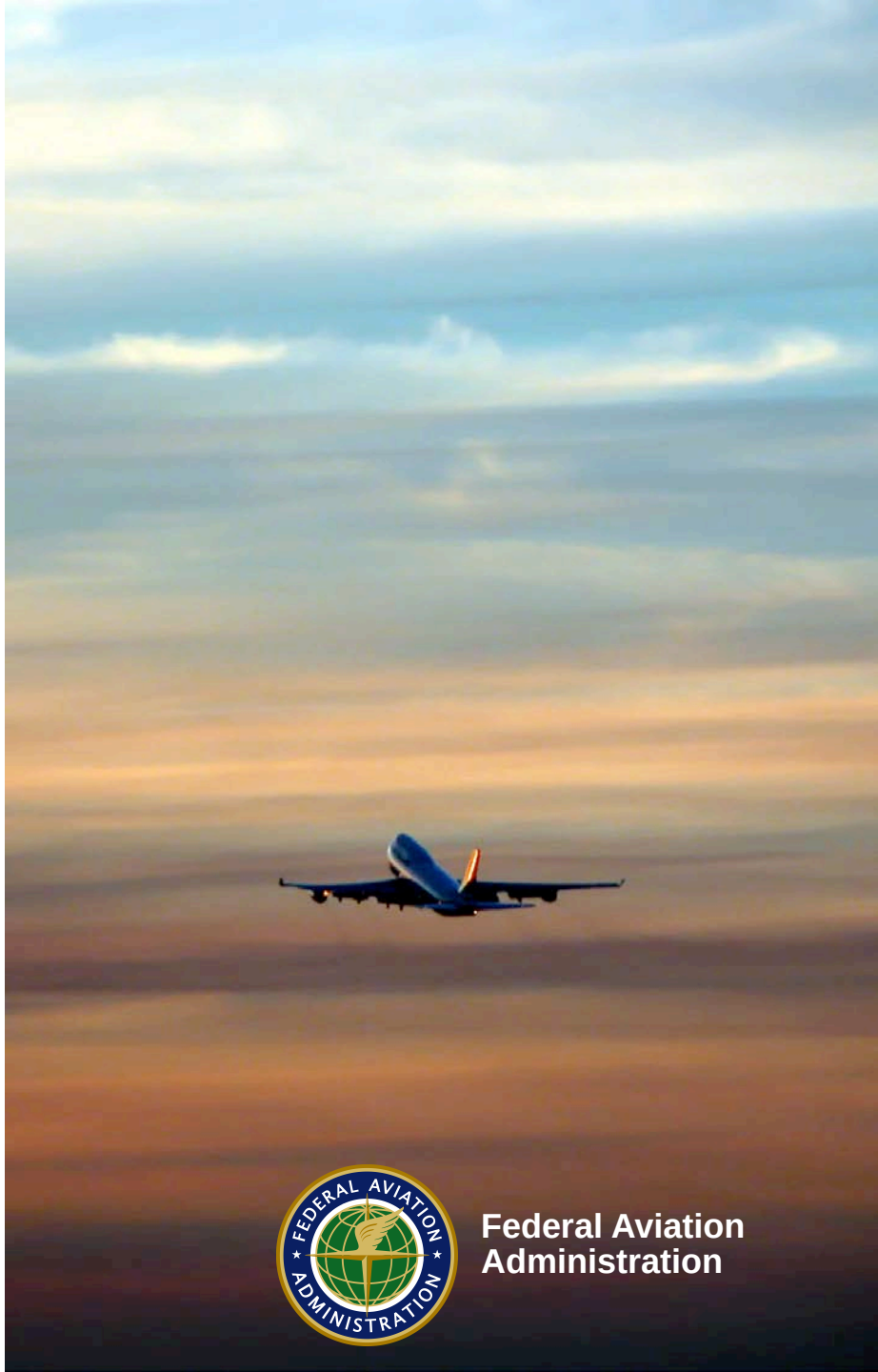
# FAA Aircraft Technology and Operations Research

Presented to: 6th UTIAS International Workshop on Aviation and Climate Change

By: Chris Dorbian
Federal Aviation Administration
Office of Environment & Energy

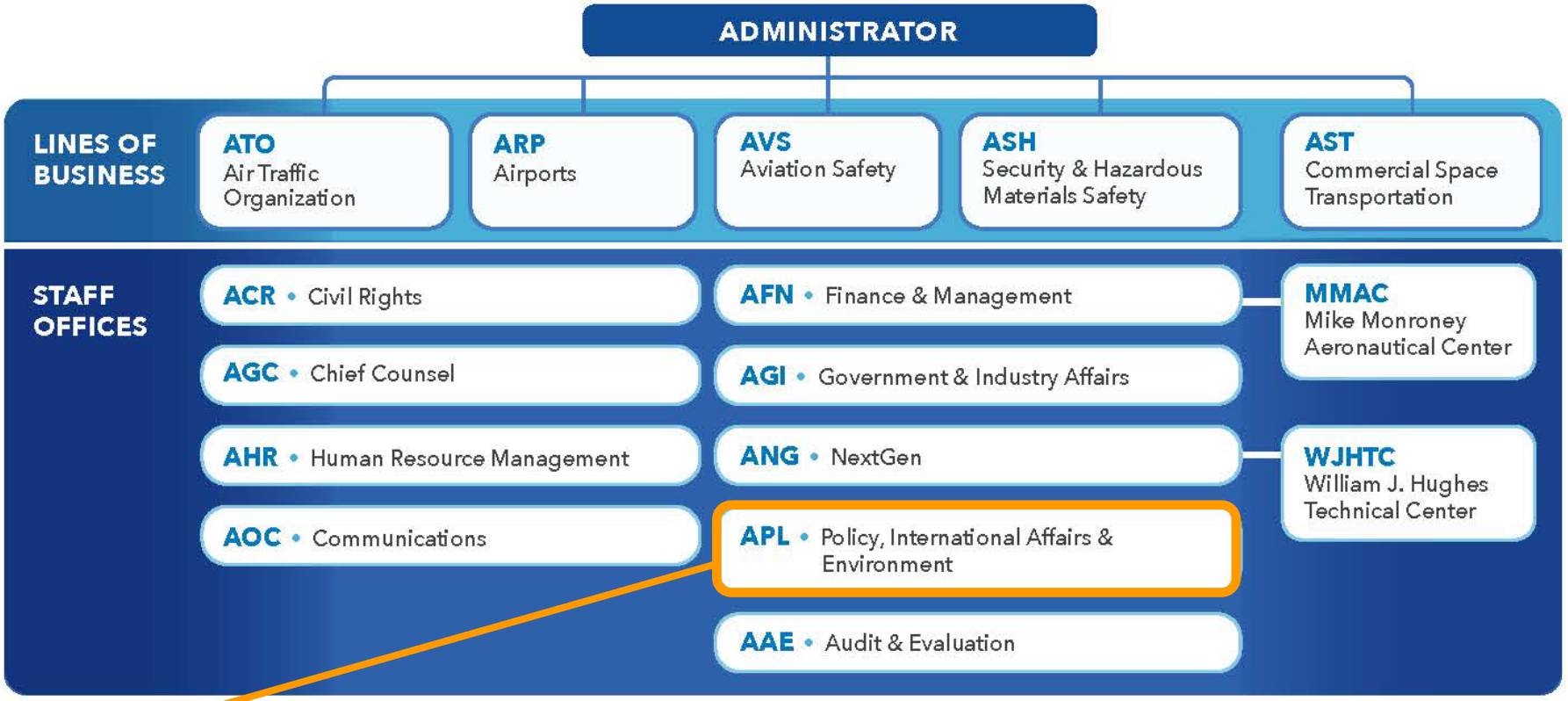
Date: May 16, 2018



# Outline

1. Office of Environment & Energy Overview
2. Aircraft and Engine Technology Development
3. Emissions Operations Research
4. Noise Operations Research

