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AEDT NO_x Prototype 1: Preliminary Modeling Enhancements to CAEP/6-IP/13 NO_X Stringency Analysis

(Prepared by U.S. Representative)

SUMMARY

During the fourth meeting of WG2 in Athens, Greece, the TG2/TG4 ad hoc group recommended methodological enhancements to inventory LTO aircraft emissions in CAEP7_WG2_TG2/4_4_WP/10. This paper demonstrates the ability to implement the recommended enhancements and replicate the CAEP/6-IP/13 aircraft NOx stringency analysis with these refinements. The model used to demonstrate this capability is a prototype predecessor of FAA's AEDT model, known as the ***NOx Prototype 1*** which employs an operation database, airport database, and performance-based aircraft methodologies, that are now common to emissions and noise models, to re-calculate and expand upon the NOx stringency analysis that was performed for CAEP/6-IP/13. In addition to the common databases and refined methodologies, the ***NOx Prototype 1*** allows CAEP to assess the effects of NOx stringencies on all categories of aircraft throughout their entire flight, compared to the CAEP/6-IP/13 report that only considered the LTO cycle for commercial jet aircraft. The analysis process was also refined by allowing emissions values to be adjusted based on the required aircraft thrust and meteorological conditions. An airport queuing model was also included, so that the effects of the flight schedule would be captured. Finally, the ***NOx Prototype 1*** results up to 10,000 feet were combined with enroute emissions to obtain full flight NOx contributions to the atmosphere.

1. Background and Work to Date

1.1 The 35th Session of the ICAO Assembly (A35) established 6 Strategic Objectives to "achieve its vision of safe, secure and sustainable development of civil aviation through cooperation amongst its member States." A35's consolidated vision and mission statement states that Strategic Objective C, *Environmental Protection - Minimize the adverse effect of global civil aviation on the environment,* will be attained, in part, by developing, adopting, and promoting new or amended measures to:

a) limit or reduce the number of people affected by significant aircraft noise;

b) limit or reduce the impact of aviation emissions on local air quality; and

c) limit or reduce the impact of aviation greenhouse gas emissions on the global climate.

1.2 At Task Group 2's (TG2) third meeting in Montreal on 8 March 2005, it was decided that Working Group 2 (WG2) would report on aircraft NOx in response to the local air quality goal (b). In assessing NOx for CAEP/6, CAEP developed a system that linked Landing and Take Off (LTO) data derived from the FESG forecast and current fleet data to an emissions model that could calculate NOx quantities based on the emission indices available in the ICAO emissions databank. TG2 discussed several issues related to the previous approach:

a) aviation emissions can include more than aircraft LTO whereas the NO_x trend is limited to the FESG aircraft fleet data

b) there are alternatives to the LTO definition that are expected to improve the measure of aircraft emissions

c) the source of LTO data, i.e. BACK[1] cycles normalized to FESG operation levels, does not allow for local considerations and trends can only be reported globally.

Overall, the assessment system will need major development to account for local conditions if they are to be considered in reporting on an environmental goal.

1.3 During the third meeting of WG2 in Montreal, a TG2/TG4 ad hoc group was formed to suggest how the assessment of aircraft NOx could be improved over the methodology used during CAEP/6.

1.4 The TG2/TG4 ad hoc group provided CAEP7_WG2_TG2/4_4_WP10, initially presented at TG2's fourth meeting in Athens, Greece and further discussed at TG2's fifth meeting in Paris, France, which described a set of proposed enhancements to the CAEP/6-IP/13 NOx emissions calculation methodology.

1.5 During WG2's fifth meeting in Paris, France, the U.S. FAA presented a "proof of concept" modeling approach to re-evaluate the CAEP/6 IP/13 NOx stringency analysis using the proposed advanced methodologies from item 1.4 above (CAEP/7-WG2-TG2-5_WP07 and WP07a). The FAA's proposed approach also included common databases required to assess interdependencies described in papers CAEP/7-WG2-TG2-5_WP06 and WP06a.

1.6 This paper discusses an implementation of the methodological and modeling enhancements discussed in 1.5. Known as the ***NOx Prototype 1***, this advanced emissions model is a prototype predecessor to the FAA's comprehensive Aviation Environmental Design Tool (AEDT), a suite of software tools and databases that will allow for a comprehensive assessment of noise and emissions interdependencies (CAEP-SG20041-WP/7).

