Office of Environment and Energy’s (AEE) Air Traffic Management Modernization / Operations Research Program Update

Presented to: REDAC Environment & Energy Subcommittee
By: Pat Moran
Date: 26 March 2014
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## FAA’s Aviation Environment and Energy (E&E) Goals

### Establish Performance Metrics for NextGen

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Aviation Environment and Energy Policy Goals</th>
</tr>
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<tbody>
<tr>
<td><strong>Noise</strong></td>
<td>Reduce the number of people exposed to significant noise around U.S. airports in absolute terms compared to today, notwithstanding aviation growth, and provide additional measures to protect public health and welfare and our national resources.</td>
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<tr>
<td><strong>Air Quality</strong></td>
<td>Achieve an absolute reduction of significant air quality health and welfare impacts attributable to aviation, notwithstanding aviation growth.</td>
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<td><strong>Climate</strong></td>
<td>Limit the impact of aircraft CO₂ emissions on the global climate by achieving carbon neutral growth by 2020 compared to 2005, and net reductions of the climate impact from all aviation emissions over the longer term (by 2050).</td>
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<td><strong>Energy</strong></td>
<td>Improve NAS energy efficiency by at least two percent per year, and develop and deploy alternative jet fuels for commercial aviation.</td>
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</table>

*Note: Although the FAA recognizes water quality as a growing environmental concern, changes to air traffic management and technologies are not likely to impact water quality. Therefore, water quality is not a research priority in this program.*
Air Traffic Management Modernizations (ATMM) Offer Important Potential E&E Improvements

AEE E&E ATMM Research Program Goals

1. Identify and accelerate the implementation of air traffic management concepts that will reduce aviation environmental impacts and/or improve energy efficiency
2. Investigate the E&E effects of operational changes implemented by the FAA.

Core Program Elements

• Research Process: Identifies, conducts, evaluates and transitions ATMM research for implementation
• Roadmap: Describes areas for ATMM Research near, medium, and long term.
• Portfolio Metrics: Assesses the portfolio’s balance with regard to addressing E&E issues and the maturity progression of research project.
AEE’s E&E ATMM Research Program has Three Core Focus Areas, Goals and Targeted Outcomes

<table>
<thead>
<tr>
<th>Core Focus</th>
<th>Research Goal</th>
<th>Goal</th>
<th>Planned Outcome</th>
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<tbody>
<tr>
<td>a. E&amp;E ATMM Exploration</td>
<td>Accelerate ATM Improvements and Efficiencies</td>
<td>Identify, explore, and prove new ATM/Operational concepts with potential E&amp;E benefits or that can accelerate ATM improvements and efficiencies</td>
<td>Improved E&amp;E performance on a per flight basis Transition to the ATO</td>
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<tr>
<td>b. Policy Assessment</td>
<td>Accelerate ATM Improvements and Efficiencies</td>
<td>Identify and assess existing policy or potential new policies to determine where policy may be changed or new policy developed to accelerate ATM improvements and efficiencies</td>
<td>Improved E&amp;E performance on a per flight basis Transition to the ATO</td>
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<td>c. Environmental Impact Assessment</td>
<td>Determine Impacts (+/-) of NextGen Operational Improvements</td>
<td>Assess the E&amp;E impacts (+/-) associated with implementation of ATM/operational improvements to understand their contribution to aviation E&amp;E goals</td>
<td>Quantitative assessment to inform business case and E&amp;E goals</td>
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## AEE ATMM Research Roadmap

<table>
<thead>
<tr>
<th>Core Focus Area</th>
<th>FY 2011</th>
<th>FY 2012</th>
<th>FY 2013</th>
<th>FY 2014</th>
<th>FY 2015</th>
<th>FY 2016+</th>
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<tr>
<td><strong>Policy Assessment</strong></td>
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<td>P43: Phase I Exploration of aircraft mission specification changes</td>
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<td>P43: Phase II Exploration of aircraft mission specification changes</td>
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<td>CLEEN transition</td>
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<td>End-around taxiway optimization</td>
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<td><strong>ATM/Operations Exploration and Development</strong></td>
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<td>P32: Near-term operational changes</td>
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<td>Gooping QPC</td>
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<td>Exploration of climb phase of flight</td>
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<td>Benefits of cruise, attitude, and speed optimization (CASO)</td>
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<td>Exploration of low power/low drag</td>
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<td>P21: Airport surface movement optimization (N-control)</td>
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<td>P21: Airport surface movement optimization (N-control)</td>
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<td>P21: Airport surface movement optimization (N-control)</td>
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<td>Scoping study to identify and evaluate promising concepts</td>
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<td>ATO transition</td>
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<td><strong>Environmental Benefits/Impact Assessment</strong></td>
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<td>Benefits assessment of CDGM and ground merging at PNAV</td>
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<td>P39: Evaluation of the MFAST tool</td>
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<td>Benefits evaluation of ADS-B implementation in the COMEX region</td>
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<td>Scope of UAS Benefits Assessment</td>
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<td>Evaluation of the effects of introducing UASs in the NAS</td>
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<td>Evaluation of the tradeoffs between vectoring and speed control</td>
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<td><strong>E&amp;E ATMM Roadmap</strong></td>
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<td>Impact Time Frame</td>
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<td>Phase of Flight</td>
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<td>Environmental Impact (+/-)</td>
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### Project Descriptions

