Meszler
Engineering Services
906 Hamburg Drive, Abingdon, Maryland 21009

March 13, 2007

Dr. Barbara Lichman
Chevalier, Allen & Lichman, LLP
695 Town Center Drive
Suite 700
Costa Mesa, California 92626

Dear Dr. Lichman,

In accordance with our conversation a few weeks ago, I have developed rudimentary air emissions inventories for the proposed modification to the Four Corner-Post Plan for McCarran International Airport. The inventories have been developed using data presented in the November 2006 Final Supplemental Environmental Assessment for the Proposed Modification to the Four Corner-Post Plan for Las Vegas McCarran International Airport, as issued by the Federal Aviation Administration of the U.S. Department of Transportation (FSEA). Since the air quality and airport activity data presented in the FSEA are limited, the developed inventories are similarly limited. For example, the inventories *do not include emissions from any ground transport or airport facility sources* as the FSEA presents no data upon which to construct such estimates. To the extent that such excluded emissions will rise (or fall) with aircraft activity, the emission impact estimates that follow will be conservatively low (i.e., actual impacts will be of a larger magnitude than those presented).

It is equally important to recognize that the emission estimates that follow are based *entirely* on the data developed by the FAA, as presented in the FSEA. While I have utilized those data to the fullest extent possible, and generated emission estimates for sources not included in the FSEA, I have *not* performed a fundamental reassessment of the FAA data -- in effect, the data are taken at face value. While a fundamental reassessment of the data could be performed, it would require a schedule and access to resources that are outside the present scope of my efforts.

As you know, the development of air emission estimates for the full range of airport sources, as well as a demonstration that provided aircraft activity data are complete and accurate is a prime responsibility of the FAA. While we could undertake these efforts ourselves, the time and budget required to do so would be commensurate with the resources typically employed by the FAA for such an effort. Moreover, such an effort does not lend itself to the limited timeframe currently available. Nevertheless, *the potential emission impacts presented for the limited analysis summarized below effectively illustrate the significance of the FAA's omission of a proper air quality analysis and the resulting inadequacy of the FSEA*.

Using data presented in Section C-2.4.1 and Tables C-2.4 and C-2.6 of the FSEA, I was able to develop rudimentary air emissions inventories for aircraft (main engines and auxiliary power units, or APU) and aircraft ground support equipment (GSE). This is in contrast to the aircraft main engine only emissions estimates summarized in the FSEA. I broke my analysis into two basic components, the first of which attempts to replicate the emission estimates developed by the FAA, while the second of which expands upon those estimates to more accurately reflect the impacts that would be expected to occur if the action proposed in the FSEA is implemented.

Replication of FAA Estimates. According to the FSEA, the FAA used version 4.4 of their EDMS model to generate the emission estimates presented in Tables 4.8, 4.9, and 4.10 of the FSEA. Using the same version of the model and the methodology described in Section C-2.4 of the FSEA, I generated comparative emission estimates for the 2004 baseline conditions defined in the FSEA. These conditions included aircraft definitions and activity as presented in Table C-2.4, average annual temperature and mixing height data as presented in Section C-2.4.1, and average taxi time as presented in Table C-2.6. Table 1 summarizes the results of my analysis.

Table 1. 2004 Emission Estimates Using EDMS Version 4.4 (tons per year)

Source	CO	VOC	NO_x	SO_2	PM-10	PM-2.5
FSEA Table 4.8	2,206.3	234.8	2,115.7	180.0	55.8	24.6
My Analysis with 15.36 Minute Taxi Time	1,877.9	194.2	2,071.6	167.9	23.0	23.0
My Analysis versus FSEA	-15%	-17%	-2%	-7%	-59%	-6%

My emission estimates differ substantially from those presented in the FSEA. This is troubling as the FSEA analysis is quite limited and should, therefore, be easy to replicate. I should qualify this with respect to PM-10 emissions, as the FSEA indicates (in Section C-2.4.2) that supplemental (i.e., non-EDMS) analysis was performed for some aircraft for which EDMS does not include PM emission rate data. Since I did not perform any non-EDMS analysis (as the specific approach employed by the FAA was not sufficiently described to allow replication), I would expect differences in our respective PM emission rates. As a result, I recommend ignoring, for purposes of this comparison, PM emission estimate differences. The sole exception is the large difference between the FAA's tabulated PM-10 and PM-2.5 emission rates. This is an obvious error and I suspect that the FAA simply included the EDMS-only portion of the PM-2.5 estimate in Table 4.8 of the FSEA by mistake. Actual PM-2.5 emissions are almost certainly intended to be 55.8 tons per year (as opposed to 24.6 tons per year) as demonstrated by the 2005 and 2010 emission estimates presented in Table 4.9 of the FSEA.

The 15 percent or greater differences for CO and VOC are too large to be attributable to minor differences in my and FAA's analysis, especially given the rudimentary nature of the analysis approach. After considering the FSEA description of the FAA analysis for some time, I ran a sensitivity analysis using an average aircraft taxi time of 18.99 minutes in place of the 15.36 minute value presented in Table C-2.6 of the FSEA. The 18.99 minute estimate is the sum of the 15.36 minute total taxi/idle time presented in Table C-2.6 and the 3.63 minute departure delay component of that time, as presented in the same table. Despite the fact that the FSEA clearly states that the latter is a component of the former (in both the footnotes to Table C-2.6 and the associated narrative is Section C-2.4.3), CO and VOC emissions are most sensitive to taxi time and therefore can only be significantly altered (without inducing equally large or larger changes in other pollutant emissions) by altering aircraft taxi time. Since 18.99 minutes was the only potential variation I could envision, I reran my analysis with an 18.99 minute taxi time. The results of this alternative analysis are presented in Table 2.

Table 2. Alternate 2004 Emission Estimates Using EDMS Version 4.4 (tons per year)

Source	CO	VOC	NO_x	SO_2	PM-10	PM-2.5
FSEA Table 4.8	2,206.3	234.8	2,115.7	180.0	55.8	24.6
My Analysis with 18.99 Minute Taxi Time	2,179.0	229.0	2,119.1	180.0	24.6	24.6
My Analysis versus FSEA	-1%	-2%	+0%	-0%	-56%	+0%

The alternative emission estimates, with the exception of PM-10 for the reasons already described, closely match those presented in the FSEA. All are within 2 percent. While this is not close enough to convince me that our analyses are now consistent since the rudimentary nature of the approach should lend itself to exact replication, the proximity of the emission estimates is sufficient to demonstrate that the FAA did not base their estimates on the specific data described in the FSEA. At a minimum, there is almost certainly a taxi time discrepancy.

Since we are interested only in the relationship between baseline and action scenario emission estimates, it is still possible to perform a more detailed investigation of the impacts of the proposed FAA action. However, to facilitate such investigation, both baseline and action scenario emission estimates must be generated to ensure that both reflect consistent approaches and assumptions. As the baseline emission estimates of the FSEA reflect the impacts of unknown analysis discrepancies, they must be replaced to allow accurate comparative analysis, but it is important to recognize that I will continue to utilize the FAA analysis approach as described in the FSEA and that any required revision to this approach or the associated emission estimates remains the responsibility of the FAA. Thus, my estimates should be viewed in a relative (i.e., action versus baseline) sense only and not necessarily reflective of actual emissions at McCarran International.

<u>Alternative Emission Impact Estimates</u>. The same data used in the attempt to replicate the FAA emissions estimates presented in the FSEA can be used to generate alternative, and more complete, emission impact estimates. Essentially these data consist of the baseline aircraft activity estimates presented in Table C-2.4, average annual temperature and mixing height estimates presented in Section C-2.4.1, and average taxi time estimates presented in Table C-2.6. Combining these estimates with reasonable assumptions about aircraft activity under the proposed action scenario allows the relative impacts of the proposed action scenario to be evaluated.

I used EDMS version 5.0 for this analysis as it represents the latest version of the EDMS model released by the FAA. This version essentially represents a more recent release of the EDMS version 4.4 model used by the FAA for the FSEA analysis. Version 4.4 of the model was released in November 2005, version 4.5 was released in June 2006, and version 5.0 was released in January 2007. Based on this release schedule, the FAA analysis should have been performed sometime between November 2005 and June 2006.

To provide an indication of the sensitivity of aircraft main engine emissions to the EDMS release used for emissions estimation, Table 3 presents a comparison of 2004 baseline emission estimates produced using EDMS version 4.4 and EDMS version 5.0. Clearly, EDMS version 5.0 produces higher emission estimates than EDMS version 4.4 for the same set of input data. VOC in particular is much greater in version 5.0, primarily due to the inclusion of main engine start emissions, a source of emissions not addressed in previous model releases. Given this sensitivity, it must be recognized that the emission estimates that follow cannot be compared directly to those in the FSEA. Nevertheless, assuming that the FAA's analysis assumptions are reasonable, the emission estimates can be used to evaluate relative action scenario impacts.

Table 3. EDMS Sensitivity of 2004 Aircraft Emission Estimates (tons per year)

Source	CO	VOC	NO_x	SO_2	PM-10	PM-2.5
My Analysis with EDMS Version 4.4	1,877.9	194.2	2,071.6	167.9	23.0	23.0
My Analysis with EDMS Version 5.0	2,065.2	488.9	2,174.6	216.6	27.7	27.7
EDMS Version 5.0 versus Version 4.4	+10%	+152%	+5%	+29%	+20%	+20%

In performing the emissions analysis, I augmented the basic FAA methodology in several appropriate ways. First, I included both GSE and APU emission estimates as these can be generated from the same basic data assembled by the FAA for the FSEA. For APU emissions, I accepted EDMS default aircraft/APU assignments and operating times. Similarly, for GSE, I accepted EDMS default aircraft/GSE assignments. Ideally, McCarran-specific analysis of the type and duration of APU use and the population, age, and frequency of GSE use would be performed, but it is not possible to undertake such an analysis in the timeframe and budget available. Default EDMS assumptions are expected to provide a reasonable first-cut surrogate, but a more detailed analysis should be an integral requirement of an appropriate FAA analysis.

