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EDMS MULTI-YEAR VALIDATION PLAN

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INTRODUCTION

The Emissions and Dispersion Modeling System (EDMS) is the air quality model required for use on airport projects by the Federal Aviation Administration (FAA). This model has continued to be improved and very recently has included several important enhancements and methodology changes. These enhancements and changes have included changes to how the model computes dispersion, now using the U.S. Environmental Protection Agency (EPA) model, AERMOD. In theory, the incorporation of AERMOD should result in substantial improvements in EDMS accuracy, but validation using field measured data is necessary to substantiate this assumption and further support EDMS's use for airport evaluations.

The validation effort can be thought of as having two distinct goals:

1. Through sensitivity analysis, determine how inputs to the model can be improved to make the predicted concentrations more accurate.
2. Determine the performance of the model by comparing it to other models and especially measurements (determination of uncertainty).

Although these are the direct goals of the project, there are other important in-direct goals such as having EDMS included in the EPA list of preferred models (40CFR Part 51, Appendix W), establishing international cooperation and recognition, and creating general acceptance of EDMS by the modeling community.

Without the validation effort, these goals could not be achieved.

EFFORTS TO-DATE

The EDMS validation plan is dynamic and continually evolving. Results from each test help determine what additional testing is needed. The validation plan was originally outlined in FAA's *EDMS 5-Year Research and Development Plan* [1]. To date, several important steps in the plan have been completed. They include:

1. Initial planning and development of major concepts and ideas was completed in 2000.
2. Testing has been completed by the Volpe Center to determine how the dispersion algorithms in AERMOD behave using area and volume sources for aircraft on the runways. The results of this testing helped to define the final release of EDMS Version 4.0.
3. Testing has been completed by the EDMS model developers, CSSI Inc., on how the final EDMS 4.0 algorithms perform. The results of this testing are provided in FAA's *Model Changes Between EDMS 3.2 and EDMS 4.0* [2].
4. International cooperation and coordination has occurred and is ongoing.

5. Coordination meetings and correspondence with EPA have occurred and are continuously ongoing.
6. Coordination with two major airports has occurred to allow aircraft plume behavior testing at one airport and measurement of local carbon monoxide concentrations in the vicinity of the other airport.
7. Measurements of the aircraft plume have been accomplished using Light Detection And Ranging (LIDAR) and the data is now being analyzed [3].
8. A complete draft test plan has been developed for carbon monoxide sampling at a major airport and testing will occur later this year [4].
9. A major effort to compare the performance of EDMS to the Atmospheric Dispersion Modeling System (ADMS) used in Europe is currently underway.
10. Comparison of EDMS to the measured concentrations at two European airports is currently underway.

The purpose of this report is to outline the planned tasks that will occur during the remainder of the year 2001 and during 2002. Future years will also be discussed, but in less detail since much of the work will depend on the results of the first two years.

2001 PLANNED TASKS

Testing of Dispersion Algorithms

Although some preliminary testing has been done on area and volume sources before implementing into EDMS Version 4.0, this important task must continue. Inclusion in future years of parameters such as plume rise, new plume standard deviations, building downwash, etc. require that the individual algorithms be tested before implementation into future versions of EDMS. Much of this testing will occur as parts of other tasks, described in the following paragraphs. This task will be ongoing and performed as required to assist in FAA's continual development of EDMS.

International Cooperation and Coordination

It has taken considerable effort to establish the FAA/Volpe group as a key contributor in discussions and work ongoing in the international community. It is particularly noteworthy that the FAA/Volpe group was invited to join AERONET (previously only attended by European delegates). AERONET is the Thematic Network of the European Commission on Aircraft Emissions and Reduction Technologies, and was created as a platform where European stakeholders can exchange information. FAA and Volpe are also members of the Society of Automotive Engineers (SAE) E-31 Committee, which has established a sub-committee to determine new test procedures for quantifying particulate matter from aircraft. Continued attendance at AERONET and SAE E-31 meetings is crucial. This will be done in partnership with FAA and is an ongoing task. In addition, joint research efforts are underway and should be continued (these efforts are discussed later in this section). This task is critical to ensuring international acceptance of FAA methodologies (including EDMS) and exchange of ideas and data on international technical issues.

Meetings with EPA

Given EPA's regulatory authority in the area of air quality, it is crucial to keep EPA informed of FAA / Volpe's many efforts, and receive EPA guidance and approval on applicable components of FAA's R&D efforts (including the validation of EDMS). FAA has continued to do this and Volpe has provided support as needed. Similarly, it is crucial that EDMS be included in 40CFR Part 51, Appendix W as an EPA preferred model. A time schedule has been set that should insure all needed work is completed in time to allow EPA to continue to classify EDMS as such in the next version of Appendix W. This task is ongoing.