# FAA Organizational Structure




**Office of Environment and Energy (AEE)**

# AEE Mission and Vision

**Mission:**

*To understand, manage, and reduce the environmental impacts of global aviation through research, technological innovation, policy, and outreach to benefit the public*

**Vision:**

*Remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation*

# The Five Pillar Approach

## Science and Tools

PILLAR 1: Improved Scientific Knowledge and Integrated Modeling

- Decision-making based on solid scientific understanding
- Work with research community through the **Aviation Sustainability Center (ASCENT)**
- Understand public health and welfare impacts
- Incorporate this knowledge within the Aviation Environmental Tool Suite

## Technology

PILLAR 2: New Aircraft Technologies

- Offer the greatest opportunity to reduce environmental impacts
- Partner with industry, research community, NASA, and Department of Defense
- Mature new engine and airframe technologies through the **Continuous Lower Energy, Emissions and Noise (CLEEN) Program**

## Alternative Fuels

PILLAR 3: Sustainable Alternative Aviation Fuels

- Reduce environmental impacts, enhance energy security, and provide economic benefits
- Collaborate with stakeholders through the **Commercial Aviation Alternative Fuels Initiative (CAAFI)**
- Test alternative jet fuels to ensure they are safe for use through **ASCENT** and **CLEEN**
- Analyze their potential for reducing the environmental impacts of aviation

## Operations

PILLAR 4: Air Traffic Management Modernization and Operational Improvements

- Increase efficiency of aircraft operations through the **Next Generation Air Transportation System (NextGen)**
- Engage with industry, research community, NASA, and Department of Defense
- Develop advanced operational procedures to optimize gate-to-gate operations
- Integrate infrastructure enhancements to the National Airspace System (NAS), improving environmental performance

## Policy

PILLAR 5: Policies, Environmental Standards, and Market Based Measures

- Implement domestic policies, programs, and mechanisms to support technology and operational innovation
- Develop and implement aircraft emissions and noise standards
- Work within the International Civil Aviation Organization (ICAO) to pursue a basket of measures to address emissions that affect climate, including a global market based measure as a gap filler
- Seek international partners to further our environmental and energy strategy

NextGEN
http://www.faa.gov/nextgen

CAAFI
http://www.caafi.org

CLEEN
NextGEN
http://www.faa.gov/go/cleen

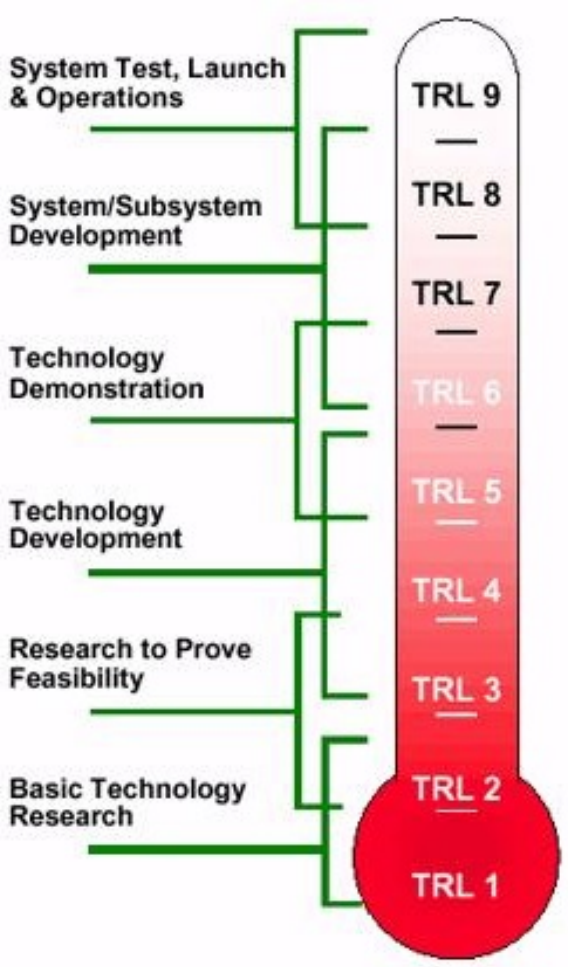
ASCENT
http://ascent.aero

# Outline

1. Office of Environment & Energy Overview
2. Aircraft and Engine Technology Development
3. Emissions Operations Research
4. Noise Operations Research

# CLEEN Program Overview

- FAA's principal environmental effort to accelerate development of new aircraft and engine technologies and advance the introduction of alternative jet fuels.
- Objective:
  - Mature previously conceived noise, emissions and fuel burn reduction technologies for civil subsonic airplanes from Technology Readiness Levels (TRL) of 3-5 to TRLs of 6-7 to enable industry to expedite introduction of these technologies into current and future aircraft and engines
  - Assess the benefits and advance the development and introduction of "drop-in" alternative jet fuels, including blends



# CLEEN Program Overview

## CLEEN Phase I (2010-2015)

- Industry partners: Boeing, General Electric, Honeywell, Pratt & Whitney, Rolls-Royce
- Federal Funding: $125M (1:1 minimum cost share is required)

## CLEEN Phase II (2015-2020)

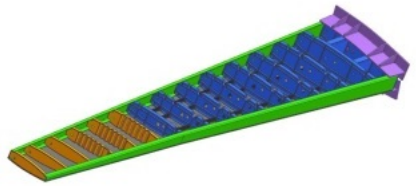
- Industry partners: Aurora Flight Sciences, Boeing, Delta/MDS/America's Phenix, General Electric, Honeywell, Pratt & Whitney, Rohr/UTC Aerospace Systems, and Rolls-Royce
- Federal Funding: $100M (1:1 minimum cost share is required)
- CLEEN II tech expected to be on a path for introduction into commercial aircraft by 2026

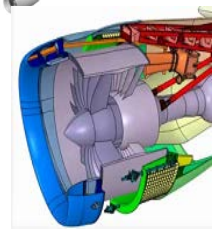
## CLEEN Fact Sheet (updated 2/12/18)

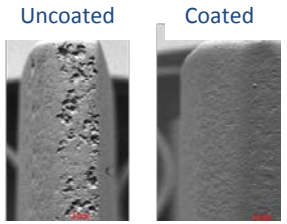
- https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=22534