I also performed the aircraft main engine emissions analysis using both performance-based times-in-mode (for non-taxi operational modes) and default ICAO/EPA times-in-mode (for non-taxi operational modes). I undertook this dual option approach as I have some concern over the accuracy of the performance-based times-in-mode emissions algorithms encoded within EDMS. Unfortunately, it is not possible to evaluate these algorithms directly as EDMS is not a public domain model and, as a result, the source code is not included in the EDMS material provided to users. Nevertheless, it is possible to gain some insight into the performance-based algorithms by comparing EDMS outputs for variable performance-based inputs.

For McCarran International, my main concern is related to the sensitivity of performance-based emission estimates to ambient conditions, primarily temperature. As you know, summertime temperature conditions in Las Vegas represent an extreme relative to most other U.S. airports. However, EDMS as implemented by FAA in their emissions analysis and myself for the analysis described herein, utilizes annual average temperature data, which the FAA quantified as 68.1 ºF for McCarran.[1] Since this is substantially below the temperature conditions that are routinely observed in the Las Vegas area during the summer months, it is important to determine whether annual average emissions can be developed using annual average temperature data. This would be possible if all affected parameters (e.g., aircraft performance, emission factors) varied linearly with temperature, but non-linear relationships would result in emissions estimate errors.

Since the specific code to implement the EDMS algorithms is not available, I executed the model for a range of average temperatures. The default annual average daily temperature employed by EDMS version 5.0 for McCarran International is 68 ºF, with annual average daily high and low temperatures of 78.35 ºF and 57.65 ºF respectively. To determine the sensitivity of the model to annual averaging, I ran the default temperature data for McCarran plus a series of alternative daily temperatures averaging 48, 58, 78, 88, 98, and 108 ºF. For each alternative temperature scenario, I maintained the ±10.35 ºF range to determine the daily maximum and minimum temperatures. So, for example, the daily maximum and minimum temperatures for the 98 ºF scenario were 108.35 and 87.65 ºF respectively. The only exception was for the 108 ºF average temperature scenario, where the maximum daily temperature was restricted to 110 ºF as that is the maximum temperature accepted by EDMS.

Figures 1 through 6 present the performance-based emissions relationships for the seven temperature scenarios evaluated. As indicated, all pollutants are modeled as inversely related to ambient temperature with the exception of VOC, CO, SO_2, PM-10, and PM-2.5 in takeoff and climbout modes. The latter exceptions are as expected, due to combustion inefficiencies that are manifested as temperatures increase (primarily the inefficiency related to decreasing air density). However, the inverse NO_x relationship in these same high thrust modes as well as why similar inefficiencies are not manifested in the low thrust modes of operation is not intuitively obvious and causes me to have some concern regarding the accuracy of the performance-based modeling. For example, while I would expect unit (i.e., mass per unit mass of fuel) NO_x emissions to decline with increasing combustion inefficiency, I would also expect fuel flow to increase

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[1] EDMS does allow for the input and use of detailed, temporally variant, ambient data. However, the development of such data is quite intensive and was not undertaken by the FAA for the FSEA analysis. Moreover, EDMS is quite restrictive in regard to the application of historic data to arbitrary evaluation years, which significantly complicates the application of identical detailed ambient data across time. Regardless, the FAA elected to utilize the annual average approach for the FSEA evaluation and that same approach was employed for the analyses described in this review.