Coordination with Airports for Testing

To date, coordination has occurred between two major airports, FAA and Volpe to facilitate LIDAR testing at one airport and measurement of local carbon monoxide concentrations in the vicinity of the other airport. This coordination must continue for additional testing that will be required as the validation effort continues. Coordination with the airports will be accomplished on a case-by-case basis. The next related tasks are follow-up contact with the airport in which the LIDAR testing occurred, follow-up contact with the airport previously identified for the measurement of carbon monoxide, and to begin coordinating with additional airports regarding the potential for future testing efforts (as described below under suggested tasks for 2002).

Determination of Aircraft Plume Characteristics Using LIDAR

The LIDAR measurements have been completed and details are discussed in the study's initial progress report [3]. In brief, the data analysis is now underway. This analysis will allow development of aircraft specific standard plume deviations in the horizontal and vertical plane. This is critical input for the dispersion model in EDMS. Also, plume rise will be determined, again a crucial input for EDMS. Finally, the effects of a blast fence on the aircraft plume will be explored. These analyses should be complete in August, 2001, and a study report published soon thereafter.

Testing of Carbon Monoxide Concentrations in the Vicinity of Airports

A complete draft test plan has been developed for carbon monoxide sampling at a major airport [4]. The actual testing will occur in late November or early December of 2001. Analysis should be completed by early 2002. This testing will permit comparisons of EDMS predicted concentrations to field measured values that the research team has quality controlled. This testing will help to determine the overall accuracy of EDMS and will also be extremely helpful in evaluating and enhancing components of the EDMS model.

Comparison of EDMS to the Measured Concentrations at Two European Airports

This task is also just beginning. It is being performed in coordination with Manchester Metropolitan University in Manchester, UK, and two large European airports. The results of this analysis will allow a direct comparison of EDMS predicted concentrations to measured concentrations. The timing of this task is very critical since it will provide part of the foundation for inclusion of EDMS 4.0 into 40CFR Part 51, Appendix W. This task should be completed by August, 2001.

It should be noted that this comparison will be for carbon monoxide as well as other pollutants such as nitrogen oxides (NOx) and possibly particulate matter (PM), as data is available. However, the focus of the analysis will be on carbon monoxide since the purpose of the study is to evaluate the performance of the dispersion algorithms without introducing modeling complexities, such as pollutant reactivity. The dispersion characteristics of EDMS must be verified before other model algorithms to avoid complications. It is with this goal that the analysis will be done.

As such, a comparison of overall measured NOx concentration could be used to evaluate dispersion if measured carbon monoxide concentration data are not available and the NOx data is. Further comparisons, such as to NO_2 only, can not be justified in this initial work since chemistry must be considered and is not presently included in EDMS. Work will be performed outside the model, to evaluate chemistry for possible later inclusion into EDMS.

Particulate matter concentrations may also be compared to EDMS predicted results. However, this analysis would only be a first step in reviewing the predicted results. This is due to the error caused by the lack of good emission data for particulate matter from aircraft.

Comparison of EDMS to ADMS

This task is just beginning. It is a "sister" task to the previous one and is also being performed in coordination with Manchester Metropolitan University in Manchester, UK, and two large European airports. The results of this comparison will allow the EDMS to be evaluated in the international arena against the most-used model for airport air quality analysis in Europe, ADMS. Along with international exposure, this will also permit an initial comparison of EDMS to a well established model. This task is expected to be complete in September of 2001.

It is of note that as in the previously described task, this comparison will be done for multiple pollutants. However, because ADMS contains chemistry algorithms that include algorithms for NO_2, only total NOx will be evaluated.

SUGGESTED TASKS IN 2002

Data Analysis From Initial Carbon Monoxide Sampling

Since the initial measurements of carbon monoxide sampling will take place in late 2001, the data analysis will begin but will not be completed until early 2002. Upon completion, a thorough comparison of EDMS to measured data that has been quality controlled by the research team will be performed. This task should be completed in early 2002.

Testing of to Carbon Monoxide and Other Pollutant Concentrations at Two Additional Airports

Since sampling will have just occurred at the first airport in November or December of 2001, it would be cost and time effective to sample at two additional airports in the winter (February or March) and spring of 2002 (April or May). This is because equipment will be recently calibrated and field tested. In addition, personnel will be recently trained and available, and supplies can be carried over from the last sample location. If this is to occur, coordination with potential airports needs to begin immediately. The sample plan for the first airport has been written in generic terms so it could be shared with potential airports immediately, reducing time requirements. It is suggested that two major airports, that meet the sample plan requirements, be identified and sampling performed in early 2002.