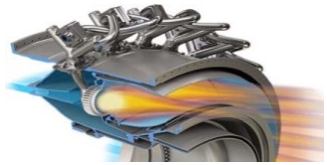
# CLEEN Phase II Technologies

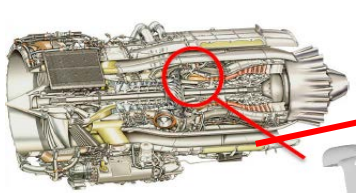
- Aurora Flight Sciences: D8 Double Bubble Fuselage
- Boeing: Structurally Efficient Wing (SEW)
- Boeing: Compact Nacelle – Short Inlet
- Delta Tech Ops/MDS Coating Technologies/America's Phenix: Leading Edge Protective Blade Coatings
- GE: TAPS III Combustor
- GE: FMS Technologies
- GE: More Electric Systems and Technologies for Aircraft in the Next Generation (MESTANG)
- GE: Low Pressure Ratio Advanced Acoustics
- Honeywell: Compact Combustor System
- Honeywell: Advanced Turbine Blade Outer Air Seal (BOAS) System
- Pratt & Whitney: High Pressure Compressor Aero-Efficiency Techs
- Pratt & Whitney: High Pressure Turbine Aero-Efficiency & Durability Techs
- Rolls Royce: Advanced RQL Low NOx Combustion System
- UTAS: Nacelle Technologies

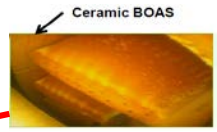


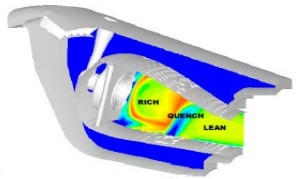


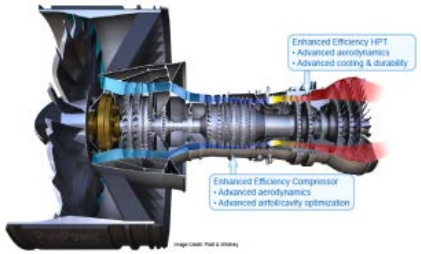


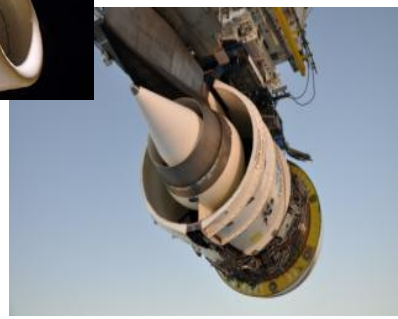





# CLEEN Highlights



**CLEEN Phase I**

- GE TAPS II Combustor entered fleet in 2016 on LEAP engine
- Pratt & Whitney Gen 2 geared turbofan propulsor technology successfully engine tested
- Boeing ceramic matrix composite nozzle flight tested on a 787 aircraft

**CLEEN Phase II**

- Aurora Flight Sciences tested key structural subcomponent that enables mass-efficient double bubble fuselage
- America's Phenix/Delta TechOps/MDS Coating Technologies currently conducting in-service flight evaluation of fan blade leading edge protective coating
- Boeing completed ground engine test of compact nacelle technology
- Rolls-Royce conducting full annular rig test for RQL low NOx combustion system
- Pratt & Whitney completed rig testing of advanced high pressure compressor technologies

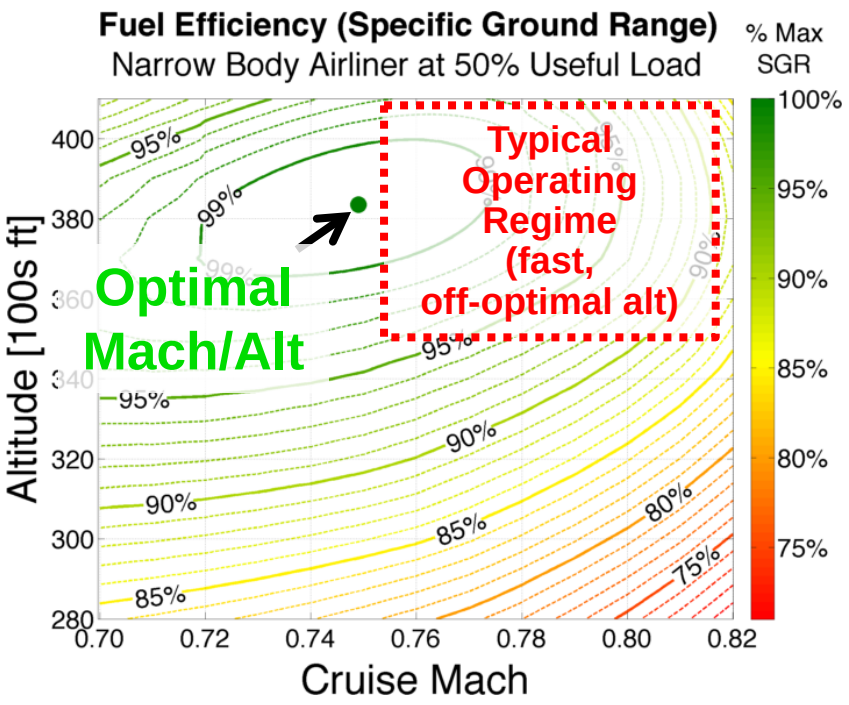
# Outline

1. Office of Environment & Energy Overview
2. Aircraft and Engine Technology Development
3. Emissions Operations Research
4. Noise Operations Research

