Aircraft Operations Environmental Assessment: Cruise Altitude and Speed Optimization

ASCENT Project 15

Project Status
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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 barriers
- Prior work: Identified/evaluated over 60 mitigations
- Current research focus:
  - Quantify benefits and barriers to implementation of Cruise Altitude and Speed Optimization (CASO)
  - Prototype a CASO decision support tool and engage with operators
Cruise Altitude and Speed Optimization: Overview

- Fuel burn reduction important for airlines, regulators, and society
  - Economic impact
  - 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

Baseline (As-Flown) Trajectory

Modified Trajectory
(Speed/Altitude)

- Speed/Altitude Optimizer

Aircraft Fuel
Burn Model

- Lissys PianoX
- Eurocontrol
- BADA 4

Improved Fuel
Burn (from changed
speed/alt)

CASO Benefits

As-Flown Fuel
Burn
Aggregate Speed Results

18 days in 2012
217,099 Flights

Max Range Cruise (MRC): Fuel-optimal speed

Long Range Cruise (LRC): 99% Efficiency Speed
Crude Oil and Jet Fuel Price Trends
Aggregate Speed Efficiency: 2015 Data

Fuel Burn Reduction Potential from MRC Speed Optimization
2015 Results (17 sample days)

- More Efficient
- Less Efficient

- Mainline 1 (n=41884)
- Mainline 2 (n=28842)
- Mainline 3 (n=27122)
- Mainline 4 (n=17888)
- Mainline 5 (n=6886)
- Regional 1 (n=15309)
- Regional 2 (n=9540)
- Regional 3 (n=5672)
Altitude Optimization

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

% Max SGR

Distance in Cruise [nm]

Flight Level

As Flown: 37,071 lbs. (baseline)
Flexible VNAV: 36,111 lbs. -2.59%
Cruise Climb: 36,174 lbs. -2.42%
1K Step: 36,186 lbs. -2.39%
2K Step: 36,391 lbs. -1.83%
Sample Altitude Efficiency Tunnels
Altitude Efficiency
Aggregate 2012 Data (2000 ft Step Climbs)

Fuel Burn Reduction Potential from 2000ft Step Climb Optimization
2012 Results (18 sample days)

- More Efficient
- Less Efficient

Probability Density

Percent Fuel Burn Reduction
Joint Altitude and Speed Optimization for 2012 Data By Airline

Joint Alt/Speed Fuel Burn Reduction vs. Baseline

- More Efficient
- Less Efficient

Data from 2012 (18 days)
Potential Barriers to Optimal Cruise Altitude and Speed

• Internal factors
  – Airline
    • Dispatcher Flight Planning Tools
    • Flight Crew Awareness/Workload
  – Air Traffic Control
    • Controller Workload (Tactical)
    • Policies and Regulations (Strategic)

• External factors
  – Weather Conditions
    • Turbulence
    • Icing

• Business Drivers
  – Schedule (Cost Index)
  – Delays and schedule reliability
  – Non-Fuel Cost Drivers
Cruise Optimization DST

A prototype tablet-based Decision Support Tool (DST) using the underlying optimization approach was developed to provide better information by leveraging existing capabilities and emerging airline trends in connectivity.

**Objective:** To identify opportunities, limitations, and practical considerations for altitude optimization in airline operations.

Prototype currently running on a Microsoft Surface.
Prototype Decision Support Tool

**Features**

- Maximum Altitude Boundary
- 98% Performance Line
- 99% Performance Line

**Prototype Decision Support Tool Interface**

- Turbulence Display Scale (Eddy Dissipation Rate)
- Current Cleared Altitude (magenta)
- Viewing Window Controls
- Recommended Vertical Profile at Desired Cost Index (white)

**Interface Elements**

- Current Aircraft Gross Weight
- Fuel over Destination (FOD)
- Alternate Trajectory FOD
- Fuel saving potential from alternate trajectory

- Estimated time of arrival (ETA)
- ETA for alternate trajectory at current selected cost index
- Change in ETA and MOD ETA
- Time until next step
Turbulence Information: Graphical Turbulence Guidance and PIREPs

• Graphical Turbulence Guidance 3.0 (GTG) from NOAA
  – Eddy dissipation rates (EDR) as metric

• Pilot Reports (PIREPs)
  – Ride report, location, time, aircraft type
Prototype System

Standalone setup independent of aircraft systems developed for testing, but future integration with aircraft systems envisioned.
Architecture (Prototype Test System)

- RAP database
- GTG database
- AWC database
- Inflight Wifi
- Wx downloader
- Wx processor
- .gribz files
- .mat files
- Wind/Temp database
- Turbulence database
- AIRMET/SIGMET/PIREP database
- Aircraft Performance Model
- Estimated Performance
- Recommended Trajectory Altitude Tunnel
- Flight Plan
- Waypoint decoder
- GPS
- Position, altitude
- Nav database
- Trajectory Generator
- Cruise Altitude and Speed Optimization
- Information Entry
- Information Display
- Operator

18
Prototype System

- Prototype developed and running on Surface tablet
- Preliminary functionality testing conducted on GPS receiver and cabin Wifi download speeds
Next Steps

• NDA has been signed with a major carrier to compare flight plans

• Compare optimal trajectories and performance estimates from DST with trajectories from airline dispatch tools

• Test GPS reception in the cockpit

• Obtain feedback from pilots on usability and utility of the DST