By measuring at two additional airports, any site bias will be minimized and a more accurate determination of EDMS accuracy concluded. Site bias is caused by such factors as local topography, local meteorology, elevation, and fleet mix. The results from multiple airports can be efficiently used to eliminate bias through statistical methods. The end result is improved prediction accuracy.

Perhaps even more important is that during these additional airport measurements, it will be easier to measure additional pollutants. It is well documented that NOx in the vicinity of airports will be a concern in the future. EDMS results lack chemistry considerations in the dispersion models, putting predicted results for reactive pollutants in doubt. Using the results of the European analysis to guide the effort, major in-roads to including chemistry assumptions into EDMS could occur. The measurements would provide the very important link to evaluate and implement these algorithms for other reactive pollutants such as NOx. Additionally, other pollutants of concern, such as particulate matter less than 2.5 micrometers in diameter could be evaluated and a database began. Additional testing can also be performed for specific sources, based on the needs that were identified from the initial studies in 2001.

LIDAR Testing at Additional Airports

The result from the initial LIDAR tests showed that this approach for measuring plume parameters is quite effective. Plume rise was shown to occur and the initial standard deviations of the plume were measured. However, just as with the carbon monoxide testing, the results could be criticized due to site bias. Site bias may occur due to input variables such as plume rise from local temperatures and elevations. This is obviously undesirable since the initial plume characteristics make a big difference in the model results, and hence the model accuracy. To avoid this potential problem, LIDAR testing

should be performed at two additional major airports (one in 2002, and one in 2003) with different localized variables, primarily weather and elevation. Sampling at these two additional locations should be more cost effective than the first location because the National Oceanic and Atmospheric Administration (NOAA), who owns the LIDAR equipment and performed the actual measurements, now understands the equipment needs and has modified the software and LIDAR appropriately. Coordination with candidate airports should begin immediately for the second airport. It is highly recommended that sampling at a third airport also occur in 2003.

Algorithm Testing

As validation data from multiple airports becomes available, it will allow specific testing of algorithms in EDMS. For example, samples taken at even intervals from an active runway will permit evaluation of the area sources and EDMS input parameters. This would either confirm that correct logic is being used for the runway in regards to dispersion algorithms or allow for modifications of the model if poor agreement is observed. This same process could be used for taxiways, aprons, and parking areas. This task should be concurrent with the analysis of data from the field sampling performed in 2001. It should continue throughout 2002.

Coordination with Other Interested or Involved Parties

As noted earlier, FAA and Volpe have worked hard to gain cooperation and coordination with EPA and our European counterparts. This effort must be continued to help this cooperation and coordination continue. Additionally, concurrence by EPA is crucial to the success of EDMS and cannot be taken lightly. Volpe will support FAA in this ongoing effort.

SUGGESTED WORK IN 2003 AND BEYOND

The work that is completed in 2001 and 2002 will determine what work is needed in the year 2003 and beyond. It is envisioned that monitoring at additional airports will be needed to allow more comparisons of modeled to measured carbon monoxide concentrations such that widespread acceptance and elimination of site bias can occur.

It is also envisioned that spot testing for specific sources will be needed. For example, the discussion of how ground support equipment and auxiliary power units should be modeled continues. Most agree that point source modeling is not adequate and area sources would be better. But how would these area sources be defined? What limits should be placed on the area? How should emissions be allocated in the defined area? All of these questions could be answered by monitoring. The results could then be made more general and included in EDMS. In addition, key variables such as which equipment are used, what is the duration of use, and what occurs between landing/takeoff cycles with this equipment could be answered during the measurement process.

The initial LIDAR results have been quite encouraging as well. It may be determined that the LIDAR testing could be used for more than is currently being done. For example, evaluation of in-use aircraft could be done to determine how the emission indices maintained by the International Civil Aviation Organization change with engine age and local climatologic effects. It is strongly recommended that a third airport be sampled using the LIDAR system in 2003.

Of course coordination with EPA and foreign organizations should be continued. This includes the validation efforts as well as other work such as the determination of better ways to measure particulate matter. Volpe will continue to support FAA in this important task.

Other validation related activities may also be needed as data continues to be analyzed and evaluated. These tasks may occur in the time frame from the year 2003 until 2005 and include:

- Detailed evaluation of EDMS algorithms that are judged to be the greatest sources of error;
- Evaluation of building downwash effects at airports;
- Evaluation of the dispersion characteristics of helicopters;
- Better methods for determining the impacts of aircraft delays and queues;
- The effect of blast screens on dispersion;
- Quantification of the uncertainties in the modeling process;
- Inclusion of topographic features in EDMS; and
- Additional tasks as the validation process continues.