# Cruise Altitude and Speed Optimization

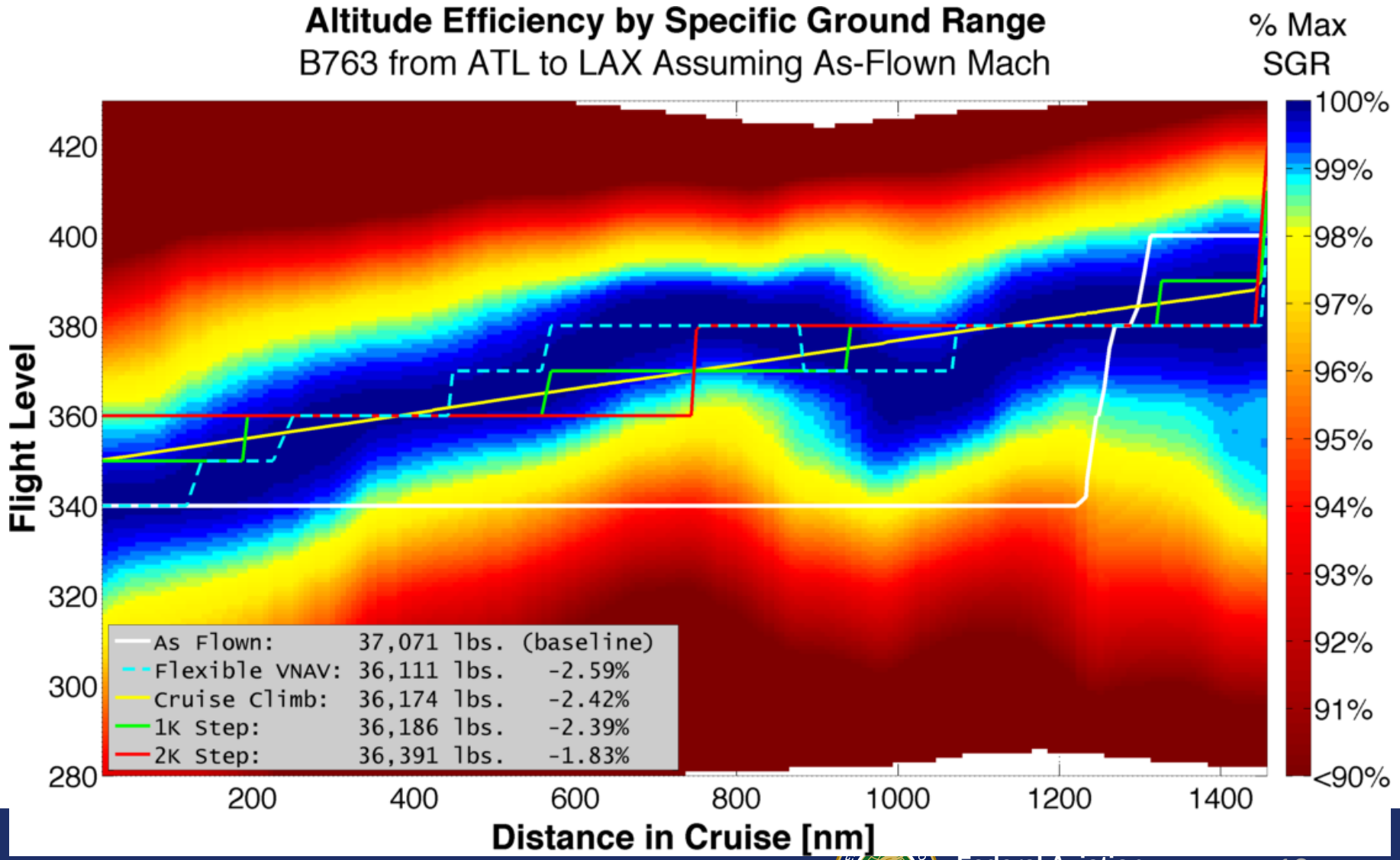
- **Fuel burn reduction important for airlines, regulators, and society**
- **Majority of flight time spent in high-altitude cruise**
- **Typical airliner cruise conditions are not fuel-optimal with respect to speed and altitude**
  - Dependent on weight, wind, and temperature
- **Opportunities**
  - Cockpit tech
  - ATM
  - Dispatch

**Typical Narrow Body Jet Efficiency Contours**




MIT ICAT

# “Altitude Tunnel”

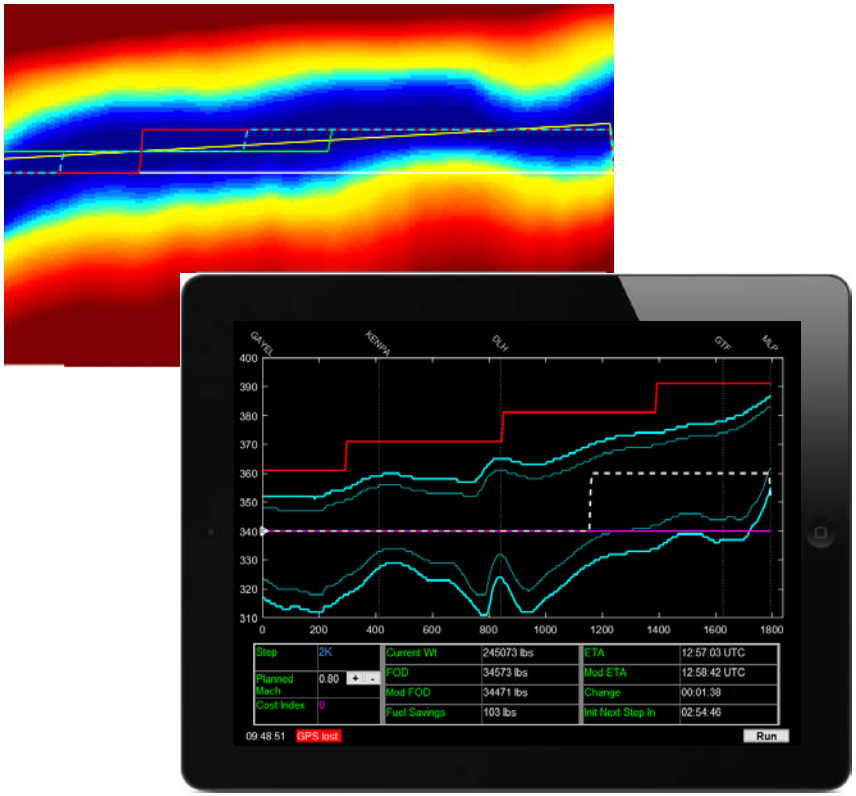


# Cruise Optimization DST

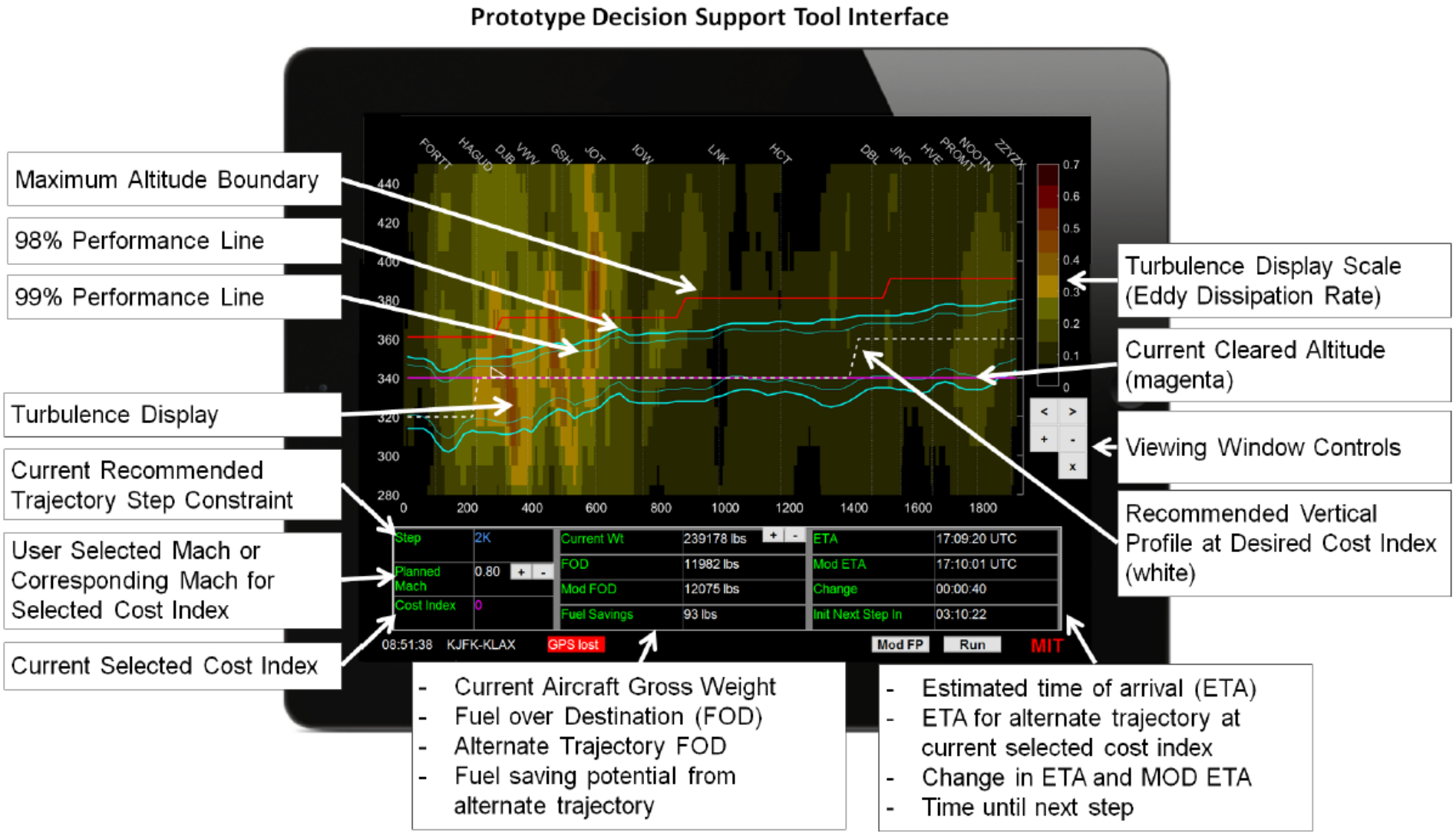
- A prototype tablet-based Decision Support Tool (DST) using the underlying **optimization approach** was developed to provide better information by leveraging existing capabilities and emerging airline **trends in connectivity**

