JPDO/IPS A Environmental Analyses and Latest Results

Briefing to Stanford University
AA260: Sustainable Aviation
May 5, 2009
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With Support From

Outline

• Joint Planning and Development Office (JPDO)/NextGen overview
• Interagency Portfolio and System Analysis Division (IPSA) analysis approach
• Recent results: 2008 portfolio assessment and high density case study

What is the JPDO?
The Joint Planning and Development Office (JPDO) was established to execute the Next Generation Air Transportation System (NGATS; a.k.a NextGen) Integrated Plan which was delivered to Congress in December, 2004

NGATS Vision/Goals:
A transformed air transportation system that provides services tailored to individual customer needs, allows all communities to participate in the global economy, and seamlessly integrates civil and military operations

Expand Capacity
Ensure Safety
Ensure our National Defense
Retain U.S. Leadership in Global Aviation
Protect the Environment
Secure the Nation

JPDO Organization
Outline

- Joint Planning and Development Office (JPDO)/NextGen overview
- Interagency Portfolio and System Analysis Division (IPSA) analysis approach
- Recent results: 2008 portfolio assessment and high density case study

Summary of IPSA Analysis Approach

- Future demand scenarios are generated using FAA forecasts.
- 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

- ACES (Sensis)
- ENV Modeling (Metron)
- GRA Security Screening Model
- Alternate future demand scenarios
- Sensis (AvDemand)
- FAA Demand Tool
- ETMS
- Future unconstrained demand
- Sensis Portfolio Simulator
- FAA Airspace Weather
- LMI Airport Capacity Model
- Boeing Airport Capacity Constraints Model
- LMI
- En Route Weather
- Boeing

NextGen allows NAS users to both reduce delay and increase throughput

Stakeholders can employ the increased capability offered by NextGen in a range of ways. Parameters chosen for simulating NextGen infrastructure, ATM and operational characteristics in this analysis resulted in the system operating at "point 2.5" which combines increased throughput with decreased average delays.
Key Modeling Assumptions for NextGen Performance Improvements

- Flight Trimming (Demand Management)
  - Future demand is based on FAA’s Terminal Area Forecast (TAF), 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 operational improvements (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 capacities 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 (OI’s)

- Trajectories and schedule incorporating impacts of OI’s
- Sub-set of OI’s
- OI’s directly analyzed
- Environmental Results

- 1) Fleet Evolution (with airframe/engine tech improvements)
- 2) Required Navigation Performance (RNP)
- 3) Continuous Descent Arrivals (CDA); now Optimized Profile Descents (OPDs)

Environmental Analyses

Environmental Results

Sample Terminal Area Extension for non-OEP Airports

- 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 a 30-day radar sample (April 2005).
- Terminal Area trajectories for remaining airports were generated algorithmically to use the primary or longest runway.

Legend
- Generic Extensions – ORD Arrivals
- Generic Extensions – ORD Departures
- ACES – ORD Baseline Arrivals
- ACES – ORD Baseline Departures
- 40 mi from ORD
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.
- Day and night operations were evolved separately so that both would reflect a broad mixture of the predicted future fleet.
- 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 technology, 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.

Example: New Technology Penetration Through 2025

NASA/Subsonic Fixed Wing’s System Level Metrics
Technology for dramatically improving noise, emissions, & performance

<table>
<thead>
<tr>
<th>Approach</th>
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<tr>
<td>- Enable major changes in engine cycle/airframe configurations</td>
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<td>- Reduce uncertainty in Multidisciplinary Design and Analysis tools and processes</td>
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<td>- Develop/test analyze advanced Multidiscipline-based concepts and technologies</td>
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<td>- Conduct discipline-based foundational research</td>
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Environmental Processing and Analysis Overview

Outline

- Joint Planning and Development Office (JPDO)/NextGen overview
- Interagency Portfolio and System Analysis Division (IPSA) analysis approach
- Recent results: 2008 portfolio assessment and high density case study

Goals of Environmental Analyses

- Coordinate with the JPDO management and Environmental Working Group (EWG); support the NextGen business case
- 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\textsubscript{x}, NO\textsubscript{x}, CO, CO\textsubscript{2}, H\textsubscript{2}O
  - 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
2008 Portfolio Assessment

- 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 are not yet available.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2008 Baseline</th>
<th>2025 Base</th>
<th>2025 Future Modifications</th>
<th>2025 NextGen n+1</th>
<th>2025 NextGen n+2</th>
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<td>Flights &amp; Airports Modeled for Environmental Impact</td>
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- 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 reached.

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.

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

- 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, NOx, SO2, NO2, and O3.

- In the 2025 base most, 70% of the 164 airports had increases in all pollutants while the 2025 nextgen n+2 has increases at 55% of airports.

* Population is held constant with the 2000 Census
Environmental Constraints from 2008 High Density Case Study

Question: What is the impact if the environmental goals are “hard” constraints?

- Our process removes flights from the schedule in order to meet the environmental noise and fuel-efficiency targets.
- The approaches consider both whole-flight trimming and removing fractions of each flight that contributes to exceeding the environmental goals. Then the environmental constraint is expressed as the sum of all flights removed or as the sum of the fractions of flights that must be removed to meet the goals.
- The intent of this approach is simply to estimate the approximate size of trimmed schedules that would meet the stated environmental goals, not to develop schedule-reduction strategies.

Noise-only Trimming (Scaling Method)

- 440,000 people exposed to 65 dBA DNL at the 34 CONUS OEP airports in the 2006 Baseline (population from 2000 US Census)
- 2025 target of ~200,000 people (applying 4% annual reduction)

Fuel Efficiency-only Trimming

Method F1 (“Spread the Pain”)

Method F2 (“Worst First”)

Combined Noise & Fuel-efficiency Trimming

Noise trimming dominates the combined results for all scenarios.

Note: Due to the fuel-efficiency QA step reducing the flight population by about 3%, the number of OEP-34 flights treated for noise trimming alone is somewhat higher than the number treated in combined noise and fuel-efficiency trimming. This does not affect the current results significantly.
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 not yet available.
- 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 show sustained environmental performance with additional flights however none of the environmental goals are achieved.
- The benefits of introducing new aircraft technologies show 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.
- If the environmental goals are treated as hard constraints, significant curtailing of operations may be required.

Future Plans

- Modeling enhancements
  - Update/expand full radar modeling beyond OEP airports (product of NASA NRA)
  - Develop an environmental screener that estimates fuel, emissions, and noise
  - Develop estimates for population exposure based on AEM results
  - Transition to new FAA Aviation Environmental Design Tool (AEDT)
- Sensitivity studies
  - Analysis of different versions of INM/NIRS for noise exposure
  - Expand constraints analysis to include evolving environmental goals and associated policies.
- New scenarios
  - Effect of “upgaging” (replacing several smaller A/C with one larger one) on capacity, environment, etc.
  - Effect of alternate vehicles (VLJs, cruise-efficient STOL, large civil tiltrotor, etc.) on NextGen (product of NASA NRA)
  - “In between” scenarios (maximize capacity, maximize environment, etc.)

Web Sites of Interest

- FAA Flight Plan: [www.faa.gov/about/plans_reports/media/flight_plan_2009-2013.pdf](http://www.faa.gov/about/plans_reports/media/flight_plan_2009-2013.pdf)

Any Questions???
Environmental Scenario
Flight Count for Each Metric

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<th>Scenario Name</th>
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Flight Count in Thousands

1. 2025 has most-traveled by 1,000 airports, all of the 2025 land-traveled scenario have 1,000 airports.
2. All of the 2025 scenarios have 1,000 airports.