Figure 1. Sensitivity of EDMS NO_x Emissions to Ambient Temperature

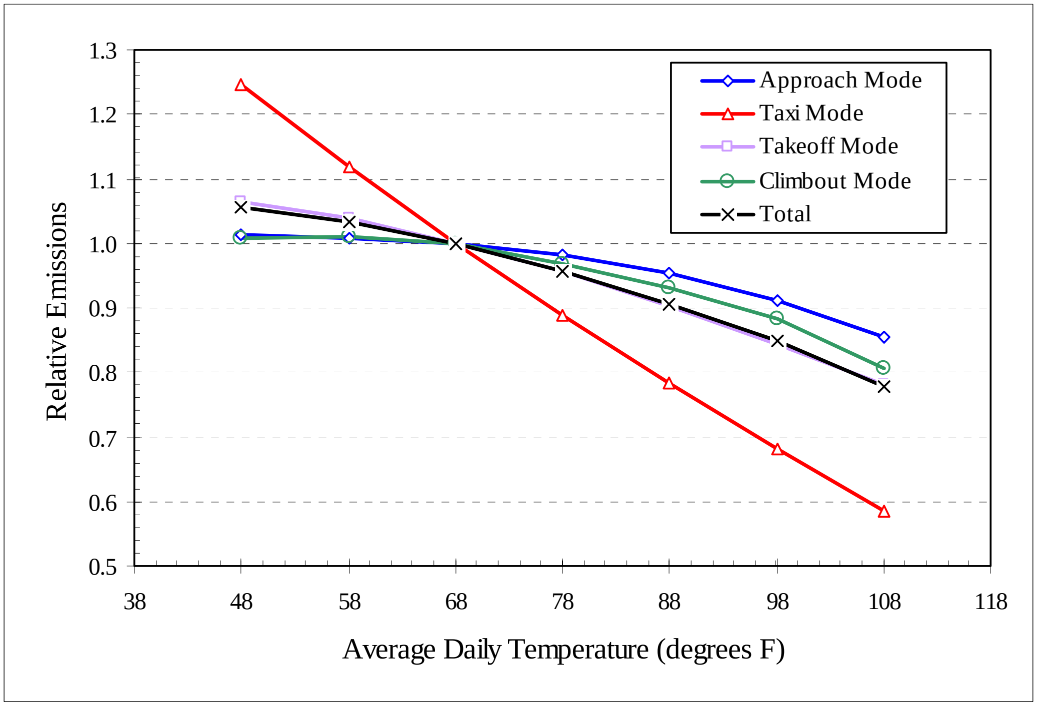


Figure 2. Sensitivity of EDMS VOC Emissions to Ambient Temperature

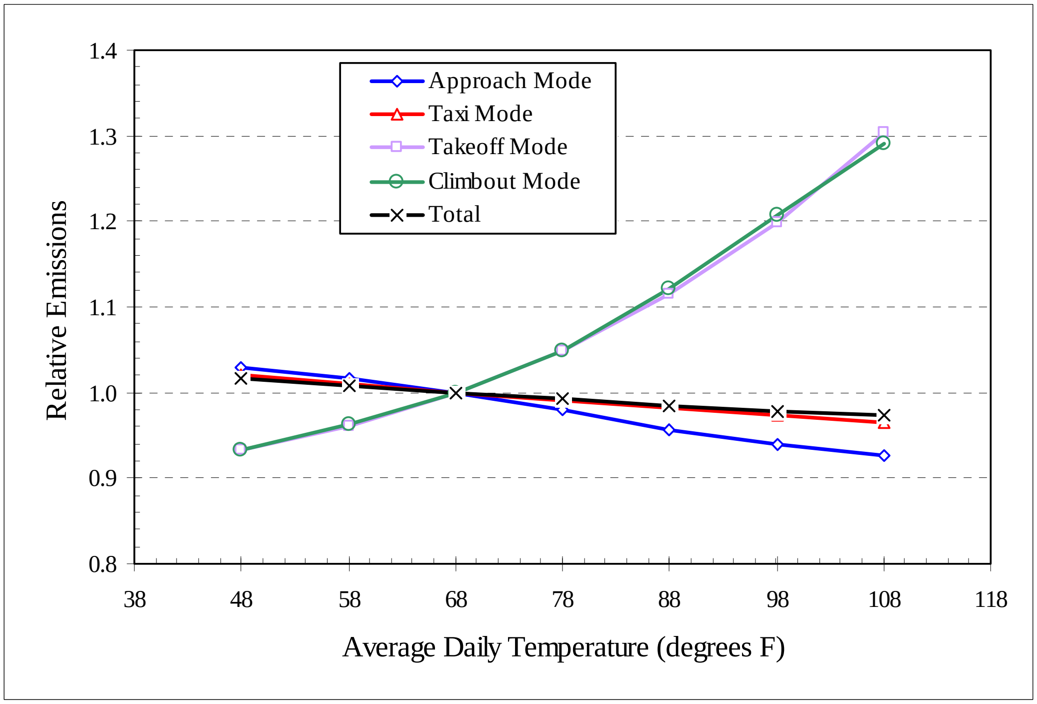


Figure 3. Sensitivity of EDMS CO Emissions to Ambient Temperature

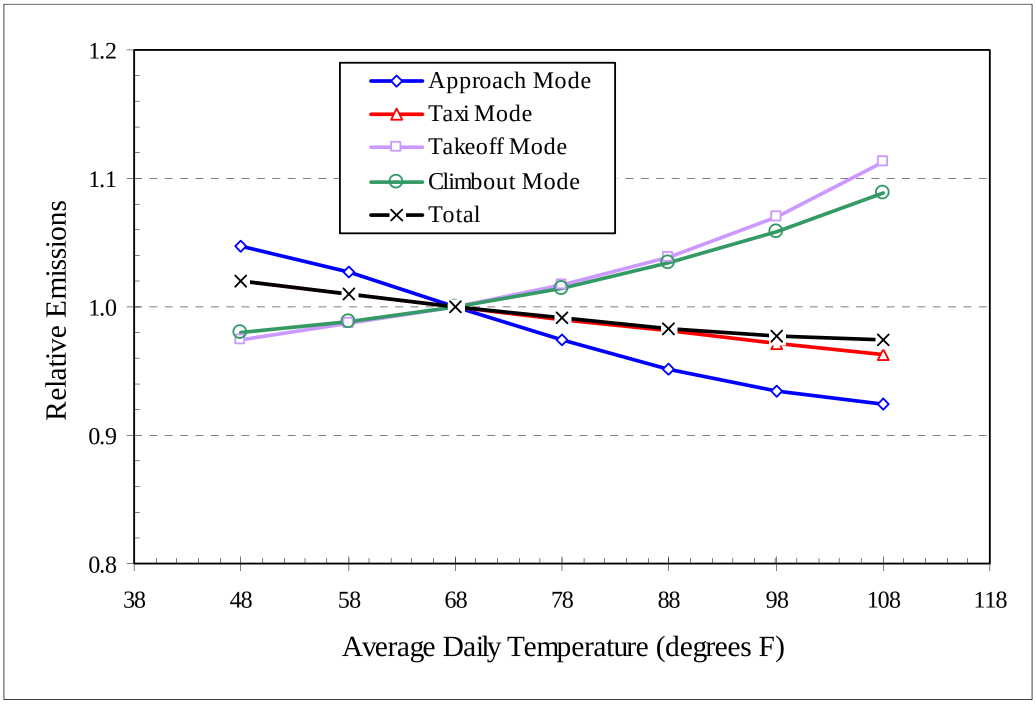


Figure 4. Sensitivity of EDMS SO_2 Emissions to Ambient Temperature

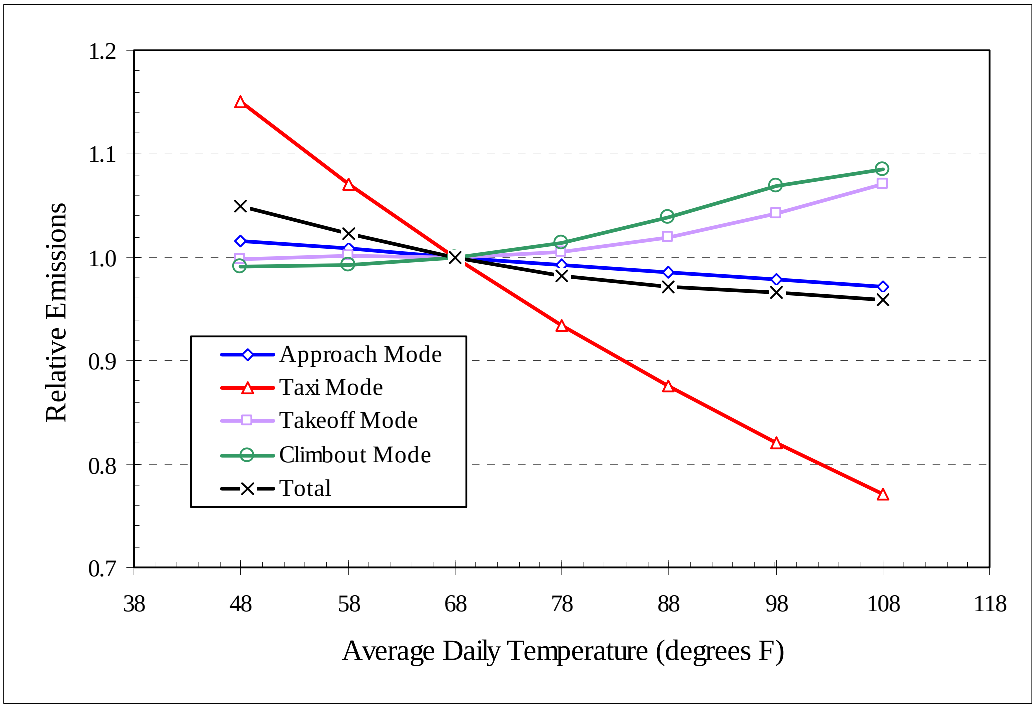


Figure 5. Sensitivity of EDMS PM-10 Emissions to Ambient Temperature

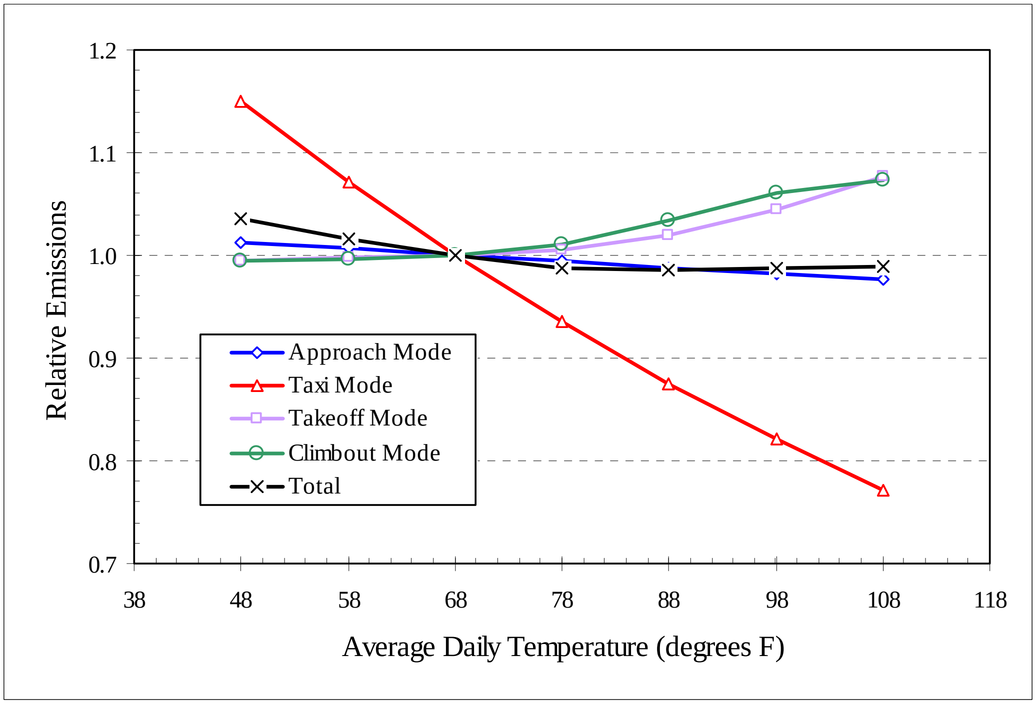
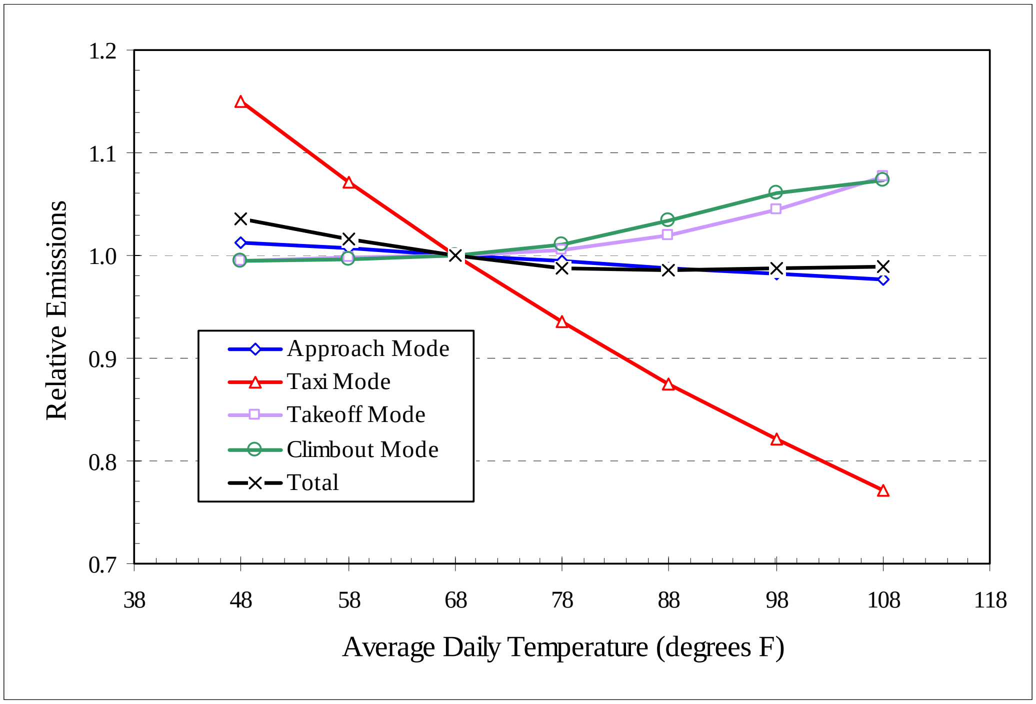


Figure 6. Sensitivity of EDMS PM-2.5 Emissions to Ambient Temperature



disproportionately to maintain equivalent aircraft thrust characteristics. The alternative would be reduced mode-specific thrust, with correspondingly longer takeoff and climbout times. While it is theoretically possible for the latter to result in lower NO_x emissions, I will defer further speculation until such time as I have had an opportunity to review the specific EDMS algorithms. That, of course, will not occur as part of this review, but should be conducted as part of a public process to which EDMS has not, to date, been subjected. I discuss this in some greater depth in the concluding section of this review.[2]

Given this uncertainty, I elected to develop emission estimates using both the performance-based and ICAO/EPA time-in-mode options available within EDMS. Fortunately, as will be shown below, a determination of whether or not the proposed action is significant is not sensitive to the option utilized. The proposed action is significant in either case, but "more significant" under the ICAO/EPA time-in-mode option.

Finally, I also generated emission estimates for aircraft reverse thrust operations. Although these operations are of short duration, they are high thrust, high NO_x modes and should be included in any aircraft emissions analysis. Nevertheless, since the FAA continues to ignore such emissions in their air quality analyses, I present aircraft emission estimates both with and without reverse thrust operations. As with the time-in-mode options, a determination of overall significance is independent of the reverse thrust assumption as the proposed action exceeds significance thresholds regardless of whether or not reverse thrust is considered.