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

- **Prototype currently running on a Microsoft Surface**



# Prototype DST Features



# Current Status

- **NDA signed with a major carrier**
- **Conducted historical analysis for validation and identification of high benefit cases**
- **Preliminary flight trials**
  - CASO DST run on computer on the ground → image sent to crew and dispatcher
  - Flight plan and position/weight updates forwarded from dispatcher
  - Initial feedback:
    - Altitude tunnel is visually compelling → potentially useful even as a static image included in the flight plan or available to dispatchers
    - Pilots/dispatchers may not always have the same turbulence forecast

# Outline

1. Office of Environment & Energy Overview
2. Aircraft and Engine Technology Development
3. Emissions Operations Research
4. Noise Operations Research

# Aviation Noise – Community Concerns

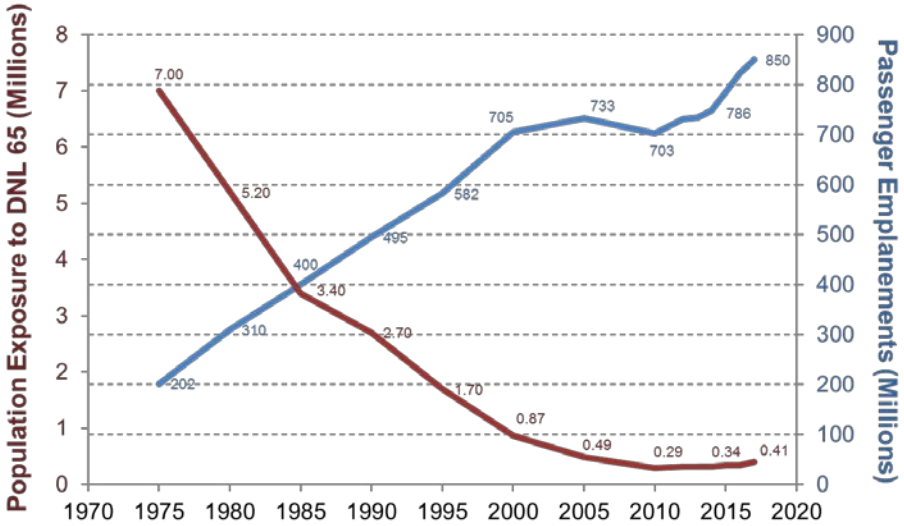
Dear FAA…

"Continuing NEXTGEN AND ignoring the health consequences RESEARCHED AND PROVEN by loud constant noise torture is a malicious action at this point. You have been contacted by MANY AFFECTED RESIDENTS AND CITIZENS making FAA aware of their suffering. … NEXTGEN = VANDALISM AND LEGALIZED NOISE POLLUTION"

""5:41AM, BOOM! Woken up by a [airline] plane arriving at [airport], 2,300 ft above my home. Horrible! But that's not the worst, it's only the beginning. 5:56AM another [airline] to [airport] 2,300 ft above my house. And then: 6:01am, 6:04am, 6:06am, 6:18am, 6:23am, 6:28am, 6:32am, 6:34am, 6:35am, 6:37am, 6:46am, 6:47am, 6:54am, 6:59am, 7:14am! It's 7:14am and I've already heard 16 planes since 5:41am. Please stop this insanity! Why are you allowed to rob me of my sleep, sanity and peace of mind?""

# Aviation Noise – Current Challenge

- Despite traffic growth, community noise exposure has decreased by a factor of 20
- Yet, implementation of precision aircraft navigation over last few years has been accompanied by increased airport community concerns regarding noise
  - Rotorcraft noise also increasingly becoming an issue
- Community noise exposure now hindering the rollout of NextGen
- Aircraft are already much quieter – what can be done operationally?
- FAA is working to ensure that airspace planners have knowledge, tools, and guidance to enable low noise procedures