- **Past Projects**: FY 2013 funded
- **FY 2014 Proposed Projects**: FY 2014 proposed projects
- **Potential Future Research not Yet Funded**: Potential future research not yet funded
- **Concept Maturity Level**: Maturity level for each project
- **Priority Level**: Priority level for each project

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**Technical Approaches**

- **SurVIFF**: Surface Vitality and Interface Forecasting Framework
- **CEN**: Collaborative Environment for Next Generation
- **ATMM**: Air Traffic Management and Operations
- **ATM**: Air Traffic Management
- **CDGM**: Connected-Direct Ground Movement
- **PBN**: Performance-Based Navigation
- **UAS**: Unmanned Aerial Systems
- **NAS**: National Airspace System
- **CASO**: Cruise, Attitude, and Speed Optimization
- **DDAs**: Delayed Departure Approaches
- **ADP**: Automated Departure Planning
- **CDM**: Congestion Mitigation and Authorization
- **E&E**: Environment and Economics
- **MFAST**: Modular Flight Management Software for Automation Tools

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**Federal Aviation Administration**

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AEE sponsors Operations Research for all phases of flight:

- **En Route**
  - Cruise Altitude and Speed Optimization

- **Terminal**
  - Delayed Deceleration Approach

- **Surface**
  - N-Control
Cruise Altitude and Speed Optimization (CASO)

- Identifying fuel savings potential from small changes in cruise altitude & speed
- Determining opportunities to realize savings in current & NextGen operations
- Work with airlines to understand operational & business constraints
CASO: High-Level Approach

- Wind and Temperature (NOAA)
- Estimated Weights (modeled with sample data from 3 airlines)

Historical Tracks (~200,000 flights)

Baseline Trajectory

Trajectory Optimizer
  - Speed
  - Altitude
  - Joint

Optimal Trajectory

Aircraft Performance Model
Lissys PianoX

Estimates fuel burn for given trajectory

Baseline Fuel Burn

CASO Benefits

Optimal Fuel Burn

Optimal (Mach, alt, or joint)

Generate Trajectories

Calculate Fuel Burn

Compare Outputs
CASO: Sample Speed Optimization Results

- **Two types of speed optimization:**
  - Max Range Cruise (MRC): Fuel-optimal speed
  - Long Range Cruise (LRC): 99% Efficiency Speed

- **Tradeoff between flight time increase and fuel burn reduction**

<table>
<thead>
<tr>
<th></th>
<th>Mean fuel burn reduction per flight</th>
<th>Mean flight time increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Range Cruise</td>
<td>105 lbs (1.93%) std. dev. = 192 lbs</td>
<td>2.52 mins (3.95%) std. dev. = 2.85 mins</td>
</tr>
<tr>
<td><strong>100% Efficiency</strong></td>
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<tr>
<td>Long Range Cruise</td>
<td>50 lbs (0.93%) std. dev. = 167 lbs</td>
<td>-0.03 mins (-0.04%) std. dev. = 2.05 mins</td>
</tr>
<tr>
<td><strong>99% Efficiency</strong></td>
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</table>
CASO: Sample Altitude Optimization Results

Three types of Altitude Optimization:

<table>
<thead>
<tr>
<th>Cruise Climb</th>
<th>Step Climb</th>
<th>Flexible VNAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Constant rate of climb</td>
<td>• Derived from cruise climb</td>
<td>• Allows climbs and descents</td>
</tr>
<tr>
<td>• Linear regression</td>
<td>• 1000-ft increments</td>
<td>• Requires 10-minute minimum level flight segments</td>
</tr>
<tr>
<td></td>
<td>• 2000-ft increments</td>
<td>• Captures atmospheric variation</td>
</tr>
<tr>
<td></td>
<td>• As-flown baseline</td>
<td></td>
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</tbody>
</table>