Table 4 presents a summary of the emissions modeling parameters I employed in my analysis. The assumptions for the first five modeling scenarios (three baseline and two action) match those described by the FAA in the FSEA exactly. Unfortunately, the two action scenarios are not properly defined by the FAA, so I have supplemented them with two more appropriate scenarios that are designated in Table 4 as the "economic activity" scenarios. The FAA action scenarios

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[2] I did review available EDMS outputs in more detail for two of the aircraft responsible for a significant fraction of McCarran activity in an effort to more definitively isolate EDMS performance assumptions. For equivalent weights, EDMS assumes that takeoff and climbout times-in-mode are about 8 and 19 percent longer at an average temperature of 98 ºF than 48 ºF respectively for an Airbus A320, and about 10 and 26 percent longer respectively for a Boeing 737-300 aircraft. For the A320, climbout fuel flow on a mass basis is about 4 percent lower at 98 ºF than 48 ºF, while the 737-300 exhibits about 5 percent lower fuel flow for the same conditions. Fuel mass-specific NO_x emission rates are about 30 percent lower at 98 ºF than 48 ºF, so that the net result is about a 20 percent climbout NO_x reduction for the A320 and a 16 percent climbout NO_x reduction for the 737-300. The A320 and the 737-300 respectively exhibit an increase of about 15 and 19 percent in climbout fuel flow at 98 ºF relative to that at 48 ºF, resulting in an effective tradeoff between fuel efficiency and NO_x. Unfortunately, it is not possible to determine the accuracy of these data without performing a substantially more detailed review of the specific EDMS algorithms and their basis, which are not available for general review.

It is perhaps also worth noting that the EDMS User's Manual (*Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01, Rev. 2 - 02/05/07, January 2007) refers to the EDMS Technical Manual as the source for determining EDMS algorithms and indicates that the technical manual can be located at the FAA's EDMS web site (www.faa.gov/about/office_org/headquarters_offices/aep/models/). Although I found no technical manual specific to EDMS version 5.0, I did find a *Technical Manual for the FAA Emissions and Dispersion Modeling System (EDMS) Version 4.2*, July 5, 2005. Unfortunately, this manual does not appear to provide any information on how EDMS adjusts emissions modeling parameters (fuel flow, emission rates, etc.) for changes in ambient temperature.

Table 4. Emissions Modeling Parameters

Emissions Scenario	Mixing Height (feet)	Aircraft Taxi Time (minutes)	Annual Aircraft Operations	Annual Aircraft LTOs
2004 Baseline	4,536	15.36	542,218	271,109
2005 Baseline	4,536	15.99	553,188	276,594
2010 Baseline	4,536	16.46	628,008	314,004
2005 Action -- FAA Activity Assumptions	4,536	15.24	553,188	276,594
2010 Action -- FAA Activity Assumptions	4,536	15.54	628,008	314,004
2005 Action -- Economic Activity Assumptions	4,536	15.99	580,414	290,207
2010 Action -- Economic Activity Assumptions	4,536	16.46	665,188	332,594

assume that overall aircraft operational levels at McCarran will be unchanged relative to their respective baseline scenarios, despite the fact that overall airfield efficiency will increase (as reflected by reduced aircraft taxi times, which include any associated ground delays). Such an assumption can only be valid if airport demand is not economically constrained, and that is not the case for McCarran International by the FAA’s own admission. Throughout Section 1.5 of the FSEA, the FAA cites the need to improve airfield efficiency to accommodate the large expected increases in airport operational levels. In Section 1.2 of the FSEA, the FAA acknowledges that it is airfield capacity that represents the effective operational constraint at McCarran, so that increasing airfield efficiency increases economic airport capacity. Yet, the FAA assumes that demand will not increase in response to improved airfield efficiency.

Market equilibrium dictates that airlines will implement a level of service at McCarran (or any other airport) that most efficiently balances their operational revenue and costs. To the extent that airlines will be able to get aircraft into and out of McCarran more efficiently, per-aircraft operational costs will decline and the break-even point at which incremental service costs outweigh incremental service revenue will be shifted toward a point of increased airport activity. While a detailed analysis of current and future operational conditions at McCarran would be required to precisely estimate the new equilibrium activity level, it is possible to make a reasonable estimate of that level using data presented in the FSEA. While this estimate may contain some uncertainty, it represents a reasonable effort to account for “reasonably foreseeable environmental consequences,” as required under §405f of FAA Order 1050.1E that defines the policies and procedures to be adhered to by the FAA in conducting environmental assessments. Clearly, an assumption of no change in aircraft activity levels in response to the easing of airport operational constraints is a “best case” analysis (i.e., least possible impact) assumption that minimizes environmental impacts and reduces the planning burden on the FAA. While the absolute magnitude of the activity increase may be uncertain, the largest possible uncertainty is associated with the FAA’s assumption of no operational change.

As an initial estimate of the likely increase in operations associated with the proposed action, I assume that airlines have economically determined their current operational levels based on the expected average per-aircraft baseline taxi times defined by the FAA (15.99 minutes in 2005 and 16.46 minutes in 2010). If this level of ground performance is economically attractive under the defined baseline conditions, then airlines will be able to economically increase activity under the action conditions until a similar level of ground performance is attained. In effect, airlines will elect to offset improvements in airfield efficiency through increased operations. Assuming changes in aircraft activity generate proportional changes in ground performance in the absence of independent influences such as changes in airfield design, etc., then it is reasonable to expect aircraft activity increases of 4.9 percent in 2005 and 5.9 percent in 2010 (relative to the action levels defined by the FAA), which would generate ground performance changes of the same magnitude and restore overall airport performance to baseline levels (albeit at higher aircraft operational levels).[3] The associated absolute activity levels are 290,207 total LTOs in 2005 and 332,594 total LTOs in 2010.

Despite the uncertainty in these activity estimates, there are methods to evaluate their reasonability without conducting a detailed economic analysis. First, the FSEA (Table 1.5) itself indicates that baseline activity at McCarran is expected to reach the increased 2005 and 2010 activity levels prior to 2007 and 2013 respectively. Thus the estimates accelerate demand increases by approximately 2-3 years. Second, the general relationship between McCarran taxi time and aircraft activity can be estimated by data presented in the FSEA. From Table C-2.6, it is possible to estimate the general relationship between aircraft activity and both total taxi time and departure delay time using the “constant constraints” baseline data for 2004, 2005, and 2010. By constant constraints, I simply intend to emphasize that the “no action” baseline data reflect no change in airport design or procedures and therefore can be viewed as reflective of economically driven changes that are predicted to occur in the absence of airport changes. By comparing the change in activity to the change in delay and taxi time across years, it is possible to determine whether activity changes induce greater or lesser changes in aircraft ground performance. These changes can then be compared to the assumed one-to-one change used to approximate increased aircraft activity under the improved efficiency action scenarios, in an effort to validate the economic activity levels assumed for these scenarios.

Figure 7 depicts the departure and taxi time changes associated with the baseline aircraft activity changes as defined in the FSEA. The chart plots the specific data for the 2005 baseline versus the 2004 baseline, the 2010 baseline versus the 2005 baseline, and the 2010 baseline versus the 2004 baseline. As indicated, the data generally show that aircraft activity changes less rapidly than departure delay and more rapidly than total taxi time. Thus, the approximating assumption used to estimate the increased aircraft activity levels under reduced taxi time conditions is likely to be conservatively low (i.e., any aircraft activity increase is likely to be larger than assumed).

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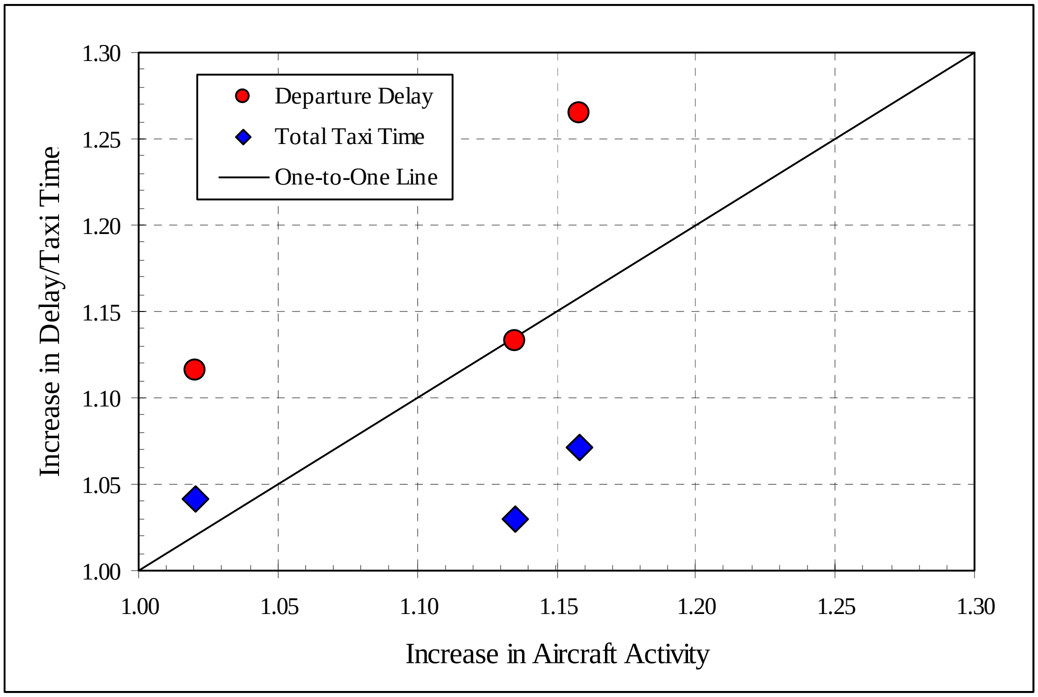
[3] Overall airport ground performance in this context is defined as the product of aircraft taxi, idle, and departure delay time multiplied by aircraft activity. If aircraft taxi, idle, and departure delay time declines by 4.7 percent in 2005 (15.24/15.99) and 5.6 percent in 2010 (15.54/16.46), then overall aircraft activity can increase by 4.9 percent (1/(1-0.047)) in 2005 and 5.9 percent (1/(1-0.056)) in 2010 and overall airport ground performance will remain unchanged. The reasonability of this definition of airport ground performance is discussed in more detail in the paragraphs that follow.