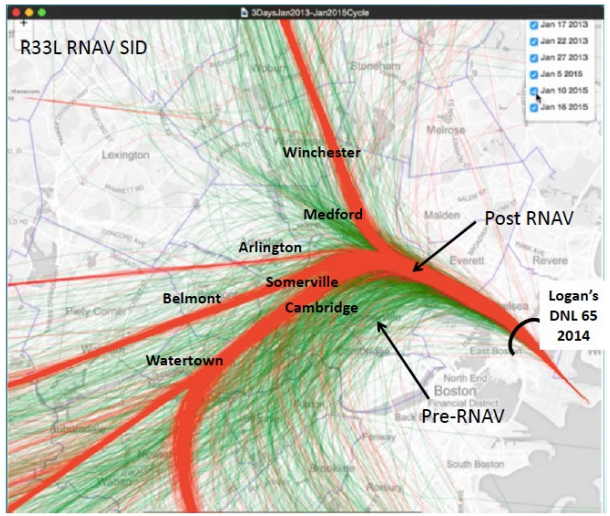




Image Source: Massport

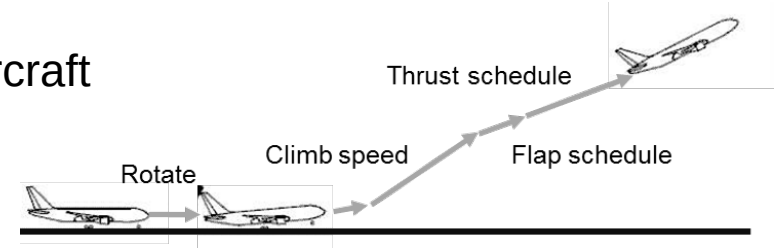
# Aircraft Operations

## Opportunities for noise reduction:

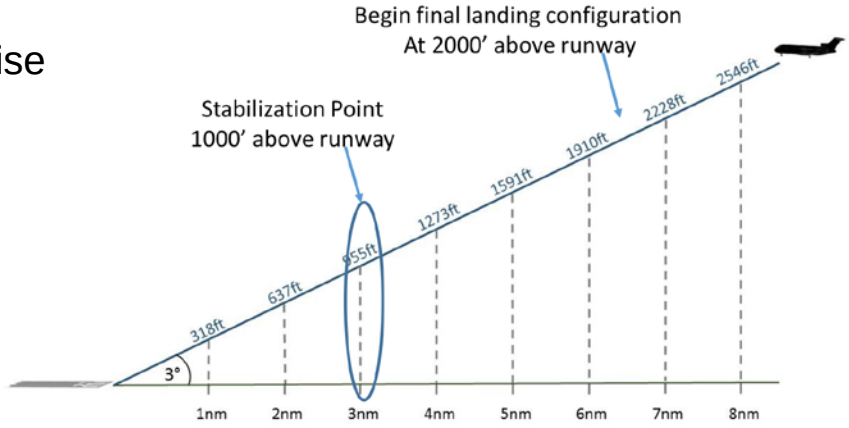
- Precision navigation determines *where* aircraft fly
- Airlines determine *what* aircraft fly and *when*
- There might be opportunities to change *how* aircraft are flown to reduce noise

## Concepts being evaluated:

- **Route changes**
- **Thrust / speed management**
  - Noise abatement procedures
  - Manage thrust and configuration to lower noise on takeoff and approach
- **Vertical profile**
  - Continuous climb operations
  - Continuous descent arrival
  - Modified approach angles
  - Staggered or displaced landing thresholds
- **Introduction of systematic dispersion**



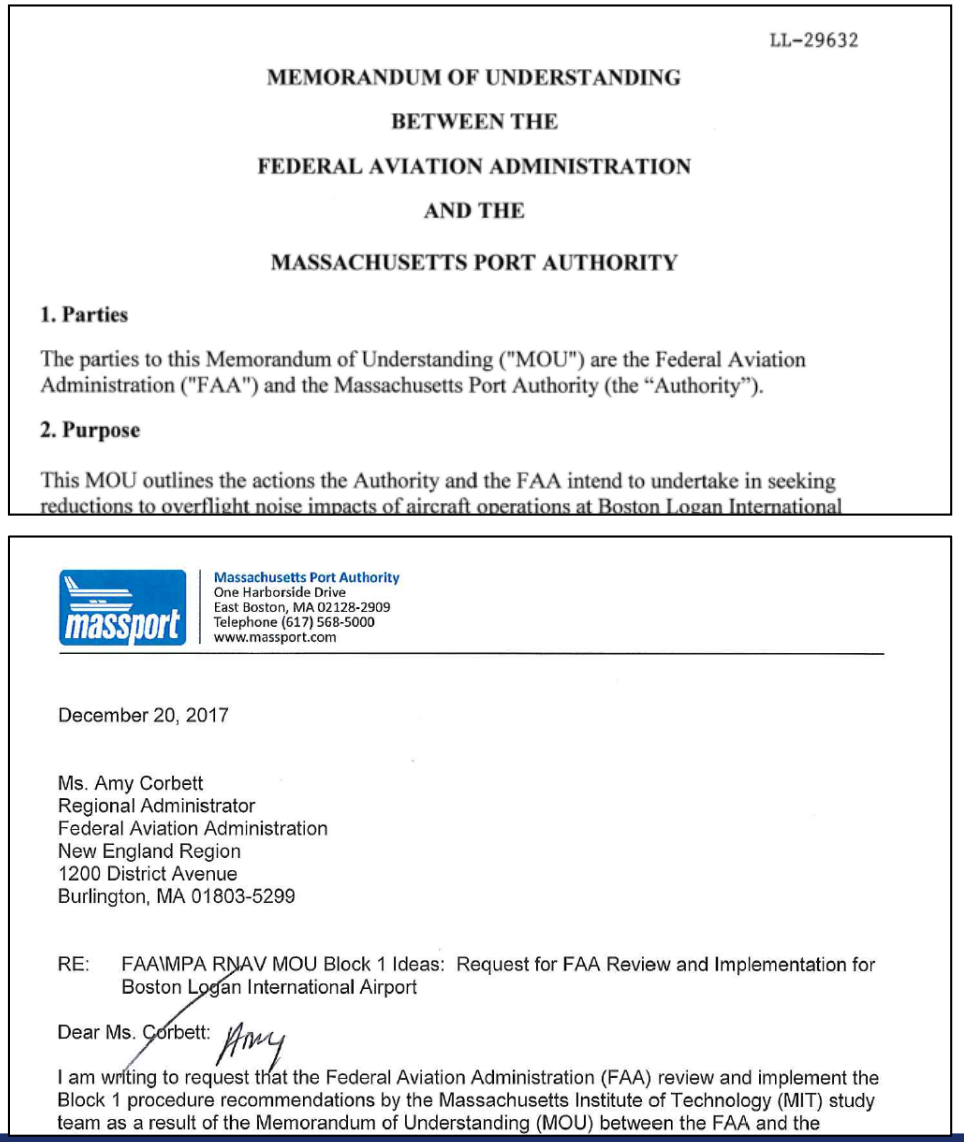

***Takeoff Profile***




***Approach Profile***

# Research Highlight: ASCENT-23 and Massport MOU

- MOU signed in September 2016 established framework for cooperation between Massport & FAA to explore operational changes to mitigate noise impacts
- MIT developed noise evaluation framework (through ASCENT-23) and is applying it (through Massport funding) to BOS to build and assess real procedures
- Massport submitted Block 1 proposal to FAA in December 2017
- FAA has begun evaluating Block 1 concepts



LL-29632

**MEMORANDUM OF UNDERSTANDING**

**BETWEEN THE**

**FEDERAL AVIATION ADMINISTRATION**

**AND THE**

**MASSACHUSETTS PORT AUTHORITY**

**1. Parties**

The parties to this Memorandum of Understanding ("MOU") are the Federal Aviation Administration ("FAA") and the Massachusetts Port Authority (the "Authority").