Sample Benefits Distribution:

1000 ft. Step Climb

Sample Size: 184121 Flights

Step Climb Altitude Optimization

[Graph showing fuel efficiency distribution]
CASO Planned Next Steps

Extended Analysis

- Analyze combined altitude/speed optimization
- Explore geographic (by region, route, airport, etc.) and operator effects on efficiency
- Evaluate applications for oceanic operations

- Stakeholder results discussions with Operators & Air Traffic
  - Dissemination & stakeholder interpretations
- Potentially identify & test modified operating practices

Knowledge Transfer & Deployment to Operational System
Delayed Deceleration Approach (DDA)

- Reduce fuel burn and emission by maintain higher airspeed with clean aerodynamic configuration for as long as possible during approach without impacting current speed gates.

![Diagram showing Delayed Deceleration Approach]

- Lower Drag
- Lower Thrust
- Lower Fuel Burn & Emissions
DDA: High Level Approach

- Establish DDA fuel reduction potential via FDR analysis
- Airport speed profile comparison via radar track analysis
  - 9 months of data: Jan-Sep 2011
  - DC Metroplex
  - NY Metroplex
  - Congested Standalone Airports (ATL & LAX)
  - Uncongested Standalone Airports (STL & RIC)
  - Boston
- Detailed analysis of DDA implementation from targeted opportunities
**DDA: Fuel Burn Reduction Potential**

**A320 Flight Data Recorder Analysis**
(similar results for B757 & B777)

30-50% fuel burn reduction potential from DDAs, 10,000 ft to touchdown
DDA: Sample Airport Track Analysis

- Using extensive radar data to analyze speed profiles
- Significant variability between airports and operating conditions

- Using extensive radar data to analyze speed profiles
- Significant variability between airports and operating conditions
DDA Planned Next Steps

Extended Analysis

• Identify opportunities for increased DDA operations
  – Specific airports, configurations, operating conditions, etc.
• Analyze noise impacts
• Assess controller/pilot impacts of DDAs
  – Proposing Human-In-The-Loop (HITL) simulations
• Explore integration of DDA into NextGen concepts
  – e.g., speed targets in RNAV approaches

Knowledge Transfer & Deployment to Operational System

• Stakeholder results discussions with Operators & Air Traffic
  – Dissemination & stakeholder interpretations
• Potentially identify & test modified operating practices
N-Control Overview

- **Surface congestion increases taxi times, fuel burn & emissions**
  - In 2010, over 200 million gallons excess taxi fuel [ASPM]

- Departure metering holds aircraft with engines off until they can be efficiently handled

- Study is developing, analyzing and field testing departure metering approaches suitable for range of airports

- Informs FAA decision support programs (e.g., TFDM)
N-Control: High Level Approach

N-control pushback rate approach developed and successfully trialed at BOS during 2010 and 2011

Need to understand adaptation challenges for range of congested airports

- LGA next focus airport

Developed & executed framework for adapting departure metering algorithms to specific airport operations
N-Control: LGA Simulation-Based Testing of Algorithms

- Simulations of operations in Aug 2012, Jan 2013 and Apr 2013
- Integration/validation of unimpeded taxi-out times, VMC/IMC, runway configurations, weather (RAPT values) and gate usage

**Estimated unimpeded taxi-out times**

<table>
<thead>
<tr>
<th>Terminal</th>
<th>August 12</th>
<th>January 13</th>
<th>April 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>T – A</td>
<td>14 min</td>
<td>14 min</td>
<td>14 min</td>
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<tr>
<td>T – B</td>
<td>13 min</td>
<td>13 min</td>
<td>13 min</td>
</tr>
<tr>
<td>T – C &amp; D</td>
<td>16 min</td>
<td>15 min</td>
<td>15.4 min</td>
</tr>
</tbody>
</table>

- Evaluation metrics include
  - Gate holds
  - Taxi-out times (and savings)
  - Runway throughput
  - Preservation of First Come First Served (FCFS) sequence (First push first takeoff)

**Simulation Results:**
FCFS is preserved to a greater extent with metering than without
N-Control: Schedule and Status

• LGA airport selection and categorization: complete
• Refined algorithm development: complete
• Refined algorithm development: complete
• Implementation design: near-complete (final approvals of ATC and airlines pending)
  − Recent personnel changes in LGA
• Operational testing and performance evaluation: planned for Spring 2014
Thank You