1.7 This is the first time in CAEP that a single model demonstrated that databases and methodologies common to noise and air quality assessments can be successfully integrated. Because of this, ***the emphasis of this paper is on the modeling demonstration and all results must be considered draft and not conclusive.*** Because of

[1] BACK Aviation Solutions/Lundkvist Fleet Database (commercial data source). Fleet database allowing the tracking of airplanes and their operating statistics, including their age.

this, all data in this paper will be marked as such. The U.S. FAA plans to present the final modeling results in the subsequent seventh meeting of WG2 in May 2006, taking into account comments and actions from WG2 members listed in section 6.

2. Technical Enhancements

2.1 As mentioned in 1.4 above, the enhancements to the CAEP/6-IP/13 NOx methodology are described in CAEP7_WG2_TG2/4_4_WP10. As a follow-on to that paper, this section summarizes the implementation of those enhancements in the model ***NOx Prototype 1***.

2.2 CAEP7_WG2_TG2/4_4_WP10 discusses the definition of the aircraft LTO can be enhanced to more accurately capture the emissions from this portion of flight and allow a comparison with the CAEP/6-IP/13 NOx stringency results. For CAEP/6, the LTO was defined as the time spent in takeoff (from the start of ground roll to 1,000 ft), climb out (from 1,000 ft to 3,000 ft), approach (from 3,000 ft to touchdown) and idle time (ground roll after landing, taxi time, queue time) for all aircraft at all airports. The time spent in each mode was based on the ICAO default times by broad aircraft category. In addition, only emission indices from the four emission certification thrust levels were utilized. This definition of the LTO was created for certification purposes and was not originally intended for emissions inventory purposes.

2.3 The ***NOx Prototype 1*** improves the calculation of LTO emissions to better meet the needs of future CAEP emissions analyses as follows:

a) **Airport-specific data**. ***NOx Prototype 1*** implements airport-specific data to enhance the accuracy of the times in mode. Specifically, the field elevation, average annual temperature, average annual pressure, and average annual humidity were used to enable a more accurate representation of an aircraft LTO. To allow a more direct comparison with the CAEP/6-IP/13 NOx results, emissions to and from 3,000 feet are presented. However, individual mixing heights can be specified in the ***NOx Prototype 1***, if a more accurate assessment of local air quality is desired.
b) **Airport-specific delays**. Where airport-specific capacity information was available, the ***NOx Prototype 1*** has the capacity to use a delay module to estimate more accurate taxi in and out times and airborne arrival delays. This required a flight schedule to be developed, as opposed to relying only on the total number of operations worldwide.
c) **Performance-based aircraft operations**. The Society of Automotive Engineers (SAE) Aerospace Information Report (AIR)-1845 methodology was used for aircraft operations below 10,000 feet and Eurocontrol's Base of Aircraft DAta (BADA) version 3.6 was used at and above 10,000 feet to calculate the times in mode with greater accuracy. Since SAE-AIR-1845 only provides outputs thrust, BADA was used to relate thrust to fuel flow. In addition to the airport-specific data listed above, the takeoff weight of each aircraft was estimated based on the stage length, and the landing weight was calculated based on the fuel burned during flight.
d) **At-Altitude Emissions**. By incorporating aircraft performance equations in conjunction with Boeing curve fitting method, approved by WG3 in CAEP/6, it was possible to refine the emissions calculations for the LTO and improve the accuracy of emissions inventory results.
e) **TL5B fuel burn penalty**. By explicitly modeling fuel burn, NOx and other emissions, the overall analysis was able to directly account for the TL5B fuel burn penalty in stringency scenarios for which TL5B aircraft are flown.

f) **Global emissions**. In addition to modeling LTO contributions to local air quality NOx emissions, ***NOx Prototype 1*** includes emissions contributions from the full gate-to-gate flight for all aircraft operations. This enables a more realistic quantification of NOx and other emissions trends as a function of the stringency scenarios.

2.4 A flight movement schedule was used to account for the location of LTOs, so that it would be possible to show the impact of any NOx stringencies according to ICAO region or other geographic division. This approach is similar to the process used by MAGENTA for the evaluation of noise stringency options at CAEP/5 and sample results are presented in section 4. The schedule in the International Official Airline Guide (IOAG) was used for scheduled operations and the Enhanced Traffic Management System (ETMS) for unscheduled flights.