**2. Purpose**

This MOU outlines the actions the Authority and the FAA intend to undertake in seeking reductions to overflight noise impacts of aircraft operations at Boston Logan International

massport

Massachusetts Port Authority
One Harborside Drive
East Boston, MA 02128-2909
Telephone (617) 568-5000
www.massport.com

December 20, 2017

Ms. Amy Corbett
Regional Administrator
Federal Aviation Administration
New England Region
1200 District Avenue
Burlington, MA 01803-5299

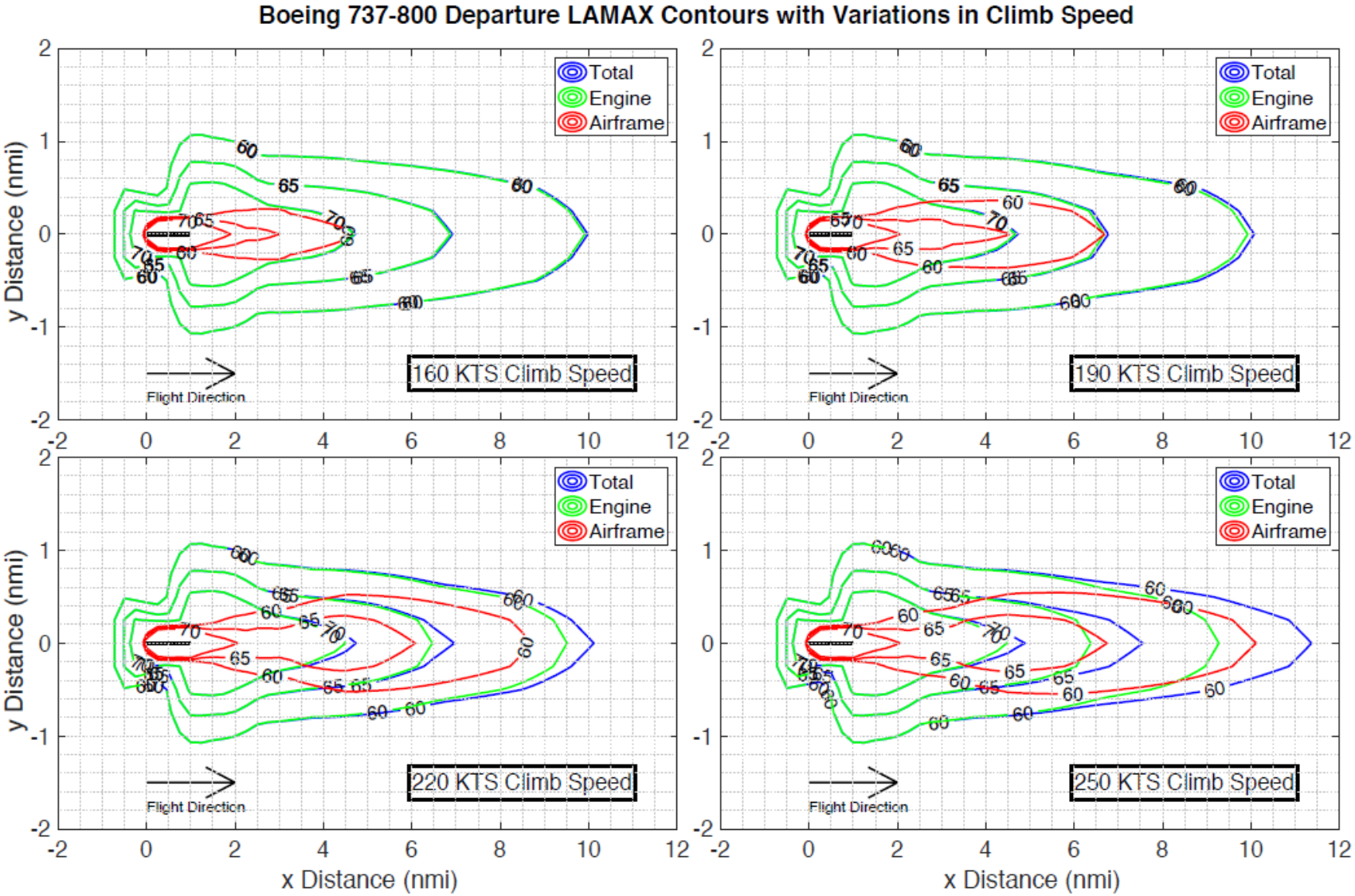
RE: FAA\MPA RNAV MOU Block 1 Ideas: Request for FAA Review and Implementation for Boston Logan International Airport

Dear Ms. Corbett:

I am writing to request that the Federal Aviation Administration (FAA) review and implement the Block 1 procedure recommendations by the Massachusetts Institute of Technology (MIT) study team as a result of the Memorandum of Understanding (MOU) between the FAA and the

# Impact of Climb Speed

## Using ANOPP to understand airframe/engine noise balance

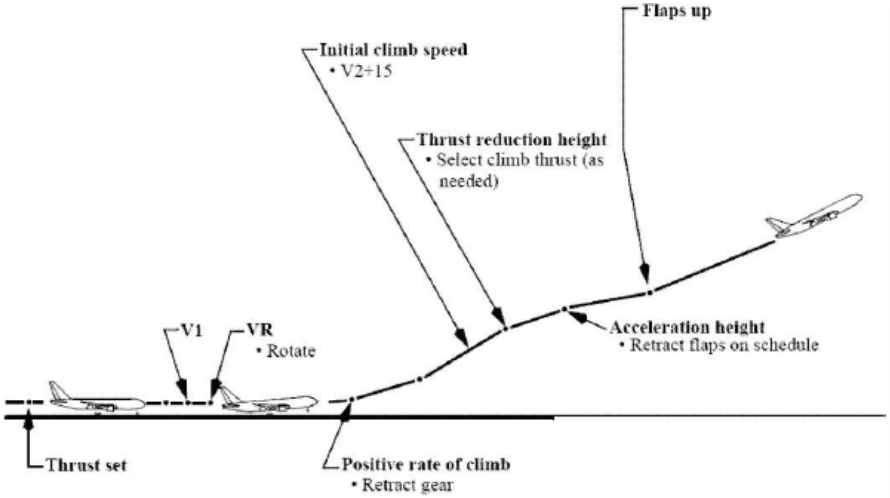



**Aerodynamic noise sensitive to "Wing Cleanliness" coefficient in ANOPP**

***Exploring clean airframe flight test or procedure validation opportunities***

# Example Concept – Reduced Speed Departure

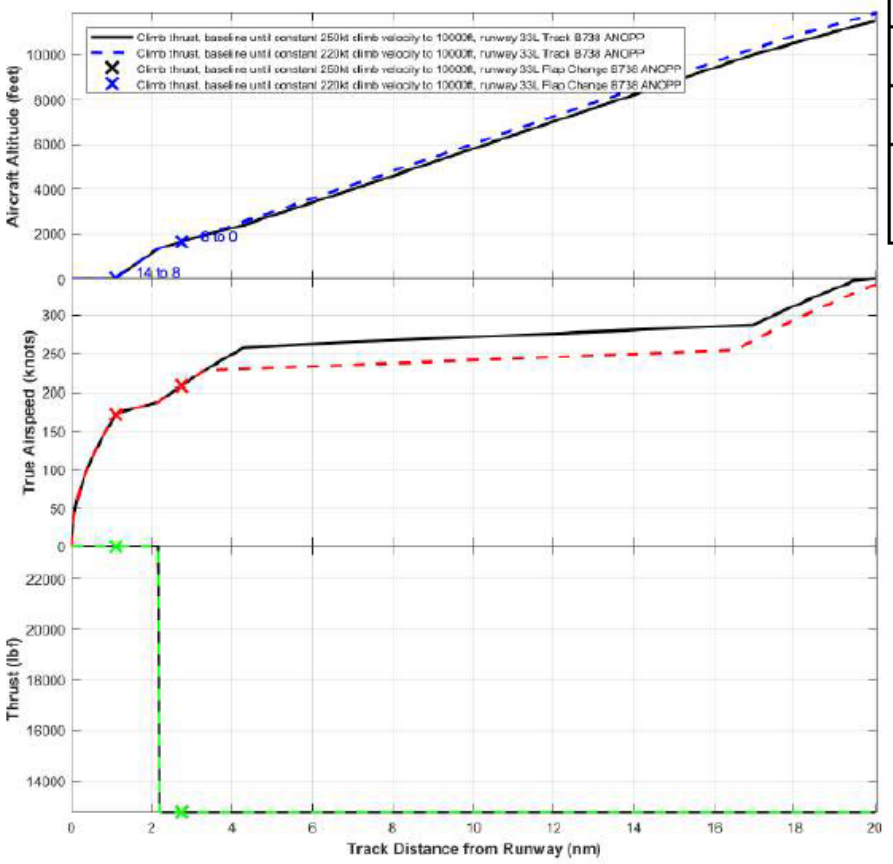
- Standard departure procedures vary by airline
- **Baseline**: Typical profile includes thrust reduction at 1,000' AGL followed by an **acceleration to 250 kt climb speed** and **flap retraction**
- **Recommended procedure:** Thrust reduction at 1,000' AGL followed by an **acceleration to 220 kt climb speed or minimum safe airspeed in clean configuration, whichever is greater** until a TBD altitude (i.e. 6,000' or 10,000')



