Presentation Outline

• Office of Environment and Energy – Background & E&E Overview
• Highlights of R&D Program
• Direction of the E&E Portfolio
  – Noise and Emissions
  – Overview of Climate Change Efforts
  – Sustainable Flight National Partnership
  – SAF Grand Challenge
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Office of Environment and Energy (AEE)
- Office within APL, responsible for broad range of environmental policies
- Roughly 45 staff members
- Responsible for roughly one-fourth of FAA RE&D Budget
AEE Organizational Structure

Executive Director
Kevin Welsh
AEE-1

Deputy Director
Julie Marks
AEE-2

Chief Scientific and Technical Advisor for Environment and Energy
Jim Hileman (AEE-3)

Special Assistant to the Chief Scientific and Technical Advisor
Fabio Grandi

Senior International Advisor
Dan Williams
AEE-5

Senior Policy Advisor
Eric Elmore
AEE-6

AEE-100 Noise Division
Don Šcata Manager

AEE-200 Technology & Operations Division
Levent Ileri Manager

AEE-300 Emissions Division
Ralph Iovinelli Manager

AEE-400 Environmental Policy Division
Katherine Andrus Manager

1 ASCENT Program Manager, as a subset of his Chief Scientist duties
2 CLEEN Program Manager, as a subset of his Division Manager duties
Environmental & Energy (E&E) Strategy

E&E Mission: To understand, manage, and reduce the environmental impacts of global aviation through research, technological innovation, policy, and outreach to benefit the public.

E&E Vision: Remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation.

E&E R&D Portfolio Activities & Programs

**ADVANCE UNDERSTANDING OF NOISE, EMISSIONS, AND THEIR IMPACTS**

- Vehicle operation
- Pollutant measurement
- Atmospheric propagation
- Societal impacts
- Aviation Environmental Tools Suite and Communication Tools
- Today’s Fleet of Aircraft and Helicopters
- Drones and Advanced Air Mobility Vehicles
- Commercial Supersonic Aircraft
- Commercial Space Vehicles

**ANALYSIS TO INFORM DECISION MAKING**

- Domestic Policies
- Aircraft and Engine Standards
- CORSIA
- Long Term Climate Goal Development

**DEVELOP INNOVATIVE SOLUTIONS TO REDUCE NOISE AND EMISSIONS**

- Aircraft and Engine Technology
- Sustainable Aviation Fuels
- Optimized Operations and Procedures

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Federal Aviation Administration
Environmental & Energy R&D Portfolio

RE&D Environment & Energy BLI*
• Advance understanding of noise and emissions
• Analysis to inform decision making

RE&D NextGen – Environmental Research – Aircraft Technology and Fuels BLI**
• Accelerate development of aircraft and engine technologies
• Testing, analysis and coordination on Sustainable Aviation Fuels (SAF)

RE&D Aviation Climate Research BLI***
• New budget line item for FY22
• Enhances efforts on SAF, technology development, and efforts related to unleaded aviation gasoline (led by AVS/ANG)

*Budget Line Items: A13.a (FY18 & FY19), A12.a (FY20), A.T (FY21), A11.u (FY22)
** Budget Line Items: A13.b (FY18 & FY19), A12.b (FY20), A.U (FY21), A11.v (FY22)
*** Budget Line Item: A11.z (FY22)
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Highlights of Ongoing R&D Efforts (E&E Portfolio)

- Research efforts continue to inform decision making
- Broad ASCENT research portfolio from impacts to innovation
- Technology maturation in CLEEN continues and we have made most of the awards for 3rd Phase of CLEEN
- Sustainable aviation fuels: CORSIA, CAAFI, and ASTM
- Exploring how to use operational procedures to help address noise concerns and climate impacts of aviation
- Released AEDT3d - executing long term vision for AEDT
- Rotorcraft noise research efforts continue: helicopters, drones and advanced air mobility
- Continuing wide-ranging portfolio on supersonic aircraft
- Supporting other parts of FAA and EPA in addressing lead emissions
- Considerable inter-agency collaboration to address CO₂ emissions
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Environmental Impacts of Aviation

**Combustion Emissions**
- CO₂: 71%
- Water: 28%
- CO, HC, NOₓ, SOₓ, Primary PM₂.₅: <1%

**Aircraft Noise**

**Atmospheric Chemistry & Physics**
- Primary PM₂.₅
- Secondary PM₂.₅
- Ozone
- CO₂, CH₄, N₂O, CO, HC, NOₓ, SOₓ, UHC

**Global Climate Change**
- Cooling Effects
- Warming Effects

**Emissions from Fuel Production**
- CH₄, N₂O, CO₂

**Population Exposure and Health Impacts**

**Sustainability Impacts**

Slide created in collaboration with NASA ARMD
Global Competition and Environmental Pressures