2.5 The existing FESG forecast remains the best-available source of forecasted operations for CAEP purposes. This forecast provides future operations by aircraft category. In order to model the impact on emissions from the future fleet, it is necessary to map the broad forecasted aircraft categories into aircraft-engine combinations. In order to localize those emissions, however, the LTOs were apportioned using the schedule described in 2.4. This approach should be applied to a regional level only, and is not considered appropriate for evaluating the impact at a specific airport.

2.6 For CAEP/6-IP/13, only commercial jet aircraft were modeled. By way of improvement, this revised approach of using ETMS data in conjunction with the BACK fleet database provides a very accurate way to model the baseline fleet mix, including turboprop, piston, non-commercial, and unscheduled flights.

2.7 An integrated and harmonized system of legacy databases and software modules was exercised such that, in the case that CAEP wished to understand the effects NOx stringencies have on global noise exposure (similar to previous results derived using MAGENTA), this same system could be exercised using identical input data resulting in fully harmonized emissions and noise results suitable for tradeoff analysis.

3. Administrative Enhancements

3.1 In addition to enhancing the technical method used to estimate the emissions from aircraft, the documentation associated with the analysis has also been improved over CAEP/6-IP/13. The entire analysis process has been thoroughly documented so that a future analysis for CAEP can be accurately reproduced to support policy decisions, if desired.

3.2 The NOx emission results from this analysis are reported according to ICAO region. Given that the fleet mix of aircraft operating in various parts of the world differs significantly, as do the number of operations, this enhanced flexibility can allow policies to be directed toward the areas where they will have the greatest benefit to the environment.

4. Results

4.1 This section presents draft results based on the current version of the ***NOx Prototype 1***. It is anticipated that these results will be refined based on feedback from TG2 members and refinements to AEDT over the coming months.

4.2 Table 1 provides a direct comparison with the CAEP/6-IP/13 results. What is most striking about this table is that while for many of the scenarios a greater number of LTOs were modeled, the total NOx in each scenario decreased. The increase in LTOs is likely due to the difference between using the route group-based FESG forecasted operations for this prototype work and the BACK cycle-based operations in the CAEP/6-IP/13 study. Since the FESG forecasted operations for this prototype work were based on normalizing OAG and ETMS flights, the inclusion of unscheduled flights from ETMS likely provided a better distribution of origin-destination (OD) pairs and hence, by aircraft type as well. These flights were typically made by smaller aircraft, whose total NOx emissions are lower. In addition, as CAEP7_WG2_TG2/4_4_WP10 indicated, the ICAO certification times overestimate the time spent in the LTO cycle. The ***NOx Prototype 1*** performance-based calculations removed this overestimation, which was even larger than the additional LTOs of the unscheduled small aircraft.

Table 1. Comparison of NOx Prototype 1-generated results with those from CAEP/6-IP/13 for Baseline scenario (NOx in short tons below 3,000 feet).

	NOx Prototype 1 *						CAEP/6-IP/13					
Seat Class	**2002**	**2006**	**2008**	**2012**	**2016**	**2020**	**2002**	**2006**	**2008**	**2012**	**2016**	**2020**
20 - 99	21,714	25,623	29,979	38,977	48,747	60,216	12,630	15,507	18,886	26,555	34,255	42,225
100 - 210	108,941	118,327	128,112	148,587	168,354	183,219	148,485	165,375	179,619	210,325	242,176	275,168
211 - 650	66,428	75,587	84,439	104,444	130,688	166,996	108,877	132,888	156,600	216,729	288,356	381,380
Total	**197,082**	**219,537**	**242,531**	**292,008**	**347,790**	**410,431**	**269,992**	**313,770**	**355,105**	**453,609**	**564,787**	**698,773**
% Change from IP13	**-27%**	**-30%**	**-32%**	**-36%**	**-38%**	**-41%**						
Percent of Total NOx												
20 - 99	11%	12%	12%	13%	14%	15%	5%	5%	5%	6%	6%	6%
100 - 210	55%	54%	53%	51%	48%	45%	55%	53%	51%	46%	43%	39%
211 - 650	34%	34%	35%	36%	38%	41%	40%	42%	44%	48%	51%	55%
LTO Counts												
20 - 99	11,389,659	12,072,458	12,784,766	14,242,075	15,784,100	17,483,371	3,615,302	4,500,883	5,448,739	7,608,327	9,735,241	11,911,474
100 - 210	12,753,038	13,734,367	14,741,056	16,636,700	18,241,168	19,325,300	13,596,379	14,764,100	15,700,006	17,746,231	19,926,451	22,284,635
211 - 650	2,173,776	2,540,231	2,871,883	3,613,505	4,605,716	6,082,047	2,986,015	3,534,049	4,045,619	5,299,321	6,812,078	8,693,656
Total	**26,316,473**	**28,347,056**	**30,397,705**	**34,492,280**	**38,630,984**	**42,890,718**	**20,197,696**	**22,799,032**	**25,194,364**	**30,653,879**	**36,473,770**	**42,889,765**
% Change from IP13	**30%**	**24%**	**21%**	**13%**	**5.90%**	**0.00%**						
Percent of Total LTOs												
20 - 99	43%	43%	42%	41%	41%	41%	18%	20%	22%	25%	27%	28%
100 - 210	48%	48%	48%	48%	47%	45%	67%	65%	62%	58%	55%	52%
211 - 650	8%	9%	9%	10%	12%	14%	15%	16%	16%	17%	19%	20%
Pounds of NOx per LTO	15	15.5	16	16.9	18	19.1	26.7	27.5	28.2	29.6	31	32.6
% Change from IP13	-44%	-44%	-43%	-43%	-42%	-41%						

