JPDO/IPSA Environmental Analyses and Latest Results

Briefing to NAS Performance Workshop
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Interagency Portfolio and
Systems Analysis Environmental Sub-team

METRON AVIATION

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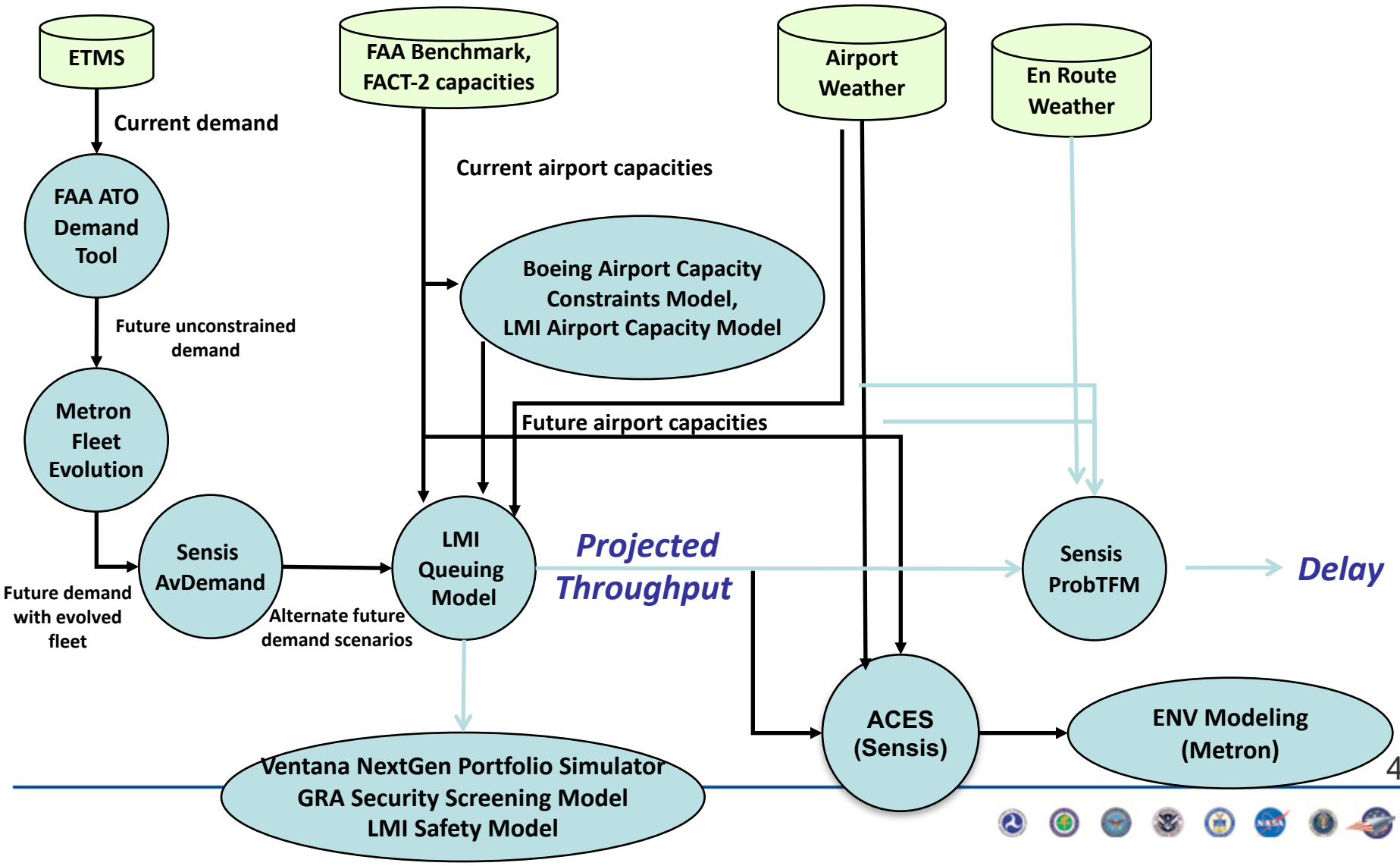
Outline

- IPSA Analysis Approach
- Results to date: 2008 Portfolio Assessment

Summary of IPSA Analysis Approach

- Future demand scenarios are generated by FAA ATO-P.
- Future baseline and NextGen airport capacities are estimated based on an airport capacity constraints analysis and performed in coordination with the FAA and Mitre for the years 2015 and 2025.
- NextGen performance related to capacity is evaluated using NAS-wide simulations.
  - Airport capacities based on the aforementioned airport constraints analysis
  - En route capacities based on prior FAA, NASA, Mitre and IPSA analyses
- NextGen performance related to environment is evaluated based on the NAS-wide analysis using a suite of environmental modeling tools
- Metrics of interest are derived from the NAS-wide analysis of throughput and delays.