- Airline industry hard hit by COVID-19
- Global competition growing
- Limited industry funding for R&D investments
- Societal pressure growing on climate globally

Technological innovation essential to enable sustainable growth & maintain U.S. global leadership
Noise R&D Update

Federal Register Notice

Provides comprehensive overview of FAA R&D efforts on noise
- Effects of Aircraft Noise on Individuals and Communities
- Noise Modeling, Noise Metrics and Environmental Data Visualization
- Reduction, Abatement and Mitigation of Aviation Noise

Includes neighborhood environmental survey results with a link to the full study
Received 4,162 comments
https://www.regulations.gov/docket/FAA-2021-0037

Expanded the aviation noise website to include details on the noise survey
https://www.faa.gov/regulations_policies/policy_guidance/noise/survey/

Have had extensive outreach on FRN including a public webinar on February 22, 2021.
Webinar link https://www.youtube.com/watch?v=Mku13gL0xGc
Helicopters, New Entrants and Commercial Space

Helicopters
• Continuing efforts to use noise measurements and modeling to improve our analytical capabilities and develop measures to reduce noise from operations

Unmanned Aerial Systems
• Conducting noise measurements and developing analytical capabilities to enable improved noise predictions for potential use in AEDT

Advanced Air Mobility Vehicles
• Conducting noise measurements and developing analytical tools to aid in designing quieter vehicles
• Looking to stand up research to enable improved noise predictions for AEDT

Supersonic Civil Aircraft
• Continuing research efforts on multiple fronts through ASCENT, CLEEN and Volpe to support standard setting in ICAO, understand environmental impacts, and to aid in the development of lower noise / emissions vehicles

Hypersonic Civil Aircraft / Commercial Space
• Monitoring environmental efforts in this area – depending on appropriations levels, will stand up research effort to examine climate/ozone impacts
Efforts Relating to Aircraft Emissions

Understanding Emissions
• Conducting Particulate Matter (PM) measurements
• Improving atmospheric modeling capabilities for regulatory tools
• Assessing impacts on air quality, climate change, and ozone layer
• Evaluating current aircraft, commercial supersonic aircraft, unmanned aerial systems, advanced air mobility, and commercial space vehicles

Reducing Emissions at the Source
• Aircraft technologies and architecture
• Modifications to fuel composition
• Vehicle operations
• Engine standard ($\text{NO}_x$, $\text{CO}_2$, and PM standards)
• Future trends analysis
• **Working across agency to address lead emissions**

Mitigation
• Alternative fuel sources
• Policy measures (CORSIA)

For more information:
ASCENT: www.ascent.aero/
CAAFI: www.caafi.org/
CLEEN: www.faa.gov/go/cleen/
Volpe: www.volpe.dot.gov/
Efforts to Support Decision-Making

- Using research portfolio to ensure we have a robust assessment of a wide range of economic and environmental impacts that could result from aviation noise, emissions, and energy policy.

- R&D program informing decision making:
  
  - Long-term aspirational CO₂ goal (ongoing)
  - Supersonic Aircraft Noise (ongoing)
  - Fuel Composition (ongoing)
  - ICAO CAEP/11 PM Standard (2019)
  - CORSIA (2019)
  - ICAO CAEP/10 CO₂ Standard (2016)
  - ICAO CAEP/9 Noise Standard (2013)
  - ICAO CAEP/8 NOx Standard (2010)

- Volpe Center and ASCENT Center of Excellence universities working directly with FAA to develop data and tools to inform decision making.
Efforts Relating to Analytical Tool Development

Aviation Environmental Design Tool (AEDT)

- Computes noise, fuel burn and emissions simultaneously
- Can analyze airport, regional, national, and global scales
- Required for all regulatory actions
- Also in use by 473 international users from 43 countries (as of Sept 2020)

AEDT Development Plan

- Have annual release cycle to continuously improve tool and ensure latest information is in use by aviation community
- Laying ground work for major upgrade in 2023 to improve noise modeling
- Developing noise screening tool to support NEPA process

For more information on AEDT or to download it, please visit: https://aedt.faa.gov/
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Biden Administration Commitment on Climate Change

- **Day One:** Took action to re-join the Paris Agreement
- **Executive Order 14008 on Tackling the Climate Crisis**
  - “put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050”
- **Leaders Summit on Climate – April 23, 2021:**
  - “Reducing emissions from international aviation. The United States is committed to working with other countries on a vision toward reducing the aviation sector’s emissions in a manner consistent with the goal of net-zero emissions for our economy by 2050, as well as on robust standards that integrate climate protection and safety. The United States intends to advance the development and deployment of high integrity sustainable aviation fuels and other clean technologies that meet rigorous international standards, building on existing partnerships, such as through ASCENT—the Aviation Sustainability Center—and pursue policies to increase the supply and demand of sustainable aviation fuels. In the International Civil Aviation Organization, we will engage in processes to advance a new long-term aspirational goal in line with our vision for reducing greenhouse gas emissions in the aviation sector, and continue to participate in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).”