*** Preliminary data. Do not cite or quote.**

4.3 Table 2 not only repeats the NOx emissions below 3,000 feet from Table 1, but expands it by including emissions within the terminal area defined as below 10,000 feet, as well as the total NOx from the entire flight, including cruise. The NOx emissions above 10,000 feet were calculated using the Boeing curve fitting methodologies used for computations in the terminal area. Even though the numbers presented in this table are draft and should not be quoted, it does illustrate possible trends that were not previously available. Some observations are:

- NOx emissions from aircraft below 3,000 feet account for approximately 10 percent of the total NOx from the entire flight. Of which, half of the NOx emissions below 3,000 feet is from 100-210 seat aircraft for local air quality impacts.
- There are less 211-650 seat aircraft than 100-210 seat aircraft, yet the larger aircraft spend more time enroute, thereby producing the most NOx emissions from the entire flight.

Table 2. Baseline NOx emissions according to altitude and entire flight, reported as short tons and percentage of entire flight *

NOx Emitted below 3,000 feet AFE – Baseline												
Seat Class	**2002**		**2006**		**2008**		**2012**		**2016**		**2020**	
	Short Tons	%	Short tons	%	Short tons	%	Short tons	%	Short tons	%	Short Tons	%
20 – 99	21,714	1%	25,623	1%	29,979	1%	38,977	1%	48,747	1%	60,216	2%
100 – 210	108,941	5%	118,327	5%	128,112	5%	148,587	5%	168,354	5%	183,219	5%
211 – 650	66,428	3%	75,587	3%	84,439	3%	104,444	4%	130,688	4%	166,996	4%
Total	197,083	10%	219,537	10%	242,531	10%	292,008	10%	347,790	10%	410,431	10%
NOx Emitted below 10,000 feet AFE – Baseline												
Seat Class	**2002**		**2006**		**2008**		**2012**		**2016**		**2020**	
	Short Tons	%	Short tons	%	Short tons	%	Short tons	%	Short tons	%	Short tons	%
20 – 99	35,352	2%	41,645	2%	48,630	2%	63,046	2%	78,637	2%	96,803	2%
100 – 210	176,432	9%	191,840	8%	207,894	8%	241,588	8%	274,086	8%	298,205	8%
211 – 650	107,498	5%	122,122	5%	136,374	5%	168,658	6%	211,010	6%	269,457	7%
Total	319,282	16%	355,607	16%	392,898	16%	473,292	16%	563,733	16%	664,466	17%
NOx Emitted during Entire Flight – Baseline												
Seat Class	**2002**		**2006**		**2008**		**2012**		**2016**		**2020**	
	Short Tons	%	Short tons	%	Short tons	%	Short tons	%	Short tons	%	Short tons	%
20 – 99	102,439	5%	116,262	5%	131,937	5%	164,287	6%	199,171	6%	239,614	6%
100 – 210	823,059	40%	884,766	39%	954,506	38%	1,099,531	37%	1,239,334	36%	1,348,425	34%
211 – 650	1,123,670	55%	1,259,197	56%	1,406,274	56%	1,717,787	58%	2,047,361	59%	2,363,295	60%
Total	**2,049,168**	100%	**2,260,225**	100%	**2,492,717**	100%	**2,981,604**	100%	**3,485,866**	100%	**3,951,334**	100%