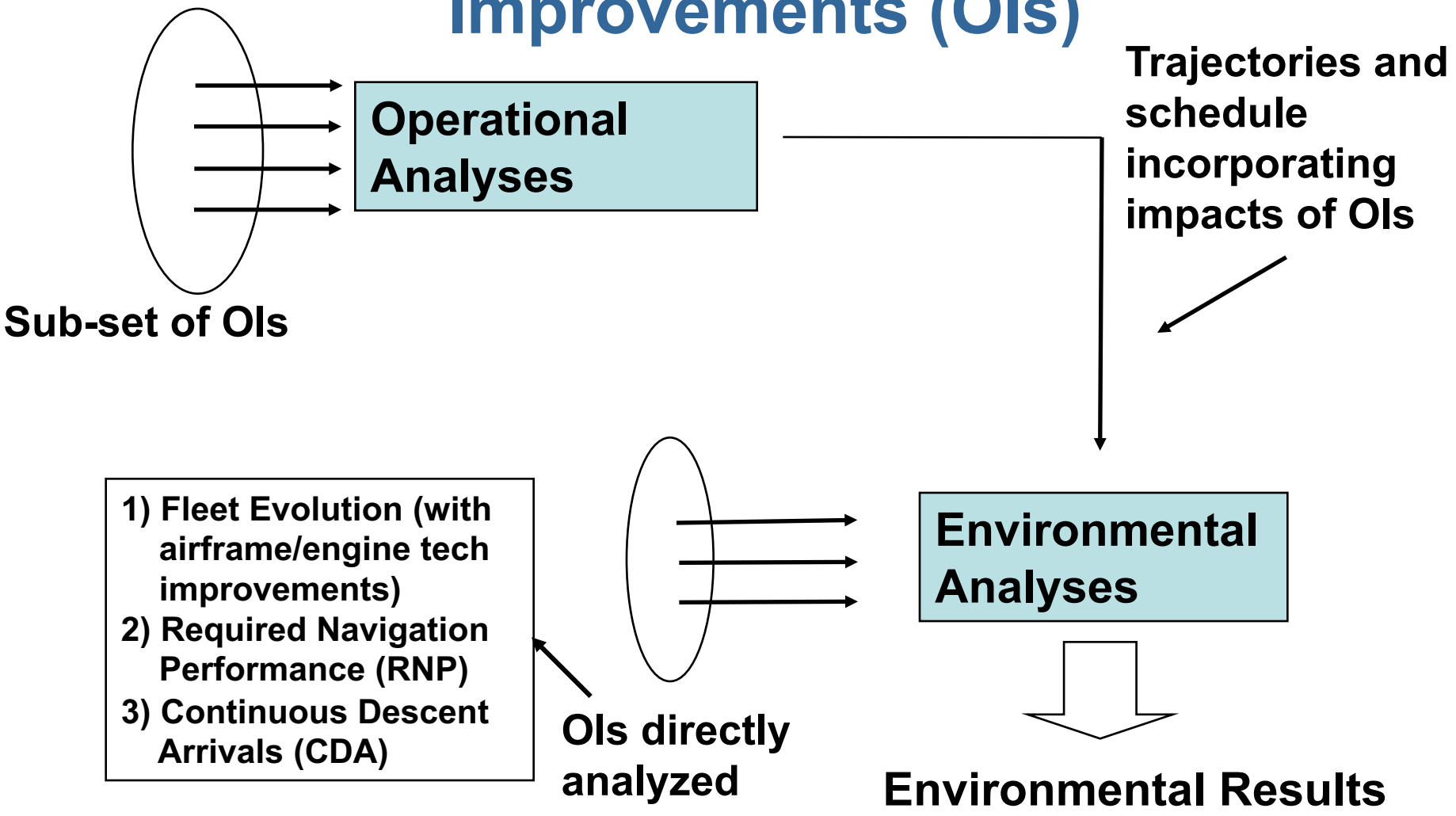
IPSA Integrated Modeling Tools



Key Modeling Assumptions for NextGen Performance Improvements

- Flight Trimming (Demand Management)
  - Future demand is based on FAA TAF forecasts, but is 'constrained' to maintain reasonable levels of delay
  - Demand is 'trimmed' primarily from OEP airports which are primary contributors to delays
- Airport Capacity Improvements
  - Airport capacity improvements are based on bottom-up analysis of the OI's and their operations impacts
  - Assumptions and analysis coordinated with FAA and Mitre and performed by IPSA
  - NextGen results in significant improvements in airport capacities (AAR/ADR) in all weather conditions (IMC/MVMC/VMC)
- En Route Airspace Capacity Improvements
  - En route airspace capacity improvements are based on prior government and industry research as well as IPSA analyses
  - NextGen capabilities such as improved traffic flow management and dynamic airspace capabilities result in increased en route capacities both NAS-wide and in congested airspace
- Weather-related ATM Improvements
  - NextGen capabilities related to mitigating the impact of bad weather are primarily captured through improved ATC/ATM/TFM capabilities.
  - Improved ATC capability in weather, to mitigate weather impact on airspace.
  - Improved airport or terminal area weather capabilities, to mitigate weather impact on airport capacity.

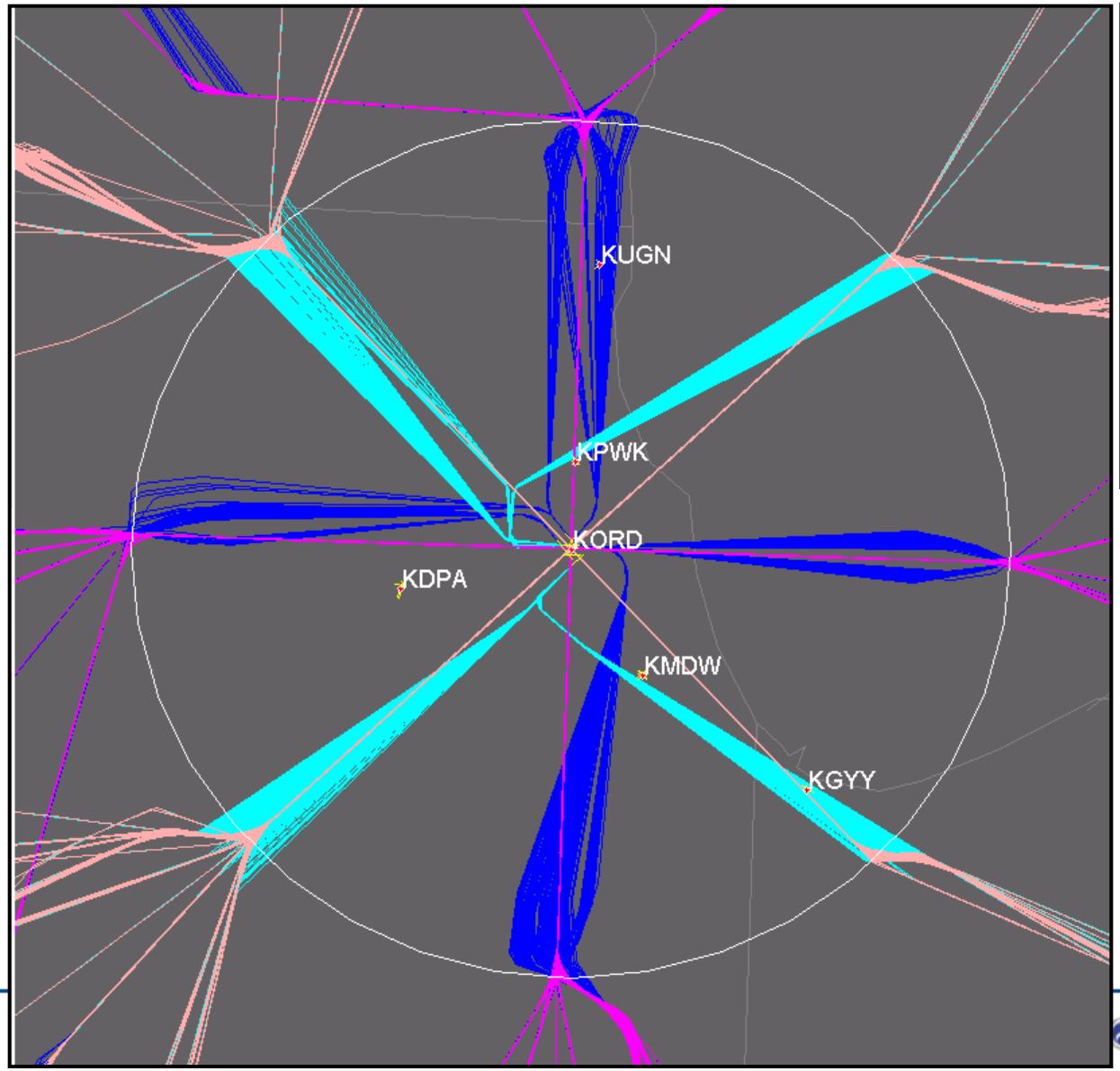
Environmental Modeling: Operational Improvements (OIs)



Trajectories – Environment

- All Enroute trajectories were extracted directly from ACES.
- All Out/Off/On/In (OOOI) times were extracted from ACES and converted to local time depending on the origin and destination airport (day/night distribution).
- Terminal Area trajectories for OEP airports were derived from 30-day radar sample (April 2005).
- Terminal Area trajectories for remaining airports were generated algorithmically to use the primary or longest runway.

