Aviation Environmental Challenges

- Aviation impacts community noise, air quality, water quality, energy usage, and climate change

- Environmental impacts from aviation could pose a critical constraint on capacity growth

- FAA are pursuing aircraft technology, alternative jet fuels, operations, and policy measures to address the environmental challenges facing aviation
Environmental Protection that Allows Sustained Aviation Growth

ENVIRONMENT AND ENERGY GOALS

**NOISE**
Reduce the number of people exposed to significant noise around U.S. airports

**AIR QUALITY**
Reduce significant air quality impacts attributable to aviation

**CLIMATE**
Achieve carbon neutral growth by 2020 relative to a 2005 baseline

**ENERGY**
Develop and deploy sustainable alternative aviation fuels
Research Programs

ASCENT Center of Excellence (COE)

- COE for Alternative Jet Fuel and Environment
- Cost share research with universities

Continuous Lower Energy, Emissions and Noise (CLEEN)

- Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
- Cost share partnership with industry

Additional Efforts

- Commercial Aviation Alternative Fuels Initiative (CAAFI)
- Contract mechanisms (e.g., SEMRS, PEARS, PEARS-II)
- Volpe Transportation Center
Addressing the Aircraft Noise Challenge

• **Understanding Impact of Noise**
  – Noise impacts: annoyance, sleep, cardiovascular health and children’s learning
  – Improving modeling capabilities
  – Evaluating current aircraft, helicopters, commercial supersonic aircraft, unmanned aerial systems, and commercial space vehicles

• **Outreach**
  – Increase public understanding
  – Community outreach

• **Mitigation**
  – Land use planning and related measures
  – Vehicle operations
  – Airframe and engine technology
  – Aircraft architecture
Addressing Aircraft Emissions

• **Understanding Impacts**
  – Particulate Matter (PM) measurements and modeling
  – Improving air quality and climate modeling capabilities
  – Evaluating current aircraft, commercial supersonic aircraft, unmanned aerial systems, and commercial space vehicles

• **Mitigation**
  – Vehicle operations
  – Alternative fuels
  – Airframe and engine technology
  – Aircraft architecture
  – Engine standard (CAEP PM standard)
  – Policy measures (CORSIA)
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

http://www.faa.gov
http://www.caafi.org
http://www.faa.gov/go/cleen
http://ascent.aero
# Improved Scientific Knowledge for Solution Development

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Key Research Questions</th>
<th>Research Programs</th>
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<tbody>
<tr>
<td>Noise</td>
<td>How do we define significance in regards to aircraft noise?</td>
<td>ASCENT COE</td>
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<tr>
<td></td>
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<td>Tech Center</td>
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<td>Volpe Center</td>
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<td></td>
<td>What are the public health and welfare impacts of aircraft noise?</td>
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<td></td>
<td>How do we certify “low-boom” supersonic aircraft?</td>
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<td>Air Quality</td>
<td>How do we define significance in regards to aircraft emissions that degrade air quality?</td>
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<td>Energy</td>
<td>How do we characterize annual variations in system-wide fuel efficiency?</td>
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<td>CLEEN Program</td>
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<td></td>
<td>How do we define sustainability of alternative jet fuels?</td>
<td>Volpe Center</td>
</tr>
<tr>
<td>Climate</td>
<td>What is the incremental impact of non-CO2 aircraft emissions on global and regional climate?</td>
<td>ASCENT COE</td>
</tr>
</tbody>
</table>
Aviation Environmental Tool Suite

Modeling range of solutions and their consequences on fuel use, noise and emissions (basket of measures for CO₂ and balanced approach for noise)
Continuous Lower Energy, Emissions & Noise (CLEEN)

- FAA led public-private partnership with 50-50 cost share from industry
- Reducing fuel burn, emissions and noise via aircraft and engine technologies and alternative jet fuels
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies

<table>
<thead>
<tr>
<th></th>
<th>CLEEN I</th>
<th>CLEEN II</th>
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</thead>
<tbody>
<tr>
<td>Time Frame</td>
<td>2010-2015</td>
<td>2016-2020</td>
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<tr>
<td>FAA Budget</td>
<td>~$125M</td>
<td>~$100M</td>
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<tr>
<td>Noise Reduction</td>
<td>32 dB cumulative noise reduction</td>
<td>32 dB cumulative noise reduction</td>
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<tr>
<td>NO\textsubscript{X} Emissions Reduction Goal</td>
<td>60% landing/take-off NO\textsubscript{X} emissions</td>
<td>75% landing/take-off NO\textsubscript{X} emissions</td>
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<tr>
<td>Fuel Burn Goal</td>
<td>33% reduction</td>
<td>40% reduction</td>
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<tr>
<td>Entry into Service</td>
<td>2018</td>
<td>2026</td>
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CLEEN Program Fact Sheets:
P3: Alternative Fuels

FAA Activities

• Testing
  ▪ Support Certification/Qualification testing
  ▪ Improve Certification/Qualification process
  ▪ Emissions measurements

• Analysis
  ▪ Environmental sustainability
  ▪ Techno-economic analysis
  ▪ Future scenarios

• Coordination
  ▪ Interagency
  ▪ Public-Private
  ▪ State & Regional
  ▪ International
Coordination: CAAFI Priorities for 2017

• Communicate Value Proposition of Sustainable Alternative Jet Fuels (SAJF)
  – Communicate economic, social, and environmental benefits of SAJF
  – Broaden base of stakeholders who can continue to enable active investment in the development, demonstration, deployment, and commercialization of SAJF