*** Preliminary data. Do not cite or quote.**

4.4 The CAEP/6-IP/13 analysis consisted of six increased NOx certification stringencies ranging from 5% to 30%. The implementation for each stringency was evaluated for the years 2008 and 2012. Tables 3 and 4, and Figure 1 illustrate the impact of imposing various NOx stringencies at these future years. As expected and in agreement with conclusions from CAEP/6-IP/13, the sooner that a large NOx stringency is imposed (in this case 2008 instead of 2012), the greater the cumulative benefit.

4.5 To assist the reader interpret the results presented in Tables 3 and 4, and Figure 1, the following brief summary is a refresher of the calculations used in CAEP/6-IP/13. Cumulative change from the Baseline scenario is defined as the sum of the differences in emissions over all years from the implementation year to the given future year, in this case 2020. Years prior to implementation have no difference in emissions, and can therefore be ignored. Emissions for intermediate years were derived from linear interpolation of the emissions for the two nearest years for which emissions were modeled. The baseline has no stringency applied, but includes the effects of traffic growth for the future years. For stringencies implemented in 2008, cumulative change through 2020 can be summarized by equation 1:

Equation 1.
$$C = \left[(2.5)S_{2008} + (4)S_{2012} + (4)S_{2016} + (2.5)S_{2020}\right] - \left[(2.5)B_{2008} + (4)B_{2012} + (4)B_{2016} + (2.5)B_{2020}\right]$$

where:

C = cumulative change,

S_y = total emissions for a given stringency in year y, and

B_y = total emissions for the baseline in year y.

For stringencies implemented in 2012, cumulative change through 2020 can be summarized by equation 2:

Equation 2.
$$C = \left[(2.5)S_{2012} + (4)S_{2016} + (2.5)S_{2020}\right] - \left[(2.5)B_{2012} + (4)B_{2016} + (2.5)B_{2020}\right]$$

where:

C = cumulative change,

S_y = total emissions for a given stringency in year y, and

B_y = total emissions for the baseline in year y.

4.6 Beyond the comparisons with CAEP/6-IP/13 results and because the ***NOx Prototype 1*** model uses common databases and methodologies also used in global analyses, Table 3 also shows how imposing a larger NOx stringency, which likely requires a greater technology level, has a potential tradeoff with CO_2 and water vapor emissions. CO_2 and water vapor are not typically reported in a local air quality analysis; therefore these results only appear relative to the entire flight. It is interesting to note that the CO_2 and H_2O values for the 15% and 20% stringencies are identical. This is an artifact of the replacements database that slated the same aircraft to be replaced, and highlights the need for an updated replacements database.

Table 3. Cumulative NOx reductions according to altitude and for the entire flight.

Cumulative Change in Emissions 2002 through 2020
(Thousands of Short Tons)

Emissions Below 3,000 feet AFE

	NOx Prototype 1 *		**CAEP/6-IP/13**	
Implementation Date	**2008**	**2012**	**2008**	**2012**
Stringency	**NO_x**	**NO_x**	**NO_x**	**NO_x**
5%	(19)	(14)	(54)	(29)
10%	(35)	(22)	(160)	(86)
15%	(47)	(29)	(217)	(116)
20%	(53)	(33)	(239)	(128)
25%	(71)	(42)	(322)	(173)
30%	(99)	(64)	(356)	(191)

Emissions Below 10,000 feet AFE* *

Implementation Date	**2008**	**2012**
Stringency	**NO_x**	**NO_x**
5%	(30)	(22)
10%	(57)	(36)
15%	(76)	(47)
20%	(86)	(53)
25%	(114)	(68)
30%	(159)	(99)

Emissions for Entire Flight* *

Implementation Date	**2008**			**2012**		
Stringency	**NO_x**	**CO_2**	**H_2O**	**NO_x**	**CO_2**	**H_2O**
5%	(253)	0	0	(298)	(15,671)	(6,144)
10%	(482)	0	0	(480)	(15,668)	(6,143)
15%	(658)	1,558	611	(620)	(14,461)	(5,670)
20%	(739)	1,558	611	(685)	(14,461)	(5,670)
25%	(1,044)	24,442	9,583	(926)	3,774	1,480
30%	(1,506)	37,619	14,750	(1,301)	11,533	4,522

*** Preliminary data. Do not cite or quote.**

Table 4. Effects of stringency implementation ranked by amount of total NOx reduction.