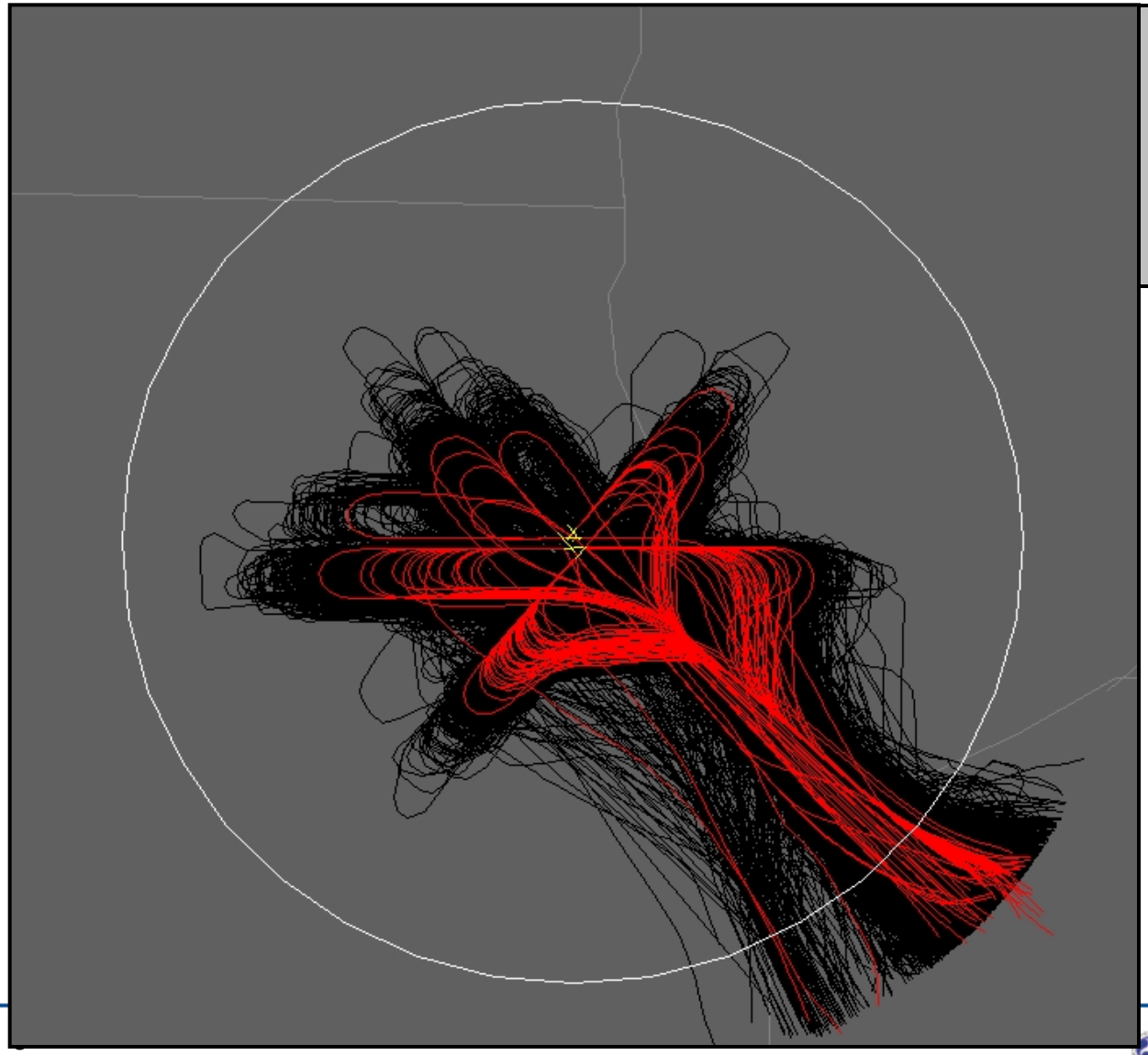
Sample Terminal Area Extension for non-OEP Airports



Legend

- Generic Extensions – ORD Arrivals
- Generic Extensions – ORD Departures
- ACES – ORD Baseline Arrivals
- ACES – ORD Baseline Departures
- 40 nmi from ORD

Sample Terminal Area Extension for OEP Airports



Fleet Evolution

- MITRE's US Air Transport Fleet Forecast 2007 – 2035 Forecast was used to evolve the US carrier fleet.
- Flights by international carriers and GA operations were not evolved.
- Cargo and passenger flights were not separated.
- Evolution was performed by seat category.
- Percentages of MITRE's Forecast by seat category were applied to evolve the fleet.
- For the 2008 Portfolio Assessment, three levels of fleet evolution were applied (Baseline or no new airframe/engine technologies, FAA CLEEN/NASA N+1, and NASA N+2). New technology aircraft were inserted beginning in 2016 for both CLEEN/N+1 and N+2. NOTE: It is recognized that the NASA N+2 technology improvements are not scheduled to be ready by 2016, but were included here in that timeframe as a "what if" scenario.

10

2008 Portfolio Assessment: Environmental Results To Date

Goals of Environmental Analyses

- **Coordinate with the JPDO Portfolio Management Division (PMD) and Environmental Working Group (EWG)**
- **Conduct analyses for each of several scenarios**
- **Calculate metrics on a national basis for the 2008 Portfolio Analysis considering Fuel, Emissions, and Noise at the top airports defined by the LMI 310.**
  - **Fuel:**
    - **Teragrams of fuel/Billion kilometers (Tg/Bkm)**
    - **Payload Fuel Efficiency (PFE) – Megajoules/(kilogram*kilometers) (MJ/(kg*km))**
  - **Local Air Quality and Green House Gas Emissions: HC, SO_x, NO_x, CO, CO_2, H_2O**
  - **Noise:**
    - **Population Exposed to Day/Night Average Noise Level (DNL)**
    - **Area Exposed (DNL)**

Goals of Environmental Analyses (2)

- **Assess the ability to achieve EWG interim environmental goals***
  - **Noise goal is 4% reduction per year in the number of people exposed to ≥65 dB DNL**
  - **Fuel efficiency goal is 1% improvement per year in efficiency, in terms of Teragrams of fuel/Billion kilometers flown**
  - **There is no specific emissions goal**
- **Distinguish the effects of NextGen procedural and avionics improvements from NextGen engine and airframe improvements.**