Figure 7. Sensitivity of Airfield Efficiency to Aircraft Activity



As presented in the FSEA, aircraft activity under the baseline (i.e., no action) scenarios is expected to grow from 271,109 LTOs in 2004 to 276,594 LTOs in 2005 and 314,004 LTOs in 2010. So the ratios of 2005-to-2004, 2010-to-2004, and 2010-to-2005 activity are 1.020, 1.135, and 1.158 respectively (as depicted by the values along the x-axis). Similarly, the FSEA estimates that total taxi time will change from 15.36 minutes per LTO in 2004 to 15.99 minutes per LTO in 2005 and 16.46 minutes per LTO in 2010, so that the corresponding taxi time ratios are 1.041, 1.029, and 1.071 (as depicted by the blue markers along the y-axis). Finally, the FSEA estimates that departure delay time will change from 3.63 minutes per LTO in 2004 to 4.05 minutes per LTO in 2005 and 4.59 minutes per LTO in 2010, so that the corresponding departure delay ratios are 1.116, 1.133, and 1.264 (as depicted by the red markers along the y-axis). If all three values changed proportionally, all of the depicted values would lie along the "one-to-one" line. Instead we see that aircraft activity generally changes at a greater rate than total taxi time and a slower rate than departure delay time.

Of course, this analysis is intended solely to demonstrate the deficiencies of the FAA's FSEA analysis. As such, I readily acknowledge that more detailed analysis is both appropriate and necessary. By demonstrating the potential emissions impacts associated with what I would characterize as a "screening" assumption, the impropriety of the FAA's existing emissions analysis will be evident. It is incumbent on the FAA to conduct the detailed aircraft activity and emissions assessment that is currently missing from the FSEA.

Table 5 summarizes the emissions impacts developed using EDMS version 5.0 in conjunction with the assumptions described above. For convenience, the table also presents the FAA's estimated emission impacts as presented in the FSEA. While my analysis includes a number of scenarios (aircraft main engines versus aircraft, GSE, and APU; performance-based times-in-mode versus ICAO/EPA-based times-in-mode; with reverse thrust versus without reverse thrust; and FAA constant activity assumptions versus economic activity assumptions), it is clear that emissions impacts under all of the scenarios that assume economic aircraft activity are 200-500 tons per year greater for CO and 100-250 tons per year greater for NO_x than impacts estimated for the FSEA. Moreover, both CO and NO_x impacts exceed applicable conformity thresholds. Impacts for all other pollutants are also greater than those presented in the FSEA, but remain below applicable conformity thresholds. These impacts would, however, necessitate detailed air quality analysis demonstrating any associated impacts on NAAQS compliance in the Las Vegas metropolitan area. Such analysis is beyond the scope of this exercise, but remains a critical missing element of the FSEA.

Given the myriad scenarios included in Table 5, I have outlined the two most complete scenarios for easy identification. These scenarios essentially include the maximum number of emission sources and assume economic activity drivers. The only difference between the two is the use of EDMS performance-based times-in-mode for one scenario versus ICAO/EPA times-in-mode for the other. Additional investigation into the propriety of the EDMS performance-based emission estimates is desirable, but the overall impact of the proposed action is evident under either estimation approach. Tables 6 through 12 present the specific emission estimates used to develop the summary impacts presented in Table 5. Finally, it is important to recognize that additional emission sources, such as landside transportation sources and airport terminal facilities, that are also sensitive to changes in aircraft activity, have not been considered in this analysis and, as a result, the estimated emission impacts are likely to be conservative.

Issues Related to EDMS Validation and Use. While the limited air quality emissions analysis described above adequately demonstrates the deficiency of the existing FSEA analysis, it is also important to briefly consider several important issues related to the FAA's emissions model and its typical application. While the use of EDMS for airport emissions inventory purposes is not new, several issues related to that use continue to make evaluations of EDMS-based emissions estimates difficult. In general, all of these issues can be traced to the fact that EDMS is not a public domain model and, as such, is not subject to continuing validation by independent researchers. This becomes especially troubling as algorithms are added or modified. For example, the FAA is currently introducing particulate emissions algorithms into the model and the accuracy of these is critical given the widespread nonattainment of the particulate NAAQS. While the FAA does maintain an EDMS Design Review Group that it portrays as independent reviewers, the group is exclusively composed of government officials and consultants who perform extensive FAA-funded analysis. There are no members representing non-FAA interests.

Perhaps the best way of illustrating the validation issue is by considering the status of FAA's representation of EDMS as an EPA "Preferred Guideline" model.[4] The EPA does, in fact,

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[4] www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/

Table 5. Emission Impact Estimates (Action minus Base, tons per year)

Sources Considered	Activity Assumptions	Year	CO	VOC	NO_x	SO_2	PM-10	PM-2.5
Estimates Published in the FSEA								
Aircraft Main Engines Only	FAA	2005	-115.9	-13.7	-17.7	-4.5	-0.6	-0.6
		2010	-163.4	-19.3	-24.5	-6.1	-0.8	-0.8
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes, Without Reverse Thrust								
Aircraft Main Engines Only	FAA	2005	-71.7	-8.1	-9.2	-3.4	-0.3	-0.3
		2010	-102.0	-11.3	-13.0	-4.7	-0.4	-0.4
	Economic	2005	**+107.9**	+24.9	**+110.6**	+11.1	+1.4	+1.4
		2010	**+158.1**	+34.4	**+157.0**	+15.4	+2.0	+2.0
Aircraft Main Engines, APU, and GSE	FAA	2005	-71.7	-8.1	-9.2	-3.4	-0.3	-0.3
		2010	-102.0	-11.3	-13.0	-4.7	-0.4	-0.4
	Economic	2005	**+273.7**	+30.8	**+131.9**	+12.9	+1.9	+1.9
		2010	**+299.2**	+39.3	**+175.9**	+16.4	+2.4	+2.4
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes, Without Reverse Thrust								
Aircraft Main Engines Only	FAA	2005	-71.6	-8.0	-10.4	-3.6	-0.3	-0.3
		2010	-101.8	-11.3	-14.7	-5.0	-0.5	-0.5
	Economic	2005	**+115.7**	+24.7	**+150.9**	+14.9	+1.8	+1.8
		2010	**+173.4**	+34.1	**+210.0**	+20.6	+2.5	+2.5
Aircraft Main Engines, APU, and GSE	FAA	2005	-71.6	-8.0	-10.4	-3.6	-0.3	-0.3
		2010	-101.8	-11.3	-14.7	-5.0	-0.5	-0.5
	Economic	2005	**+281.5**	+30.6	**+172.3**	+16.8	+2.3	+2.3
		2010	**+314.5**	+39.0	**+228.9**	+21.6	+2.9	+2.9
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes, With Reverse Thrust								
Aircraft Main Engines Only	FAA	2005	-71.7	-8.1	-9.2	-3.4	-0.3	-0.3
		2010	-102.0	-11.3	-13.0	-4.7	-0.4	-0.4
	Economic	2005	**+108.2**	+25.0	**+119.5**	+11.5	+1.5	+1.5
		2010	**+158.5**	+34.5	**+169.3**	+16.0	+2.1	+2.1
Aircraft Main Engines, APU, and GSE	FAA	2005	-71.7	-8.1	-9.2	-3.4	-0.3	-0.3
		2010	-102.0	-11.3	-13.0	-4.7	-0.4	-0.4
	Economic	2005	**+273.9**	+30.9	**+140.8**	+13.4	+2.0	+2.0
		2010	**+299.6**	+39.4	**+188.2**	+17.1	+2.5	+2.5
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes, With Reverse Thrust								
Aircraft Main Engines Only	FAA	2005	-71.6	-8.0	-10.4	-3.6	-0.3	-0.3
		2010	-101.8	-11.3	-14.7	-5.0	-0.5	-0.5
	Economic	2005	**+116.0**	+24.8	**+159.8**	+15.4	+1.9	+1.9
		2010	**+173.8**	+34.2	**+222.4**	+21.2	+2.6	+2.6
Aircraft Main Engines, APU, and GSE	FAA	2005	-71.6	-8.0	-10.4	-3.6	-0.3	-0.3
		2010	-101.8	-11.3	-14.7	-5.0	-0.5	-0.5
	Economic	2005	**+281.7**	+30.7	**+181.2**	+17.3	+2.4	+2.4
		2010	**+314.9**	+39.1	**+241.3**	+22.3	+3.1	+3.0

Table 6. 2004 Baseline Emissions (tons per year)