Below 3,000 Feet AFE

RANK	NOx Prototype 1 * SCENARIO	CAEP/6-IP/13 SCENARIO
Highest	Stringency 30% 2008	Stringency 30% 2008
2nd	Stringency 25% 2008	Stringency 25% 2008
3rd	Stringency 30% 2012	Stringency 20% 2008
4th	Stringency 20% 2008	Stringency 15% 2008
5th	Stringency 15% 2008	Stringency 30% 2012
6th	Stringency 25% 2012	Stringency 25% 2012
7th	Stringency 10% 2008	Stringency 10% 2008
8th	Stringency 20% 2012	Stringency 20% 2012
9th	Stringency 15% 2012	Stringency 15% 2012
10th	Stringency 10% 2012	Stringency 10% 2012
11th	Stringency 05% 2008	Stringency 05% 2008
Lowest	Stringency 05% 2012	Stringency 05% 2012

Below 10,000 Feet AFE *

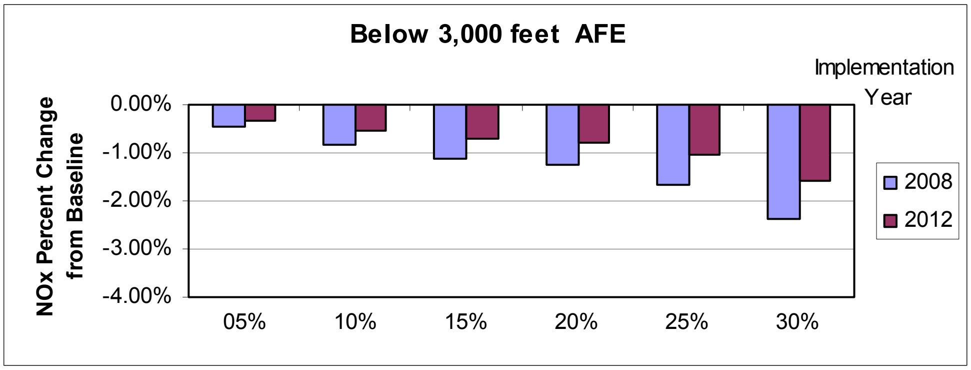
RANK	SCENARIO
Highest	Stringency 30% 2008
2nd	Stringency 25% 2008
3rd	Stringency 30% 2012
4th	Stringency 20% 2008
5th	Stringency 15% 2008
6th	Stringency 25% 2012
7th	Stringency 10% 2008
8th	Stringency 20% 2012
9th	Stringency 15% 2012
10th	Stringency 10% 2012
11th	Stringency 05% 2008
Lowest	Stringency 05% 2012