• Enhance Fuel Qualification Approach
  – Work with stakeholders to define and enable a broadly-supported, streamlined certification/qualification program
  – Foster development of a more durable, higher capacity process to handle the significant queue of potential SAJF candidates

• Implement Frameworks & Share Best Practices
  – Develop tools to evaluate readiness of feedstocks and fuels and their potential economic, social and environmental benefits to identify prime targets of opportunity for early commercialization
  – Expand best practices development and sharing across SAJF supply chain (including at airports) and with partners worldwide

• Develop U.S. SAJF Supply by Aligning Efforts to Enable Commercial Deployment
  – Leverage Farm to Fly 2.0 and ASCENT to focus on real-world implementation
  – Foster producer-buyer engagement that leads to offtake agreements
  – Pursue initiatives to enable supply chain development and facilitate commercialization of SAJF
  – Build upon Federal Alternative Jet Fuels R&D Strategy
Program Goals:
• Identify and accelerate implementation of air traffic management concepts that will reduce aviation environmental impacts and/or improve energy efficiency
• Investigate energy and environmental effects of operational changes
• Transition research for implementation

Key Program Elements:
• Target all phases of flight and all environmental aspects
• Identify new opportunities to reduce community noise
• Coordinate/collaborate with ATO, ARP, ANG, NASA, etc.

Considerable efforts also ongoing to reduce helicopter noise
Opportunities for noise reduction:
- Precision navigation determines *where* aircraft fly
- Airlines determine *when* the aircraft fly
- There might be opportunities to change *how* aircraft are flown to reduce noise

Concepts being evaluated:¹
- **Route changes**
- **Thrust / speed management**
  - Noise abatement departure 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
  - Want to keep aircraft higher for longer periods and reduce level offs
- **Introduce systematic dispersion**

¹ Concepts are being evaluated by the MIT Team as a part of the Massport-FAA MOU (see Project 23 website), MITRE, and other efforts within FAA.
For more information on ASCENT Project 23: https://ascent.aero/project/analytical-approach-for-quantifying-noise-from-advanced-operational-procedures/
Science and Analysis to Support Decision-Making

- Aviation environmental policies impact noise, climate and air quality. Using the aviation environmental tool suite to assess the impacts of noise and emissions for policy assessment.

- Tool suite informing decision making:
  - CAEP/11 PM Std (2019)
  - CAEP/10 CO\textsubscript{2} Std (2016)
  - CAEP/9 Noise Std (2013)
  - CAEP/8 NO\textsubscript{x} Std (2010)

- FAA uses cost/benefit analysis elements to supplement cost-effectiveness analysis in CAEP

- Tool suite provided analytical support to CORSIA development

- Developing capabilities to support NextGen business case evaluation

Additional information on APMT-Impacts and its use is available at: http://partner.mit.edu/projects/valuation-and-trade-offs-policy-options
Not shown on graph:
- Airports Cooperative Research Program (ACRP) provides ~$5M/year for environment projects

Million Dollars

- NextGen - Environment Portfolio (F&E 1A08 Funds)
- Airport Technology Research - Environment & Noise
- NextGen - Environmental Research - Aircraft Technologies and Fuels (RE&D A13.b Funds)
- Environment & Energy (RE&D A13.a Funds)
FY17 Environment and Energy Funding Breakout

Breakout of FY17 RE&D A13.a and A13.b Budget Line Items

- Contractors: 8%
- Reserve: 3%
- Volpe Center: 9%
- ASCENT COE: 28%
- CLEEN II: 52%
ASCENT COE Update – External Reporting

Annual Tech Report available from: https://ascent.aero/resources/

<table>
<thead>
<tr>
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<td>Industry partners</td>
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Need universities to work closely with FAA and others to update all project websites on ascent.aero
### ASCENT COE Update – Funding Summary

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<th>University</th>
<th>Funding</th>
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<td>Georgia Institute of Technology</td>
<td>$ 6,200,000</td>
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<td>Massachusetts Institute of Technology</td>
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<td>Missouri Univ. of Science and Technology</td>
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<td>Pennsylvania State Univ. (Penn State)</td>
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<td>University of Dayton</td>
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<td>Washington State University</td>
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<td>University of Hawaii</td>
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<td>University of Washington</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$ 38,400,000</strong></td>
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*Note: totals as of August 2017*

Funding levels provided to ASCENT universities since September 2013 (does not include cost share generated by universities)

Geographical Distribution of ASCENT Funding
Recent Successes

capabilities and solutions that are helping today

- Noise impacts work is starting to deliver results. Community noise survey is complete. Published report on pilot phase of aircraft noise sleep impacts study.
- Provided critical analytical support to development of Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).
- Measurement technique and data providing foundation for ICAO CAEP PM standard.
- Integrated tool suite and analyses provided the scientific data used to support the decision making for the ICAO CAEP CO₂ standard.
- Alternative fuels scenarios adopted by ICAO CAEP for future trends assessment and research efforts instrumental for alternative fuel inclusion within CORSIA.
- CLEEN aircraft and engine technologies appearing in next generation of aircraft with FMS technologies retrofitted into today’s fleet - reduces noise, emissions and fuel use for many years to come.
- Certification of five alternative jet fuel pathways – certification enabled United Airlines to buy and use biofuel at LAX as well as purchases by Gulfstream.
- Aviation Environmental Design Tool (AEDT) being used extensively.
- Analytical framework being used to develop operational procedure concepts that could provide noise reduction.