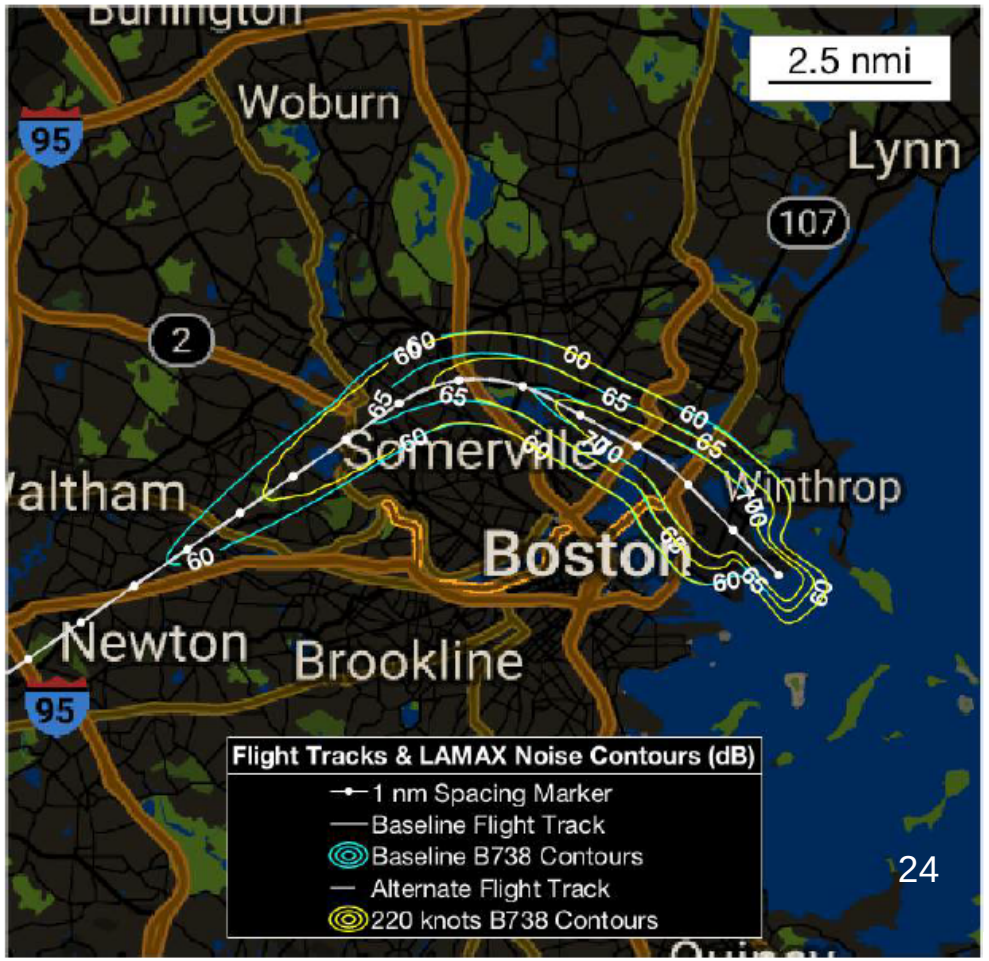


Simulator Tested for Flyability

# 737-800 Reduced Speed Climb: 220 knots




| | |
|---|---|
| **Aircraft** | B737-800 |
| **Metric** | $L_{A,MAX}$ |
| **Noise Model** | ANOPP |
| **Notes** | Runway 33L: Maintain Standard Climb Thrust & **220 KIAS to 10,000'** |

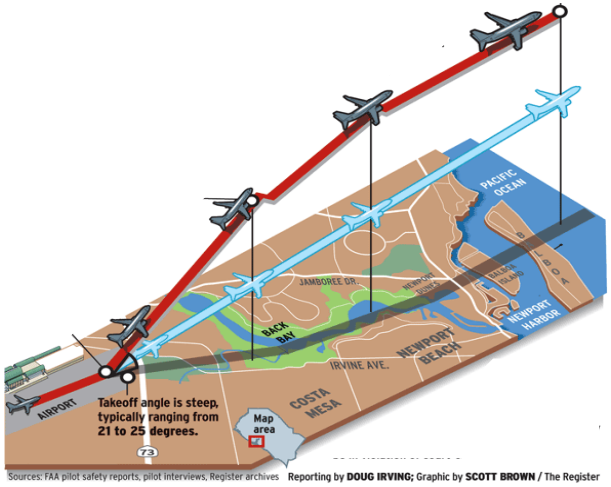



**Population Exposure**

| | 60dB | 65dB | 70dB |
|---|---|---|---|
| Standard Departure | 187,106 | 69,266 | 25,904 |
| Delayed Acceleration | 162,558 | 53,905 | 25,691 |
| Reduction | 24,548 | 15,361 | 213 |

# Closing Observations

- Environmental and energy constraints are significant
- Aviation noise causing considerable challenges today (not to mention new entrants)
- Aviation greenhouse gas emissions may prove the most significant long-term challenge to mobility
- Need a balanced approach to address aviation environmental impacts and energy concerns




**Chris Dorbian**

**Federal Aviation Administration**
**Office of Environment and Energy**

**Email: christopher.dorbian@faa.gov**

# Online Materials

## FAA Environment and Energy

- http://www.faa.gov/go/environment

## Center of Excellence (COE) Program

- University research on alt jet fuels and environment
- http://ascent.aero and http://partner.mit.edu/

## Continuous Lower Energy, Emissions and Noise (CLEEN)

- Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
- http://www.faa.gov/go/cleen

## Commercial Aviation Alternative Fuels Initiative (CAAFI)

- Coalition that focuses the efforts of commercial aviation to engage the emerging alternative fuels industry
- http://caafi.org