*** Goals are defined for the FAA's Flight Plans and have been adapted to timelines consistent with IPSA analysis.**

Environmental Scenarios Modeled

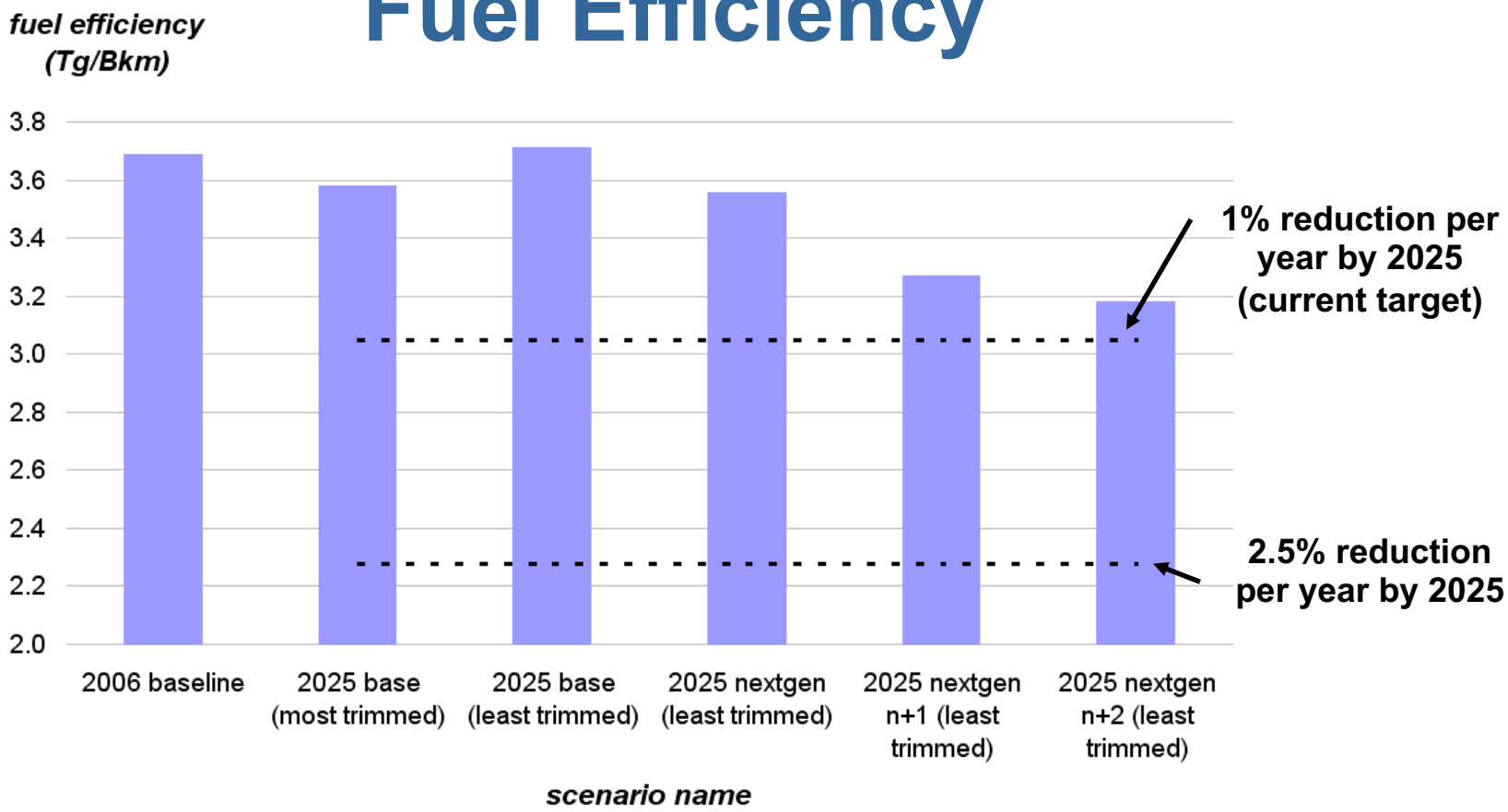
	Scenario Name					
	2006 baseline	2025 base most trimmed	2025 base least trimmed	2025 nextgen least trimmed	2025 nextgen n+1 least trimmed	2025 nextgen n+2 least trimmed
Demand Management						
Baseline Trimmed	N/A	X				
NextGen Trimmed	N/A		X	X	X	X
Fleet Evolution						
Baseline (no new technology)	N/A	X	X	X		
CLEEN/NASA N+1 Projections	N/A				X	
NASA N+2 Projections	N/A					X
Operational Improvement						
NextGen (Airport/Terminal/Enroute)	N/A			X	X	X

- **Monetization of these results will be computed via the FAA's Aviation Environmental Portfolio Management Tool (APMT)**
- **To support the 2009 Business Case, runs have been added in 2050 for both *baseline most* and *nextgen n+1 least trimmed*. Results for these runs will be available shortly.**

