8 work program. (See associated CAEP/7 model evaluation working paper, CAEP/7-WP/19.)

8. CONCLUSIONS

8.1 The U.S. Federal Aviation Administration is developing a comprehensive suite of software tools that will allow for thorough assessment of the environmental effects of aviation. The main goal of the effort is to develop a new, critically needed capability to assess the interdependencies among aviation-related noise, emissions, and cost valuations.

8.2 Substantial progress has been made developing the Aviation Environmental Design Tool. The model currently uses harmonized databases and modules. Additional development work is required and is underway to fully integrate all databases and modules in AEDT. A comprehensive validation and verification effort is also underway.

8.3 This paper serves to keep CAEP informed of the progress of the AEDT development effort. CAEP participants will continue to be informed of the progress of the development and related sample problems and demonstration analyses efforts.

— END —