Source	Operating Mode	VOC	CO	NO_x	SO_2	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	33.1	351.4	186.9	34.8	3.0	3.0
	Reverse Thrust	1.2	5.2	176.3	9.5	1.6	1.6
	Taxi	162.9	1,440.5	219.2	71.6	6.9	6.9
	Main Engine Start	275.8	0.0	0.0	0.0	0.0	0.0
	Takeoff	7.7	103.9	889.4	53.7	9.2	9.2
	Climbout	9.5	169.4	879.1	56.5	8.6	8.6
	Total -- with Reverse Thrust	490.1	2,070.4	2,350.8	226.1	29.3	29.3
	Total -- without Reverse Thrust (*see note following table*)	488.9 *234.8*	2,065.2 *2,206.3*	2,174.6 *2,115.7*	216.6 *180.0*	27.7 *55.8*	27.7 *24.6*
GSE		119.5	3,406.6	382.2	27.8	10.3	9.9
APU		5.2	89.0	64.2	9.0	0.0	0.0
Grand Total - with Reverse Thrust		614.8	5,566.0	2,797.2	262.9	39.6	39.2
Grand Total - without Reverse Thrust		613.6	5,560.8	2,620.9	253.5	38.0	37.6
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	24.7	319.8	428.9	70.1	6.0	6.0
	Reverse Thrust	1.2	5.2	176.3	9.5	1.6	1.6
	Taxi	160.8	1,427.5	209.0	72.9	7.0	7.0
	Main Engine Start	275.4	0.0	0.0	0.0	0.0	0.0
	Takeoff	3.6	33.7	498.2	27.1	4.4	4.4
	Climbout	20.2	428.3	1,845.3	124.1	18.9	18.9
	Total -- with Reverse Thrust	485.8	2,214.6	3,157.5	303.7	37.8	37.8
	Total -- without Reverse Thrust	484.6	2,209.4	2,981.3	294.2	36.3	36.3
GSE		119.5	3,406.6	382.2	27.8	10.3	9.9
APU		6.0	101.8	69.6	9.9	0.0	0.0
Grand Total - with Reverse Thrust		611.3	5,723.0	3,609.3	341.4	48.1	47.8
Grand Total - without Reverse Thrust		610.1	5,717.8	3,433.1	331.9	46.6	46.2
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-25%	-9%	+130%	+101%	+100%	+100%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-5%	+2%	+1%	+1%
	Main Engine Start	-0%					
	Takeoff	-53%	-68%	-44%	-49%	-52%	-52%
	Climbout	+113%	+153%	+110%	+120%	+118%	+118%
	Total -- with Reverse Thrust	-1%	+7%	+34%	+34%	+29%	+29%
	Total -- without Reverse Thrust	-1%	+7%	+37%	+36%	+31%	+31%
GSE		0%	0%	0%	0%	0%	0%
APU		+14%	+14%	+8%	+10%		
Grand Total - with Reverse Thrust		-1%	+3%	+29%	+30%	+22%	+22%
Grand Total - without Reverse Thrust		-1%	+3%	+31%	+31%	+23%	+23%

Italicized data are taken directly from the FSEA and are included for rudimentary comparative purposes only as the FSEA emissions analysis did not use the latest planning tools used to support this memorandum.

Table 7. 2005 Baseline Emissions (tons per year)

Source	Operating Mode	VOC	CO	NO$_x$	SO$_2$	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	33.6	363.4	192.9	35.7	3.1	3.1
	Reverse Thrust	1.2	5.3	180.7	9.7	1.6	1.6
	Taxi	173.6	1,539.4	232.2	75.9	7.3	7.3
	Main Engine Start	281.9	0.0	0.0	0.0	0.0	0.0
	Takeoff	7.8	109.7	915.3	55.0	9.4	9.4
	Climbout	9.7	179.9	906.4	58.0	8.9	8.9
	Total -- with Reverse Thrust	507.9	2,197.6	2,427.4	234.2	30.2	30.2
	Total -- without Reverse Thrust (*see note following table*)	506.7 *252.7*	2,192.4 *2,377.7*	2,246.7 *2,195.9*	224.5 *187.8*	28.6 *57.2*	28.6 *57.2*
GSE		113.3	3,265.3	361.6	28.3	9.8	9.5
APU		6.1	103.2	71.5	10.2	0.0	0.0
Grand Total - with Reverse Thrust		627.2	5,566.1	2,860.5	272.7	40.1	39.7
Grand Total - without Reverse Thrust		626.0	5,560.9	2,679.8	263.0	38.4	38.1
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	25.0	334.4	440.5	71.6	6.1	6.1
	Reverse Thrust	1.2	5.3	180.7	9.7	1.6	1.6
	Taxi	171.5	1,526.0	222.6	77.4	7.4	7.4
	Main Engine Start	281.4	0.0	0.0	0.0	0.0	0.0
	Takeoff	3.7	35.1	510.9	27.7	4.5	4.5
	Climbout	20.6	455.5	1,892.9	126.8	19.3	19.3
	Total -- with Reverse Thrust	503.4	2,356.3	3,247.6	313.2	38.9	38.9
	Total -- without Reverse Thrust	502.1	2,351.0	3,066.9	303.5	37.3	37.3
GSE		113.3	3,265.3	361.6	28.3	9.8	9.5
APU		6.1	103.2	71.5	10.2	0.0	0.0
Grand Total - with Reverse Thrust		622.7	5,724.8	3,680.7	351.7	48.8	48.4
Grand Total - without Reverse Thrust		621.5	5,719.5	3,500.0	342.1	47.2	46.8
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-26%	-8%	+128%	+101%	+99%	+99%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-4%	+2%	+2%	+2%
	Main Engine Start	-0%					
	Takeoff	-53%	-68%	-44%	-50%	-52%	-52%
	Climbout	+113%	+153%	+109%	+119%	+118%	+118%
	Total -- with Reverse Thrust	-1%	+7%	+34%	+34%	+29%	+29%
	Total -- without Reverse Thrust	-1%	+7%	+37%	+35%	+31%	+31%
GSE		0%	0%	0%	0%	0%	0%
APU		0%	0%	0%	0%		
Grand Total - with Reverse Thrust		-1%	+3%	+29%	+29%	+22%	+22%
Grand Total - without Reverse Thrust		-1%	+3%	+31%	+30%	+23%	+23%

Italicized data are taken directly from the FSEA and are included for rudimentary comparative purposes only as the FSEA emissions analysis did not use the latest planning tools used to support this memorandum.

Table 8. 2010 Baseline Emissions (tons per year)

Source	Operating Mode	VOC	CO	NO_x	SO_2	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	36.9	439.5	231.2	41.0	3.6	3.6
	Reverse Thrust	1.3	5.9	208.2	11.0	1.8	1.8
	Taxi	203.6	1,837.1	274.2	88.3	8.6	8.6
	Main Engine Start	320.3	0.0	0.0	0.0	0.0	0.0
	Takeoff	8.8	146.6	1,074.1	63.4	10.8	10.8
	Climbout	11.1	247.7	1,071.4	67.0	10.2	10.2
	Total -- with Reverse Thrust	582.0	2,676.7	2,859.1	270.6	35.0	35.0
	Total -- without Reverse Thrust (*see note following table*)	580.7 *304.6*	2,670.9 *2,967.8*	2,650.9 *2,583.0*	259.6 *217.9*	33.2 *61.9*	33.2 *61.9*
GSE		76.3	2,267.8	235.8	6.0	6.9	6.6
APU		6.8	114.9	83.7	11.7	0.0	0.0
Grand Total - with Reverse Thrust		665.1	5,059.5	3,178.6	288.4	42.0	41.7
Grand Total - without Reverse Thrust		663.8	5,053.6	2,970.4	277.4	40.1	39.8
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	27.4	428.5	511.5	81.4	7.0	7.0
	Reverse Thrust	1.3	5.9	208.2	11.0	1.8	1.8
	Taxi	201.3	1,821.9	263.1	90.1	8.7	8.7
	Main Engine Start	319.7	0.0	0.0	0.0	0.0	0.0
	Takeoff	4.0	44.4	588.8	31.5	5.1	5.1
	Climbout	23.7	634.3	2,183.9	144.2	21.9	21.9
	Total -- with Reverse Thrust	577.5	2,935.1	3,755.4	358.3	44.6	44.6
	Total -- without Reverse Thrust	576.2	2,929.2	3,547.2	347.3	42.8	42.8
GSE		76.3	2,267.8	235.8	6.0	6.9	6.6
APU		6.8	114.9	83.7	11.7	0.0	0.0
Grand Total - with Reverse Thrust		660.6	5,317.8	4,074.9	376.0	51.6	51.3
Grand Total - without Reverse Thrust		659.3	5,311.9	3,866.7	365.0	49.7	49.4
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-26%	-2%	+121%	+99%	+95%	+95%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-4%	+2%	+2%	+2%
	Main Engine Start	-0%					
	Takeoff	-54%	-70%	-45%	-50%	-53%	-53%
	Climbout	+114%	+156%	+104%	+115%	+114%	+114%
	Total -- with Reverse Thrust	-1%	+10%	+31%	+32%	+27%	+27%
	Total -- without Reverse Thrust	-1%	+10%	+34%	+34%	+29%	+29%
GSE		0%	0%	0%	0%	0%	0%
APU		0%	0%	0%	0%		
Grand Total - with Reverse Thrust		-1%	+5%	+28%	+30%	+23%	+23%
Grand Total - without Reverse Thrust		-1%	+5%	+30%	+32%	+24%	+24%

Italicized data are taken directly from the FSEA and are included for rudimentary comparative purposes only as the FSEA emissions analysis did not use the latest planning tools used to support this memorandum.