Flights & Airports Modeled for Environmental Impact

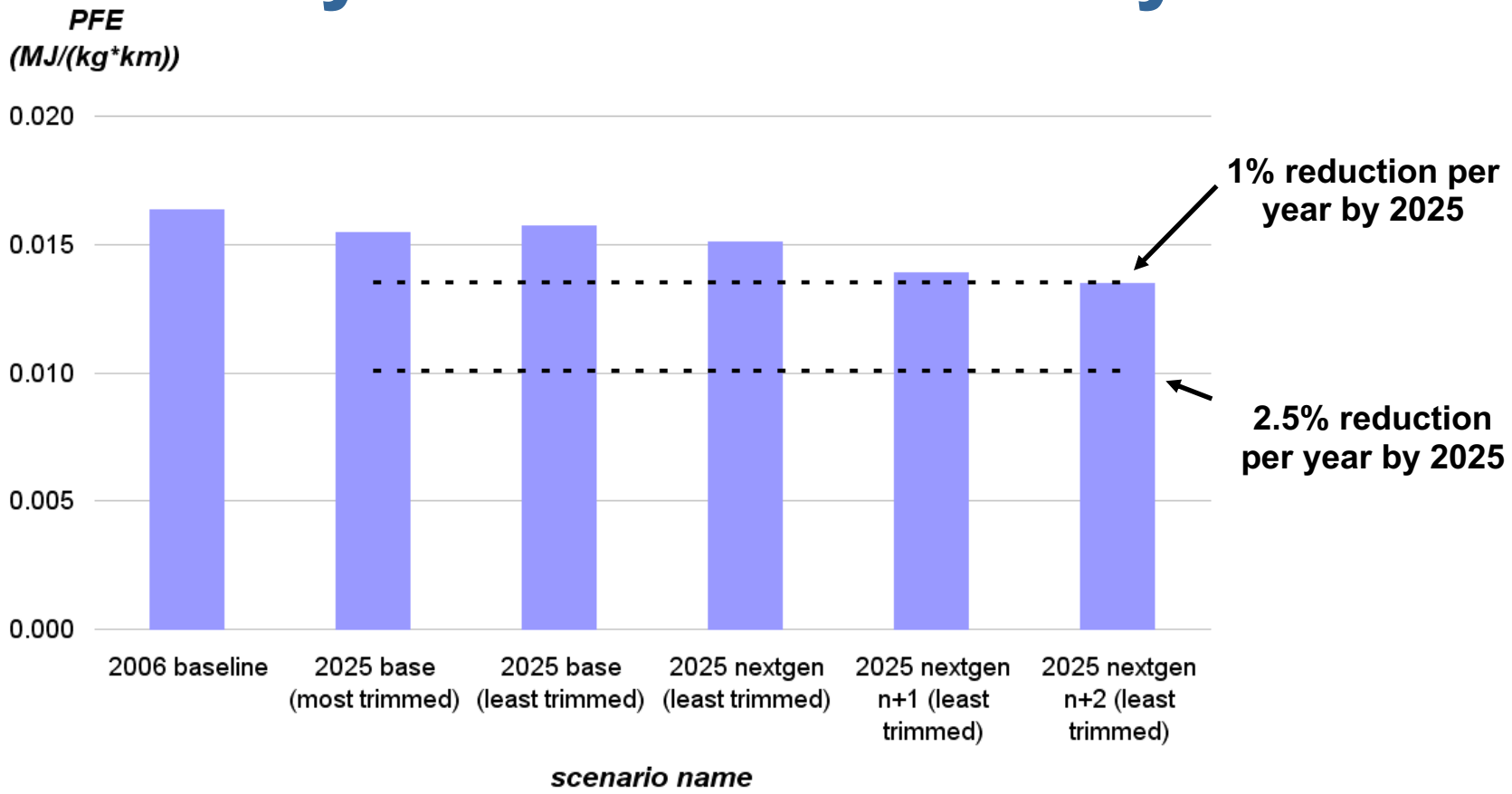
- The ACES 2006 baseline and 2025 scenarios served over 1500 airports and ranged from 95k flights to 135k flights in 2025. Total IFR and VFR flights were evenly split.
- Fuel over distance and payload-based fuel metrics were computed using nearly 90% of the IFR operations. Calculations for both metrics are based only on flights with PFE from 0.002 to 0.1 MJ/(kg*km).
- Higher fidelity noise for the CONUS OEP airports accounted for nearly 70% of the IFR operations.
- Using the Area Equivalency Method noise areas were computed for over 1200 airports accounting for ~95% of the total operations.
- Local Air Quality including HC, NOx, SOx, and CO computed for 294 of the LMI 310 airports and included almost 90% of the IFR operations.

Fuel Efficiency



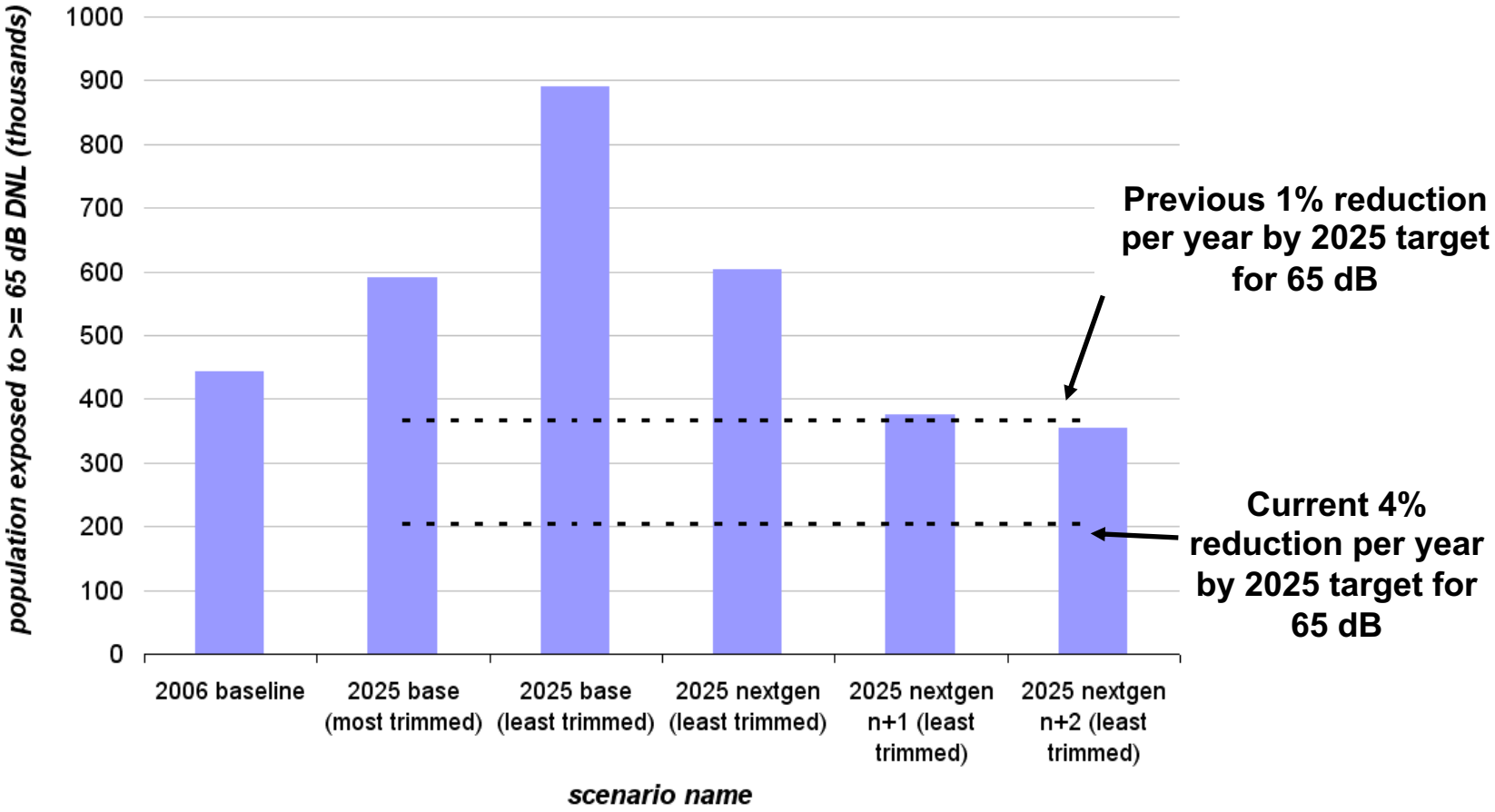
- The similarities between *2025 base most* and *2025 nextgen least* suggest that by implementing NextGen operational improvements while not introducing new airframe/engine technologies allows fuel efficiency to remain constant while supporting ~11% more flights.
- By evolving the fleet to NASA's N+1 and N+2 projected technology levels beginning in 2016, neither reaches the current goal of 1% reduction per year in fuel efficiency, although significant improvement is seen.