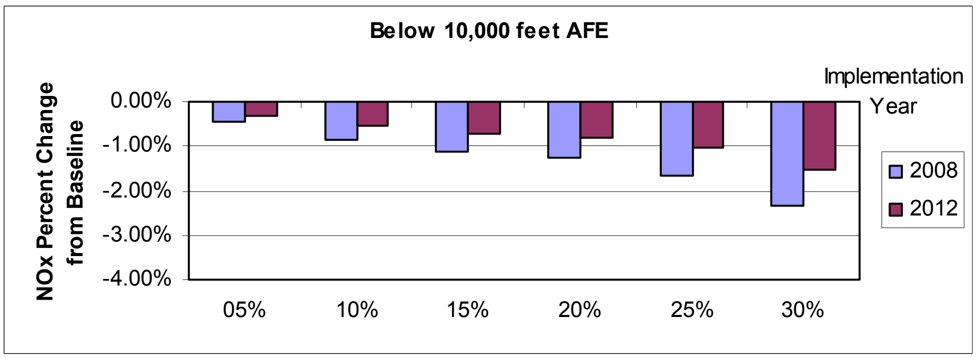
Entire Flight *

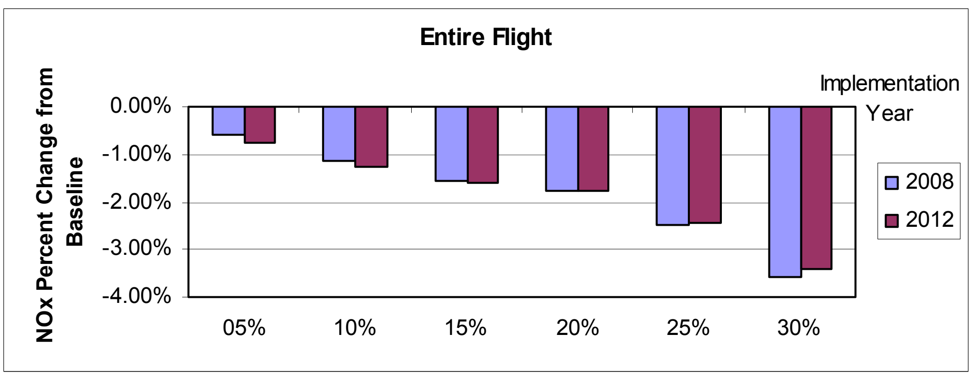
RANK	SCENARIO
Highest	Stringency 30% 2008
2nd	Stringency 30% 2012
3rd	Stringency 25% 2008
4th	Stringency 25% 2012
5th	Stringency 20% 2008
6th	Stringency 20% 2012
7th	Stringency 15% 2008
8th	Stringency 15% 2012
9th	Stringency 10% 2008
10th	Stringency 10% 2012
11th	Stringency 05% 2012
Lowest	Stringency 05% 2008

*** Preliminary data. Do not cite or quote.**

Figure 1. NOx percent change in cumulative emissions from baseline between 2002-2020 according to altitude *







*** Preliminary data. Do not cite or quote.**

4.7 To demonstrate the functionality offered by the ***NOx Prototype 1*** to report emissions by geographic area, Table 5 provides a detailed look at the impact of a 15% stringency imposed in 2008 on annual NOx emissions for a subset of ICAO regions. This table highlights the ability to show differences in traffic levels and fleet mix observed in the different regions. A map of the ICAO regions shown in provided in Figure 2.

Table 5. NOx emissions by year and ICAO region for a 15% stringency implemented in 2008

Emissions Below 3,000 feet AFE, with Comparison to CAEP/6-IP/13

Year	All Regions Combined	
	NOx Prototype 1 *	**CAEP/6-IP/13**
2008	242	389
2012	290	489
2016	343	601
2020	403	737

Emissions Below 10,000 feet AFE *
(thousands of short tons)