Table 9. 2005 Action Emissions -- FAA Activity Assumptions (tons per year)

Source	Operating Mode	VOC	CO	NO_x	SO_2	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	33.6	363.4	192.9	35.7	3.1	3.1
	Reverse Thrust	1.2	5.3	180.7	9.7	1.6	1.6
	Taxi	165.6	1,467.7	223.0	72.5	6.9	6.9
	Main Engine Start	281.9	0.0	0.0	0.0	0.0	0.0
	Takeoff	7.8	109.7	915.3	55.0	9.4	9.4
	Climbout	9.7	179.9	906.4	58.0	8.9	8.9
	Total -- with Reverse Thrust	499.8	2,126.0	2,418.2	230.8	29.9	29.9
	Total -- without Reverse Thrust (*see note following table*)	498.6 *239.0*	2,120.7 *2,261.8*	2,237.5 *2,178.2*	221.2 *183.3*	28.3 *56.6*	28.3 *56.6*
GSE		113.3	3,265.3	361.6	28.3	9.8	9.5
APU		6.1	103.2	71.5	10.2	0.0	0.0
Grand Total - with Reverse Thrust		619.2	5,494.4	2,851.3	269.4	39.7	39.4
Grand Total - without Reverse Thrust		618.0	5,489.2	2,670.6	259.7	38.1	37.8
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	25.0	334.4	440.5	71.6	6.1	6.1
	Reverse Thrust	1.2	5.3	180.7	9.7	1.6	1.6
	Taxi	163.4	1,454.4	212.2	73.8	7.0	7.0
	Main Engine Start	281.4	0.0	0.0	0.0	0.0	0.0
	Takeoff	3.7	35.1	510.9	27.7	4.5	4.5
	Climbout	20.6	455.5	1,892.9	126.8	19.3	19.3
	Total -- with Reverse Thrust	495.3	2,284.7	3,237.1	309.6	38.6	38.6
	Total -- without Reverse Thrust	494.1	2,279.4	3,056.4	299.9	37.0	37.0
GSE		113.3	3,265.3	361.6	28.3	9.8	9.5
APU		6.1	103.2	71.5	10.2	0.0	0.0
Grand Total - with Reverse Thrust		614.7	5,653.2	3,670.3	348.1	48.4	48.1
Grand Total - without Reverse Thrust		613.5	5,647.9	3,489.6	338.4	46.8	46.5
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-26%	-8%	+128%	+101%	+99%	+99%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-5%	+2%	+1%	+1%
	Main Engine Start	-0%					
	Takeoff	-53%	-68%	-44%	-50%	-52%	-52%
	Climbout	+113%	+153%	+109%	+119%	+118%	+118%
	Total -- with Reverse Thrust	-1%	+7%	+34%	+34%	+29%	+29%
	Total -- without Reverse Thrust	-1%	+7%	+37%	+36%	+31%	+31%
GSE		0%	0%	0%	0%	0%	0%
APU		0%	0%	0%	0%		
Grand Total - with Reverse Thrust		-1%	+3%	+29%	+29%	+22%	+22%
Grand Total - without Reverse Thrust		-1%	+3%	+31%	+30%	+23%	+23%

Italicized data are taken directly from the FSEA and are included for rudimentary comparative purposes only as the FSEA emissions analysis did not use the latest planning tools used to support this memorandum.

Table 10. 2010 Action Emissions -- FAA Activity Assumptions (tons per year)

Source	Operating Mode	VOC	CO	NO_x	SO_2	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	36.9	439.5	231.2	41.0	3.6	3.6
	Reverse Thrust	1.3	5.9	208.2	11.0	1.8	1.8
	Taxi	192.4	1,735.1	261.3	83.6	8.1	8.1
	Main Engine Start	320.3	0.0	0.0	0.0	0.0	0.0
	Takeoff	8.8	146.6	1,074.1	63.4	10.8	10.8
	Climbout	11.1	247.7	1,071.4	67.0	10.2	10.2
	Total -- with Reverse Thrust	570.7	2,574.7	2,846.1	266.0	34.6	34.6
	Total -- without Reverse Thrust (*see note following table*)	569.4 *285.3*	2,568.9 *2,804.4*	2,638.0 *2,558.5*	255.0 *211.8*	32.7 *61.1*	32.7 *61.1*
GSE		76.3	2,267.8	235.8	6.0	6.9	6.6
APU		6.8	114.9	83.7	11.7	0.0	0.0
Grand Total - with Reverse Thrust		653.8	4,957.5	3,165.6	283.7	41.5	41.2
Grand Total - without Reverse Thrust		652.5	4,951.6	2,957.5	272.7	39.7	39.4
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	27.4	428.5	511.5	81.4	7.0	7.0
	Reverse Thrust	1.3	5.9	208.2	11.0	1.8	1.8
	Taxi	190.1	1,720.1	248.4	85.1	8.2	8.2
	Main Engine Start	319.7	0.0	0.0	0.0	0.0	0.0
	Takeoff	4.0	44.4	588.8	31.5	5.1	5.1
	Climbout	23.7	634.3	2,183.9	144.2	21.9	21.9
	Total -- with Reverse Thrust	566.2	2,833.2	3,740.7	353.2	44.1	44.1
	Total -- without Reverse Thrust	564.9	2,827.4	3,532.5	342.2	42.3	42.3
GSE		76.3	2,267.8	235.8	6.0	6.9	6.6
APU		6.8	114.9	83.7	11.7	0.0	0.0
Grand Total - with Reverse Thrust		649.3	5,216.0	4,060.2	371.0	51.1	50.8
Grand Total - without Reverse Thrust		648.0	5,210.1	3,852.0	360.0	49.3	49.0
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-26%	-2%	+121%	+99%	+95%	+95%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-5%	+2%	+1%	+1%
	Main Engine Start	-0%					
	Takeoff	-54%	-70%	-45%	-50%	-53%	-53%
	Climbout	+114%	+156%	+104%	+115%	+114%	+114%
	Total -- with Reverse Thrust	-1%	+10%	+31%	+33%	+28%	+28%
	Total -- without Reverse Thrust	-1%	+10%	+34%	+34%	+29%	+29%
GSE		0%	0%	0%	0%	0%	0%
APU		0%	0%	0%	0%		
Grand Total - with Reverse Thrust		-1%	+5%	+28%	+31%	+23%	+23%
Grand Total - without Reverse Thrust		-1%	+5%	+30%	+32%	+24%	+24%

Italicized data are taken directly from the FSEA and are included for rudimentary comparative purposes only as the FSEA emissions analysis did not use the latest planning tools used to support this memorandum.

Table 11. 2005 Action Emissions -- Economic Activity Assumptions (tons per year)

Source	Operating Mode	VOC	CO	NO_x	SO_2	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	35.3	381.3	202.4	37.4	3.2	3.2
	Reverse Thrust	1.3	5.5	189.6	10.1	1.7	1.7
	Taxi	182.2	1,615.1	243.6	79.6	7.6	7.6
	Main Engine Start	295.8	0.0	0.0	0.0	0.0	0.0
	Takeoff	8.2	115.1	960.3	57.7	9.8	9.8
	Climbout	10.2	188.7	951.0	60.8	9.3	9.3
	Total -- with Reverse Thrust	532.9	2,305.8	2,546.8	245.7	31.7	31.7
	Total -- without Reverse Thrust	531.6	2,300.3	2,357.2	235.6	30.0	30.0
GSE		118.9	3,426.0	379.4	29.7	10.3	9.9
APU		6.4	108.3	75.0	10.7	0.0	0.0
Grand Total - with Reverse Thrust		658.1	5,840.1	3,001.3	286.1	42.0	41.6
Grand Total - without Reverse Thrust		656.8	5,834.5	2,811.7	276.0	40.3	39.9
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	26.2	350.9	462.2	75.1	6.4	6.4
	Reverse Thrust	1.3	5.5	189.6	10.1	1.7	1.7
	Taxi	179.9	1,601.1	233.6	81.2	7.8	7.8
	Main Engine Start	295.3	0.0	0.0	0.0	0.0	0.0
	Takeoff	3.8	36.9	536.0	29.1	4.7	4.7
	Climbout	21.6	477.9	1,986.1	133.0	20.2	20.2
	Total -- with Reverse Thrust	528.1	2,472.3	3,407.4	328.6	40.9	40.9
	Total -- without Reverse Thrust	526.9	2,466.7	3,217.8	318.5	39.2	39.2
GSE		118.9	3,426.0	379.4	29.7	10.3	9.9
APU		6.4	108.3	75.0	10.7	0.0	0.0
Grand Total - with Reverse Thrust		653.4	6,006.5	3,861.9	369.0	51.2	50.8
Grand Total - without Reverse Thrust		652.1	6,001.0	3,672.3	358.9	49.5	49.1
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-26%	-8%	+128%	+101%	+99%	+99%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-4%	+2%	+2%	+2%
	Main Engine Start	-0%					
	Takeoff	-53%	-68%	-44%	-50%	-52%	-52%
	Climbout	+113%	+153%	+109%	+119%	+118%	+118%
	Total -- with Reverse Thrust	-1%	+7%	+34%	+34%	+29%	+29%
	Total -- without Reverse Thrust	-1%	+7%	+37%	+35%	+31%	+31%
GSE		0%	0%	0%	0%	0%	0%
APU		0%	0%	0%	0%		
Grand Total - with Reverse Thrust		-1%	+3%	+29%	+29%	+22%	+22%
Grand Total - without Reverse Thrust		-1%	+3%	+31%	+30%	+23%	+23%

Table 12. 2010 Action Emissions -- Economic Activity Assumptions (tons per year)