Payload Fuel Efficiency



- Calculations are based only on flights with PFE from 0.002 to 0.1 MJ/(kg*km).
- GC distance is modified to use the modeled flight distance if the GC distance is either zero (same origin and destination) or less than the flight distance (international flights).
- By evolving the fleet to NASA's N+2 projected technology levels beginning in 2016 (which is not currently expected), the current 1% reduction per year in fuel efficiency is reached.

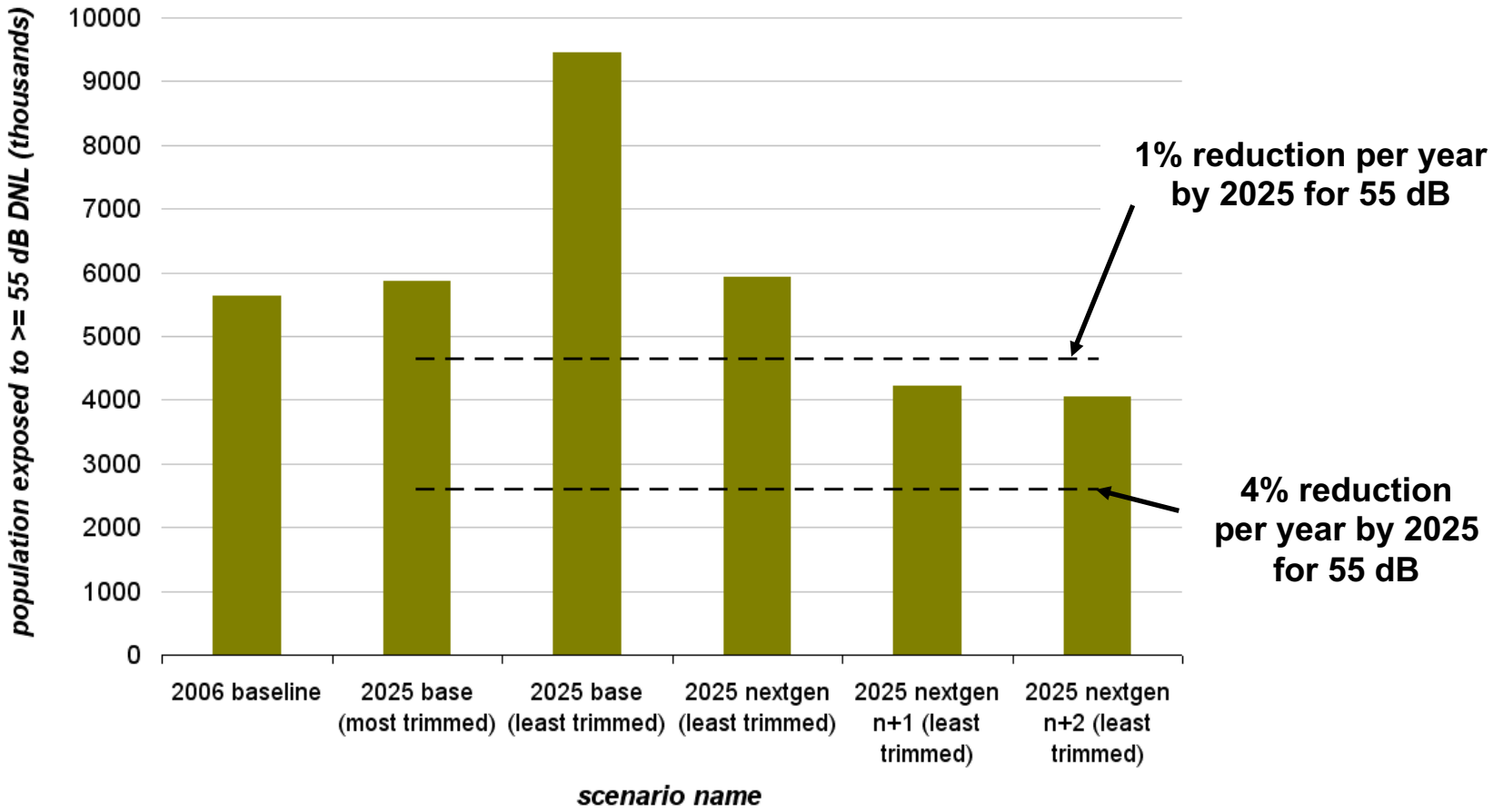
Population Exposed to Noise – 65 dB DNL



- Again, similarities between *2025 base most* and *2025 nextgen least* suggest that by implementing NextGen operational improvements (RNP & CDA) and not introducing new airframe/engine technologies results in population exposed to significant noise increases by 2% while supporting ~11% more flights.
- By evolving the fleet to NASA's N+2 projected technology levels beginning in 2016 (which is not currently expected), the previous 1% reduction per year in population exposed to significant noise is reached, but the newer 4% goal is not.