While there is a need for this testing, and perhaps more, it is recommended that the decisions on which testing at what time be dynamic and open. As such, the test plan should be revised as the subjects “ripen”. In this way, allocation of critical resources can be done in an informed manner.

SUMMATION

In summary, testing is proceeding, having begun in 2000 with major concepts and ideas determined. In 2001, this planning was made more specific and detailed. The detailed planning led to sampling beginning. By the end of the year 2001, several tasks now underway will be complete. This includes: the initial LIDAR testing and analysis; comparison to ADMS; comparison to measured pollutant concentrations at two major European airports; and the initial carbon monoxide sampling at the first airport.

In 2002, the initial comparison of the measured carbon monoxide concentrations to the predicted values using EDMS will be complete for the first airport. It is suggested that carbon monoxide sampling at two additional major airports be accomplished to avoid site bias and possible criticism in 2002. The additional sites should form a more average database resulting in more accurate predictions and better acceptance of EDMS. Additionally, other pollutant concentrations such as NOx and PM could be measured

during this testing. It is also recommended that LIDAR testing be done at a second airport in 2002 and a third in 2003, again to avoid site bias, resulting in more general inputs for EDMS and better acceptance of the model.

Other tasks in the year 2003 and beyond will depend on the previous validation efforts. The results of these efforts will allow determination of what is needed the most and allow critical resources to be applied in a cost effective manner. It is envisioned that more carbon monoxide sampling and LIDAR sampling may be needed. These samples may need to be source specific if it is determined that sources need to be better quantified during dispersion modeling. Many other considerations as listed in previous bullet items may also be important.

Coordination and cooperation with EPA and foreign organizations should be ongoing throughout this time period. Considerable effort has been expended to gain this coordination and cooperation and it should not be allowed to diminish.

Figure 1 shows a timeline of the major single events of the validation plan. Table 1 lists all tasks discussed and summarizes the product received from each of these tasks.

REFERENCES

1. U.S. Department of Transportation, *Emissions and Dispersion Modeling System 5-Year Research and Development Plan,* Version FY01.1, Federal Aviation Administration, Washington, DC, October, 2000.

2. U.S. Department of Transportation, *Model Changes Between EDMS 3.2 and EDMS 4.0*, prepared by CSSI, Inc. for the Federal Aviation Administration, Washington, DC, May, 2001.

3. Wayson, R.L., G.G. Fleming, and B. Kim, *The Use of Light Detection And Ranging (LIDAR) for Determining Plume Characteristics; Progress Report*, Volpe National Transportation Systems Center, Cambridge, MA, June, 2001.

4. Wayson, R.L. G.G. Fleming, and B. Kim, *Validation of the Federal Aviation Administration's Emissions and Dispersion Modeling System: Measurement and Comparison of Local Concentrations, Draft Test Plan,* John A. Volpe National Transportation Systems Center, Cambridge, MA, June, 2001.

Table 1. Summary of Key Validation Tasks and Expected Products of These Tasks

TASK	E XPECTED COMPLETION DATE	EXPECTED RESULTS
Initial Planning and Development of Concepts	Completed in 2000	Beginning of Validation Plans And Communications with the Modeling Community
Coordination and Cooperation	Ongoing	Acceptance by EPA And the Modeling Community Of EDMS
LIDAR Testing: Airport 1	December, 2001	Standard Deviation of Plumes in Vertical and Horizontal; Plume Rise; Effects of Blast Shield
Modeled v. Monitored Comparison for 2 European Airports	September, 2001	Initial Validation Effort for EDMS, Which is Needed for Appendix W
Comparison of EDMS Performance to ADMS)	December, 2001	Determination of Overall Model Results to an Established Model
CO Measurements: Airport 1	March, 2002	True Validation Effort of Dispersion Algorithms with Quality Controlled Data
CO, NOx, PM Measurements at Airport 2	August, 2002	True Validation Effort for Dispersion, Beginning of Chemistry Considerations, and PM Check Using Quality Controlled Data
CO, NOx, PM Measurements at Airport 3	November, 2002	True Validation Effort for Dispersion, Beginning of Chemistry Considerations, and PM Check Using Quality Controlled Data
LIDAR Testing: Airport 2	November, 2002	Standard Deviation of Plumes in Vertical and Horizontal; Plume Rise; Effects of Blast Shield and Check on Site Bias
Continued Effort in Years 2003 and Beyond	TBD	Testing of Specific Algorithms, Elimination of Site Bias, Further Considerations Such as Chemistry, Check on Particulate Matter

Figure 1. EDMS Validation Timeline By Year Of Important Milestones