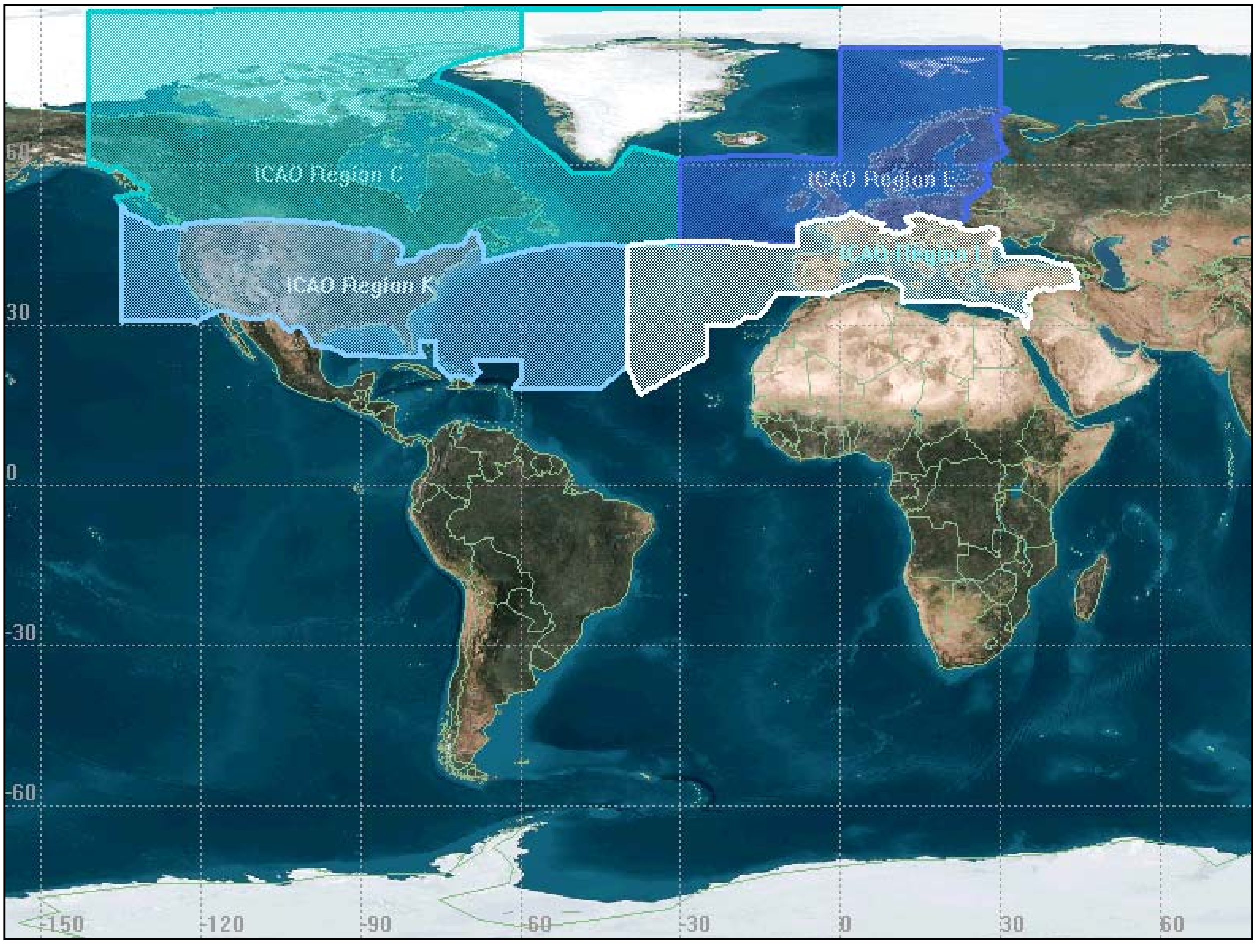
Year	ICAO Region			
	K	**C**	**E**	**L**
2008	116	8	54	48
2012	133	10	68	59
2016	154	11	85	71
2020	181	13	102	83

Entire Flight (thousands of short tons) *

Year	ICAO Region			
	K	**C**	**E**	**L**
2008	758	56	359	269
2012	873	65	438	325
2016	998	74	515	384
2020	1,136	82	574	441

*** Preliminary data. Do not cite or quote.**

Figure 2. Map of ICAO regions C, E, K, and L.



5. Conclusion

5.1 In order to assist ICAO in attaining the goal to "limit or reduce the impact of aviation emissions on local air quality," enhancements over the previous NOx stringency analysis (described in CAEP/6-IP/13) have been implemented in the form of the ***NOx Prototype 1***, a predecessor model of FAA's Aviation Environmental Design Tool (AEDT). Improvements include both technical and administrative enhancements to the methodologies used previously and draft results from the tool have been presented.

5.2 The technical enhancements implemented in the ***NOx Prototype 1*** include:

- Incorporation of aircraft performance data, methodologies, and a global airport, operations and fleet database that are necessary to assess interdependencies
- Use of meteorological data
- Use of the Boeing curve fitting method as recommended by WG3
- A broader range of aircraft type and traffic types – no longer restricting the analysis to commercial jets
- Use of schedule data and delay modeling
- Addition of unscheduled flights

All of these enhancements improved the overall emissions estimate and demonstrated that the previous methodology used overestimated total NOx emissions in the LTO cycle by 30% or more.

5.3 The entire ***NOx Prototype 1*** modeling analysis has been thoroughly documented. This will ensure that the study is repeatable and that any follow-on studies can benefit from the work conducted in this area to date.

6. ACTIONS for TG2

6.1 TG2 is invited to:

a. Agree that the ***NOx Prototype 1*** demonstrates that a single model is capable of using a global operations database, airport database, and performance-based aircraft methodologies that are common to emissions and noise models

b. Agree that performance-based aircraft operations used along with thrust-specific emission indices based on the Boeing curve fitting method is a more accurate alternative to quantify LTO emissions

c. Note that the same global operations database, airport database, and performance-based aircraft methodologies used in this analysis would be common to a global noise analysis, thereby demonstrating a positive step towards assessing interdependencies

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