*** Population is held constant with the US 2000 Census**

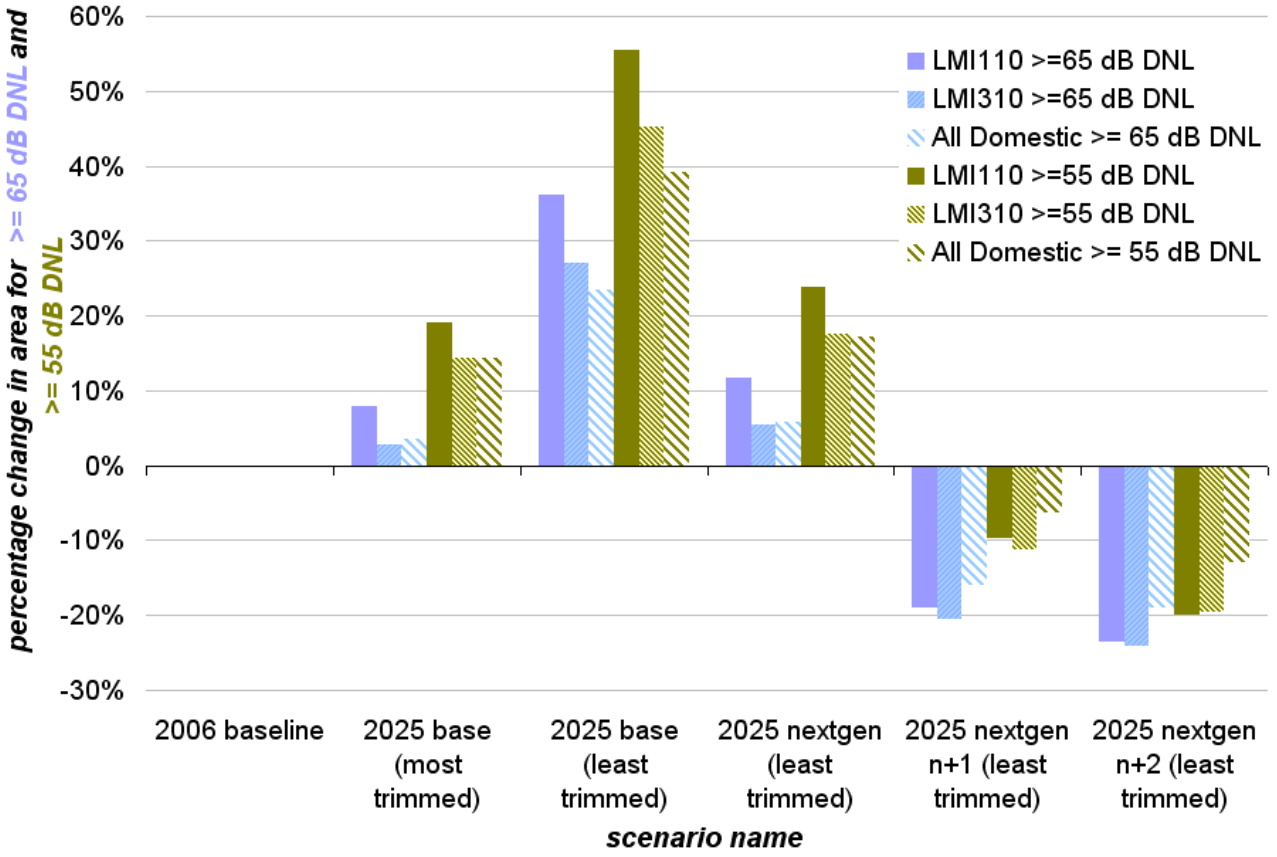
Population Exposed to Noise – 55 dB DNL



- There are currently no goals defined for population exposed to 55 dB DNL, however trends are similar to those seen for more significant noise levels.
- Again, similarities between *2025 base most* and *2025 nextgen least* suggest that by implementing NextGen operational improvements (RNP & CDA) and not introducing new airframe/engine technologies allows population exposed to 55 dB DNL noise increases by 1% while supporting ~11% more flights.

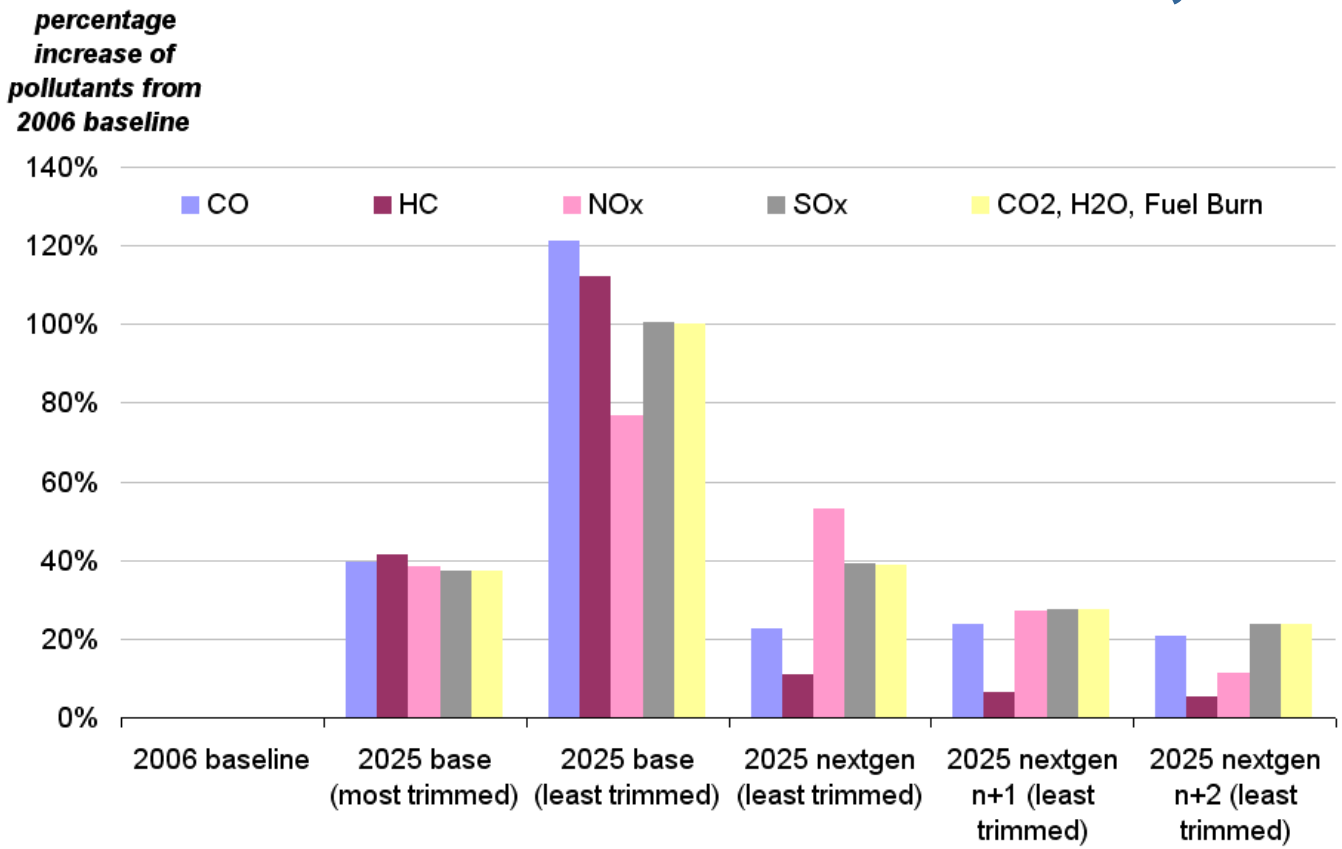
*** Population is held constant with the US 2000 Census**

Changes in Areas of Noise Contours



- Similarities between *2025 base most* and *2025 nextgen least* are still noticeable but do not include Terminal Area improvements (RNP & CDA).
- Most of the benefits are seen at the larger airports where the majority of the operations occur.

Changes in Local Air Quality Emissions Inventories – below 3,000 feet



- 113 of the 294 LMI airports processed are in counties that are currently considered nonattainment areas and an additional 51 airports are in counties that are currently considered maintenance areas. Attainment criteria is based upon EPA defined National Air Quality (NAQ) standards for one of the following pollutants: CO, NO2, SO2, and 8-Hour Ozone.
- In the *2025 base most* 70% of the 164 airports had increases in all pollutants while the *2025 nextgen n+2* has increases at 54% of airports.

