Aircraft Operations Environmental Assessment:
Cruise Altitude and Speed Optimization

ASCENT Project 15

Project managers: Chris Dorbian, FAA
Stephen Merlin, FAA

Principal investigators: R. John Hansman, MIT
Tom Reynolds (Lincoln Laboratory)

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Project Overview

• Funding: FAA Office of Environment & Energy (FAA/AEE)

• High-Level objective: Identify & evaluate operational mitigations to reduce environmental impacts of aviation in the near/mid-term with minimal implementation barrier

• Prior work: Identified/evaluated over 60 mitigations

• Current research focus: Quantify benefits and barriers to implementation of:
  – Cruise Altitude and Speed Optimization (CASO)
  – Delayed Deceleration Approach (DDA)
Cruise Altitude and Speed Optimization: Overview

- Fuel burn reduction important for airlines, regulators, and society
  - Economics
  - Environmental impact
- 2012 Radar analysis shows 56% of domestic flight time spent in high-altitude cruise
- Efficiency Metric: “Specific Ground Range”
  - Maximizes ground distance per unit of fuel consumption
  - Accounts for wind and temperature
- Typical airliner cruise conditions are not fuel-optimal with respect to speed and altitude
  - Opportunities in flight planning, dispatch, and cockpit procedures
  - Potential applications in the NextGen ATM framework
CASO High-Level Approach

Radar Tracks

- Weight Estimation
- Weather Correction (Wind/Temp)

Modified Trajectory (Speed/Altitude)

- Speed/Altitude Optimizer

Aircraft Fuel Burn Model

- Lissys PianoX
- Eurocontrol
- BADA 3.11

CASO Benefits

Improved Fuel Burn (from changed speed/alt)

As-Flown Fuel Burn

Baseline (As-Flown) Trajectory
Altitude Optimization

Altitude Efficiency by Specific Ground Range
B763 from ATL to LAX Assuming As-Flown Mach

Distance in Cruise [nm]
Joint Altitude and Speed Optimization

Joint Alt/Speed Fuel Burn Reduction vs. Baseline

Data from 2012 (18 days)
Relative Speed Efficiency

MRC (Speed) Fuel Burn Reduction vs. Baseline

Data from 2012 (18 days)
Relative Speed Efficiency

MRC (Speed) Fuel Burn Reduction vs. Baseline

Data from 2015 (2 days)

PianoX Model
Prototype Electronic Flight Bag Decision Support Tool

<table>
<thead>
<tr>
<th>Step</th>
<th>Current Wt</th>
<th>ETA</th>
<th>Mod ETA</th>
<th>Change</th>
<th>Init Climb In</th>
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</thead>
<tbody>
<tr>
<td>1K</td>
<td>320000 lbs</td>
<td>06:02:30 ETE</td>
<td>06:03:45 ETE</td>
<td>1.25 mins</td>
<td>01:03:20</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10000 lbs</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10500 lbs</td>
<td></td>
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</tbody>
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Mach Commanded. Highlighted Magenta

Calculated Cost Index from commanded Mach

Flight Plan  CASO  VSD  Settings
Delayed Deceleration Approach (DDA) Concept

- Keep aircraft “clean” for longer on approach when appropriate without impacting terminal area entry or final approach stabilization criteria
  - Between these speed gates, opportunity for encouraging more efficient approach speed profiles

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<table>
<thead>
<tr>
<th>Distance to touchdown</th>
<th>Airspeed</th>
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<tbody>
<tr>
<td>Terminal area entry speed</td>
<td></td>
</tr>
<tr>
<td>Final approach speed</td>
<td></td>
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</table>
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- "Clean" configuration
- "Dirty" configuration

```
<table>
<thead>
<tr>
<th>Runway</th>
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<tbody>
<tr>
<td>Delayed Decel. =&gt; Low Power/ Low Drag</td>
</tr>
<tr>
<td>Typical Conventional</td>
</tr>
<tr>
<td>Sample flap 1</td>
</tr>
<tr>
<td>Sample flap 2</td>
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</table>
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"Clean" configuration

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"Dirty" configuration
**European A320 Flight Data Recorder Analysis**
(similar results for B757 & B777)

- Lowest fuel burn flights (green profiles) associated with delayed deceleration

30-50% fuel burn reduction potential from DDAs, 10,000 ft to touchdown
DDA Speed Profile Analysis: NYC Metroplex

- Earlier decelerations generally observed under IMC compared to VMC
- LGA under IMC has earliest decelerations

"Large" arrivals from ZDC, 8 sample days

"Large" arrivals from ZDC JAN – SEP 2011

- LGA VMC n = 10,530
- LGA IMC n = 1,600
- JFK VMC n = 9,070
- JFK IMC n = 1,048
- EWR VMC n = 4,435
- EWR IMC n = 775
DDA Airport Comparison

“Large” arrivals from ZDC, JAN – SEP 2011

- Significant variability between airports & operating conditions
- In general, best performance from less constrained airports
- Worst performance from constrained metroplex airports
- Large difference between VMC and IMC for many airports
- In process of extending to more airports & updating with 2015 data

* Relatively small sample size

Time Flown Below 180 kts for 50% of Flights (mins)
Outreach Meetings

1. Meeting with airlines and ATC to discuss results and operational implications
   - Airline flight planning, dispatch, and operations departments
   - Procedures used for flight planning with respect to efficiency (i.e. cost index policy, altitude selection, cockpit and ground weather sources)
   - Initial meetings
     - Delta
     - American
     - United
   - Additional meetings being scheduled