Source	Operating Mode	VOC	CO	NO_x	SO_2	PM-10	PM-2.5
Estimates Using SAE AIR 1845-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	39.1	465.5	244.9	43.4	3.8	3.8
	Reverse Thrust	1.4	6.2	220.5	11.6	1.9	1.9
	Taxi	215.7	1,945.9	290.4	93.5	9.1	9.1
	Main Engine Start	339.2	0.0	0.0	0.0	0.0	0.0
	Takeoff	9.3	155.3	1,137.7	67.1	11.4	11.4
	Climbout	11.7	262.3	1,134.9	70.9	10.8	10.8
	Total -- with Reverse Thrust	616.4	2,835.2	3,028.4	286.6	37.1	37.1
	Total -- without Reverse Thrust	615.0	2,829.0	2,807.9	275.0	35.2	35.2
GSE		80.8	2,402.1	249.8	6.4	7.4	7.0
APU		7.2	121.7	88.6	12.4	0.0	0.0
Grand Total - with Reverse Thrust		704.5	5,359.0	3,366.8	305.4	44.4	44.1
Grand Total - without Reverse Thrust		703.1	5,352.8	3,146.3	293.8	42.5	42.2
Estimates Using ICAO/EPA-Based Times-in-Mode for Non-Taxi Modes							
Aircraft	Approach	29.0	453.9	541.8	86.2	7.4	7.4
	Reverse Thrust	1.4	6.2	220.5	11.6	1.9	1.9
	Taxi	213.2	1,929.8	278.7	95.5	9.2	9.2
	Main Engine Start	338.7	0.0	0.0	0.0	0.0	0.0
	Takeoff	4.3	47.0	623.6	33.4	5.4	5.4
	Climbout	25.1	671.9	2,313.2	152.8	23.2	23.2
	Total -- with Reverse Thrust	611.7	3,108.9	3,977.7	379.5	47.3	47.3
	Total -- without Reverse Thrust	610.3	3,102.6	3,757.3	367.8	45.3	45.3
GSE		80.8	2,402.1	249.8	6.4	7.4	7.0
APU		7.2	121.7	88.6	12.4	0.0	0.0
Grand Total - with Reverse Thrust		699.7	5,632.7	4,316.1	398.3	54.6	54.3
Grand Total - without Reverse Thrust		698.3	5,626.4	4,095.7	386.6	52.7	52.4
Ratio of ICAO/EPA Estimates to SAE AIR 1845Estimates							
Aircraft	Approach	-26%	-2%	+121%	+99%	+95%	+95%
	Reverse Thrust	0%	0%	0%	0%	0%	0%
	Taxi	-1%	-1%	-4%	+2%	+2%	+2%
	Main Engine Start	-0%					
	Takeoff	-54%	-70%	-45%	-50%	-53%	-53%
	Climbout	+114%	+156%	+104%	+115%	+114%	+114%
	Total -- with Reverse Thrust	-1%	+10%	+31%	+32%	+27%	+27%
	Total -- without Reverse Thrust	-1%	+10%	+34%	+34%	+29%	+29%
GSE		0%	0%	0%	0%	0%	0%
APU		0%	0%	0%	0%		
Grand Total - with Reverse Thrust		-1%	+5%	+28%	+30%	+23%	+23%
Grand Total - without Reverse Thrust		-1%	+5%	+30%	+32%	+24%	+24%

maintain a “Guideline on Air Quality Models.” It is codified as 40 CFR Part 51 Appendix W. EDMS is included under Section 6.2.4(c) as “appropriate for air quality assessment of primary pollutant impacts at airports or air bases.” However, it is important to recognize that Section 6 of Appendix W covers models developed for special regulatory programs that are generally are implemented under separate guidance documents, which, in the case of EDMS are developed by the FAA. Between 1993 and November of 2005, EDMS was also included in Appendix A to Appendix W, which provides summaries of “preferred” air quality models. However, EDMS was removed from this appendix in 2005 since, as explained in the Federal Register notice addressing the regulatory revisions (70FR68217):

> The Emissions and Dispersion Modeling System (EDMS) was developed jointly by the Federal Aviation Administration (FAA) and the U.S. Air Force in the late 1970s and first released in 1985 to assess the air quality of proposed airport development projects. …
>
> In 1988, version 4a4 revised the dispersion module to include an integral dispersion submodel: GIMM (Graphical Input Microcomputer Model). This version was proposed for adoption in the Guideline’s appendix A in February 1991 (56 FR 5900). This version was included in appendix A in July 1993 (58 FR 38816) and recommended for limited applications for assessments of localized airport impacts on air quality. FAA later updated EDMS to Version 3.0.
>
> In response to the growing needs of air quality analysts and changes in regulations (e.g., conformity requirements from the Clean Air Act Amendment of 1990), FAA updated EDMS to version 3.1, which is based on the CALINE3 and PAL2 dispersion kernels. In our April 2000 NPR we proposed to adopt the version 3.1 update to EDMS. However, this update had not been subjected to performance evaluation and no studies of EDMS’ performance have been cited in appendix A of the Guideline. Comment was invited on whether this compromises the viability of EDMS 3.1 as a recommended or preferred model and how this deficiency can be corrected. [emphasis added]
>
> Several commenters expressed concern about EDMS 3.1 as a recommended model in appendix A. Indeed, there were concerns that EDMS 3.1 had not been as well validated as other models, nor subjected to peer review, as required by the Guideline’s subsection 3.1.1. One of these commenters suggested that EDMS 3.1 should be presented only as one of several alternative models. [emphasis added]
>
> At the 7th Conference, FAA proposed for appendix A adoption an even newer, enhanced version of EDMS — version 4.0, …
>
> In response to written comments on our April 2000 NPR, at the 7th Conference (transcript) FAA promised a complete evaluation process that would include sensitivity testing, intermodel comparison, and analysis of EDMS predictions against field observations. … [emphasis added]
>
> As we explained in our September 8, 2003 Notice of Data Availability, FAA has decided to withdraw EDMS from the Guideline’s appendix A. We stated that no new information was therefore provided in that notice, and we affirmed support for EDMS’ removal from appendix A. This removal, which we promulgate today, obviates the need for EDMS’ documentation and evaluation at this time. [emphasis added]

Thus, while EDMS is referenced in the EPA’s Guideline on Air Quality Models, it is no longer included as a preferred model. Moreover, the discussion of the reasons for its removal from the list of preferred models clearly illustrates the continuing lack of evaluation and peer review associated with EDMS development. The potential impacts of this deficiency only increase in magnitude as the model becomes more complex and addresses more pollutants.

As a model that is used to develop emission inventories and air quality impact analyses for federal actions that are subject to mandatory public review and comment, it is absolutely necessary that the model itself be subjected to the same public review and comment as estimates produced through its algorithms. Fully informed comment can only be made if the underlying algorithms are transparent and validated. Absent such transparency, public review is constrained to the point where the public process associated with federally proposed airport actions is compromised.

Regardless of whether the FAA itself desires to undertake the appropriate validation analysis, the source code and all associated reference documents for EDMS should be publicly available for independent reviewers to evaluate. Moreover, prior to the acceptance of EDMS revisions, the model itself should be subjected to a formal review and comment period. Only in this manner can the legally required public process associated with proposed federal actions be sufficiently fulfilled, and the FAA and stakeholder community get beyond the continuing disagreements over whether specific features of EDMS are complete and accurate. Among the issues of greatest concern from an emissions estimation standpoint are:

- <u>The development of PM emission factors</u>. As you know, I have expressed extensive concern over the PM algorithms employed by the FAA and their consultants in the past and this concern is not alleviated by the FAA's formal inclusion of PM algorithms within EDMS. The timing of this issue is particularly opportune as the current algorithms within the model are in their initial development stage. For the analysis results presented in this review I used the EDMS PM algorithms exclusively as the main issue of concern was the proper formulation of the FSEA air quality analysis, not the particular algorithms employed. This should not be mistaken as tacit approval of the EDMS algorithms, but rather as a desire to avoid the introduction of a potentially confusing issue into a discussion that can be adequately addressed without the resulting complexity. Nevertheless, in any subsequent emissions analysis designed to address the deficiencies in the current FSEA, the FAA should adequately address the uncertainty associated with any included PM estimates.

- <u>The development of performance-based times-in-mode, fuel flows, and emission factors, and the sensitivity of these data to changes in meteorological conditions</u>. As indicated by the emission estimates presented in this review, there is a significant difference in aircraft emission estimates developed using the model's performance-based algorithms and the model's ICAO/EPA algorithms, especially with regard to NO_x emissions. For this reasons, the model algorithms for implementing the performance-based estimates should be thoroughly evaluated and open to public scrutiny.

- <u>The estimation of reverse thrust impacts on emissions</u>. It is unclear why the FAA refuses to include algorithms designed to estimate reverse thrust emissions in EDMS. Although reverse thrust operations are of short duration, they represent a high NO_x mode of operation and should be considered.

- <u>The use of default engine assignments in emissions modeling</u>. FAA consultants routinely accept the default engine assignments encoded within EDMS. This is true for the analysis conducted by the FAA for the FSEA and, by extension, to the analysis summarized in this review since it is based on the FAA aircraft definition data presented in the FSEA. As with the PM emission estimates discussed above, this should not be mistaken as tacit approval of the default engine approach, but rather a desire to avoid the introduction of a potentially confusing issue into a discussion that can be adequately addressed without the resulting complexity. Nevertheless, in any subsequent emissions analysis designed to address the deficiencies in the current FSEA, the FAA should adequately address any uncertainty associated with the selection of default engine assignments.

  EDMS default engine assignments reflect the "most popular" engine for an airframe, based on total airframe sales. This includes all air carriers operating that airframe, regardless of the location of those operations. Since the distribution of air carrier-specific operations at one airport will vary from those at another, the probability of a national engine distribution being accurate at any given airport is small. Aircraft/engine tracking is difficult, but there are several aircraft census databases that track airframe ownership by air carrier and identify the associated characteristics of those airframes, including equipped engines. The use of such databases easily allows the uncertainty of the EDMS "most popular" engine to be refined to the level of individual air carriers. Since operations at the air carrier level of detail are known at individual airports, this allows for the development of substantially improved emissions inventories for any given airport.

  A secondary method of more accurately addressing the difference in emissions profiles across engines would be to develop a population-weighted average engine profile. While this would be less accurate than developing airline-specific engine profiles, it would be far superior to the "single default engine" approach currently employed within EDMS.

In closing, I would hope that it is recognized that many of my comments are necessarily general in nature due to the fact that the air quality analysis within the FSEA is limited. It is very likely that I will have additional, more detailed comments in response to any supplemental air quality analysis performed by the FAA. Nevertheless, I hope that this information is satisfactory and provides you with an appropriate understanding of my concerns related to the air quality components of the FSEA. If you have any questions or need any additional information, please do not hesitate to call or e-mail.

Respectfully,

Daniel J. Meszler, P.E.