*** 2025 base (most trimmed) has ~6 thousand fewer flights serving the 294 airports than the other 2025 scenarios.**

Environmental Summary

- Noise and fuel metrics have been calculated for the 2025 timeframe and compared with a 2006 baseline or reference year.
  - Both the flight schedule and fleet projections for 2025 were derived from the FAA's forecasts
  - Several alternative fleets were also developed by using FAA and NASA aircraft environmental projections.
  - Five future scenarios were considered
  - Two 2050 runs have been added; results should be available shortly
- Several targets were reviewed for fuel efficiency, noise and emissions.
- Neither the noise or fuel targets were achieved with the baseline fleet or operations.
- The benefits of introducing new operational improvements
  - shows sustained environmental performance with additional flights however none of the environmental goals are achieved.
- The benefits of introducing new aircraft technologies
  - shows an improvement in overall system fuel efficiency and with the introduction of PFE, the N+2 projections achieve the current goal of 1% improvement per year.
  - allowed the original noise goal of 1% reduction per year to be achieved in 2025, however the current goal of 4% reduction was not met.

Backup Slides

Environmental Scenario Flight Count for Each Metric

		Scenario Name																	
		2006 baseline			2025 baseline most trimmed			2025 baseline least trimmed			2025 nextgen least trimmed			2025 nextgen n+1 least trimmed			2025 nextgen n+2 least trimmed		
Data	**Airports**	#Flt	#IFR	#VFR	#Flt	#IFR	#VFR	#Flt	#IFR	#VFR	#Flt	#IFR	#VFR	#Flt	#IFR	#VFR	#Flt	#IFR	#VFR
ACES	1,546 *	95.4	48.1	47.3	126.1	61.5	64.6	135	68.4	68.4	135	68.4	68.4	135	68.4	68.4	135	68.4	68.4
Environmental Metric	**Airports**	#Flt	%A-IFR	%A-VFR	#Flt	%A-IFR	%A-VFR	#Flt	%A-IFR	%A-VFR	#Flt	%A-IFR	%A-VFR	#Flt	%A-IFR	%A-VFR	#Flt	%A-IFR	%A-VFR
Noise Contours (AEM)	1,231	91.6	0.92	1	121.6	0.93	1	130.1	0.93	1	130.1	0.93	1	130.1	0.93	1	130.1	0.93	1
High Fidelity Noise	34	33.6	0.66	0.04	42.4	0.65	0.04	48.9	0.68	0.04	48.9	0.68	0.04	48.9	0.68	0.04	48.9	0.68	0.04
Fuel Efficiency	1,207	45.6	0.91	0.04	58.2	0.91	0.04	64.9	0.91	0.04	64.9	0.91	0.04	65	0.91	0.04	65	0.91	0.04
PFE	1,445 **	44	0.88	0.04	56.6	0.88	0.04	62.9	0.88	0.04	63.6	0.89	0.04	63.4	0.89	0.04	63.4	0.89	0.04
Local Air Quality	294	43.9	0.87	0.04	56.4	0.88	0.04	63.1	0.88	0.04	63.1	0.88	0.04	63.1	0.88	0.04	63.1	0.88	0.04

Flight Counts in Thousands

* 2025 base most trimmed has 1,544 airports, all of the 2025 least trimmed scenarios have 1,543 airports

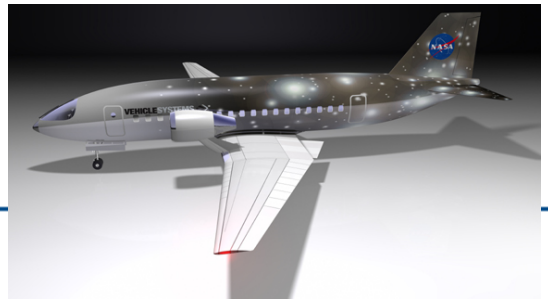
** all of the 2025 scenarios have 1,444 airports

SFW System Level Metrics

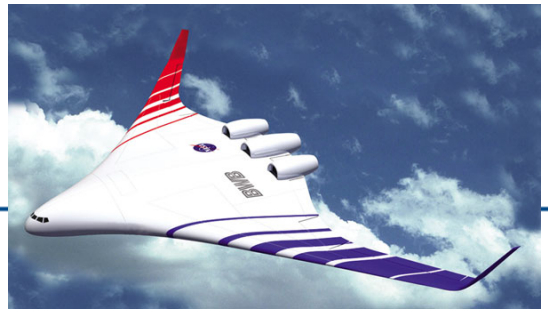
CORNERS OF THE TRADE SPACE	N+1 (2015 EIS) Generation Conventional Tube and Wing (relative to B737/CFM56)	N+2 (2020 IOC) Generation Unconventional Hybrid Wing Body (relative to B777/GE90)	N+3 (2030-2035 EIS) Generation Advanced Aircraft Concepts (relative to user defined reference)
Noise	- 32 dB (cum below Stage 4)	- 42 dB (cum below Stage 4)	55 LDN (dB) at average airport boundary
LTO NOx Emissions (below CAEP 6)	-60%	-75%	better than -75%
Performance: Aircraft Fuel Burn	-33%**	-40%**	better than -70%
Performance: Field Length	-33%	-50%	exploit metro-plex* concepts

** An additional reduction of 10 percent may be possible through improved operational capability
* Concepts that enable optimal use of runways at mutiple airports within the metropolitan areas
EIS = Entry Into Service; IOC = Initial Operating Capability

N+1 Conventional



N+2 Hybrid Wing/Body



N+3 Generation

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Key Drivers for NextGen Modeling

- **Airport Capacity Improvements**
  - Airport capacity improvements are based on bottom-up analysis of the OI's and their operations impacts
  - Assumptions and analysis coordinated with FAA and Mitre and performed by ISPA
  - NextGen results in significant improvements in airport capacities (AAR/ADR) in all weather conditions (IMC/MVMC/VMC)
- **Flight Demand Adjustment (Flight Trimming)**
  - Future demand is based on FAA Terminal Area Forecast (TAF)
  - Throughput is restricted (1.2 D/C limit for the quarter-hour and 0.9 for the rolling hour) to keep delays at a reasonable level;
    - Baseline (most) trimming is consistent with baseline capabilities (no new runways) while
    - NextGen (least) trimming is based on NextGen capabilities (new runways)
- **Fleet Evolution**
  - Fleet Forecast was derived from the FAA's Aerospace Forecast and provided by MITRE.
  - Three levels of fleet evolution were applied (Baseline or no new technology, FAA CLEEN/NASA N+1, andNASA N+2). New technology aircraft were inserted beginning in 2016 for both CLEEN/N+1 and N+2.

Key Drivers for NextGen Environmental Modeling

- **Terminal Area Capacity Improvements**
  - Required Navigation Performance (RNP) procedures are defined for all operations into or out of OEP airports.
  - Continuous Descent Arrivals are defined for all arrivals into OEP airports.
- **En Route Airspace Capacity Improvements**
  - En route airspace capacity improvements are based on prior government and industry research as well as IPSA analyses
  - NextGen capabilities such as improved traffic flow management and dynamic airspace capabilities result in increased en route capacities both NAS-wide and in congested airspace