Fact sheet from President Biden’s Leaders Summit on Climate:
https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/23/fact-sheet-president-bidens-leaders-summit-on-climate/
On September 9, 2021, government and industry leaders discussed actions being taken by the government and industry to federal actions and industry to “produce three billion gallons of sustainable fuel, reduce aviation emissions by 20% by 2030, and grow good-paying, union jobs.”

Speakers included the White House National Climate Advisor; Secretaries of Agriculture, Transportation, and Energy; NASA Administrator; Secretary of the USAF; Senator Brown; Representatives Schneider and Brownley; and CEOs for several trade associations and companies; among others.

Actions that are being undertaken are captured in a White House Fact Sheet

White House Sustainable Aviation Fact Sheet:
Key federal actions include:

- A new Sustainable Aviation Fuel Grand Challenge to inspire the dramatic increase in the production of sustainable aviation fuels to at least 3 billion gallons per year by 2030;
- New and ongoing funding opportunities to support sustainable aviation fuel projects and fuel producers totaling up to $4.3 billion;
- An increase in R&D activities to demonstrate new technologies that can achieve at least a 30% improvement in aircraft fuel efficiency;
- Efforts to improve air traffic and airport efficiency to reduce fuel use, eliminate lead exposure, and ensure cleaner air in and around airports; and
- The demonstration of U.S. leadership both internationally and through the federal example.

Fact Sheet announces third phase of CLEEN and efforts in ASCENT on SAF and contrail avoidance as well as efforts related to ICAO and leaded aviation gasoline fuels.

White House Sustainable Aviation Fact Sheet:
Climate Change - Direction of the R&D Portfolio

Background on Aviation and Climate Change

- Aviation has two primary contributors to climate change: CO₂ emissions and aviation-induced cloudiness
- Taking a holistic approach to de-carbonizing aviation (SAF, technology, operations, policy) and ensure international leadership from the U.S. on aviation climate issues

Climate Research Portfolio Direction

- Technology Development: required for to address climate crisis and noise challenge
- Sustainable Aviation Fuels: most promising near to medium-term means to reduce aviation CO₂ emissions, critical to decarbonization in the long term
- Operational Procedures: seeking opportunities to reduce fuel use and laying ground work to develop decision support tools to address aviation induced cloudiness
- International leadership: R&D program provides the scientific data and analyses that are required for the U.S. to lead direction of international aviation climate negotiations
- Advancing Understanding: conducting research to better understand the impacts of non-CO₂ combustion emissions from all flight vehicles
- Analytical Tools: providing the models that are used across the globe to quantify aviation fuel burn and emissions
- Emerging Technologies and Energy Sources: need to give appropriate consideration to emerging technologies and concepts, but avoid looking for a “silver bullet”
Domestic Fuel Efficiency

National Airspace System (NAS) is operating much more efficiently today than 30 years ago — moving more passengers on the same amount of energy.

Today’s fleet of aircraft has an average fuel efficiency of 57.5 passenger-miles per gallon of fuel; for comparison, a modern Toyota Prius hybrid, which has a fuel economy of 54 miles per gallon (MPG).

Notes: * Gasoline-Gallon Equivalents (GGE) are used to compare gasoline, diesel, and electricity on a level basis. Alterations to the source data were made to account for the inefficiencies of electricity production. This impacts rail the most because it has the highest level of electric power.

** Domestic flights only. All fuel use is attributed to passengers, none to cargo that might be using the same airplane.

*** Includes passenger cars, vans, and small buses operating in response to calls from passengers to the transit operator who dispatches the vehicle.
Domestic Aviation Emissions

2019 U.S. Domestic Aviation CO₂ Emissions

Total: 162 MT CO₂

- Airport Scope 1 Emissions (from airport-owned or controlled sources) - 0.6 MT CO2
- Airport Scope 2 Emissions (due to use of purchased energy) - 3.1 MT CO2
- Domestic Jet Fuel Emissions (commercial flights within U.S.) - 140 MT CO2
- Domestic Jet Fuel Emissions (GA flights within U.S.) - 17 MT CO2
- Domestic Aviation Gasoline Emissions (flights within U.S.) - 1.8 MT CO2

Notes:
- Airport scope 1 and 2 emissions from ACI 2021 Long-Term Carbon Goal Study for Airports (Fig 23)
- Jet fuel and aviation gasoline emissions based on FAA Aerospace Forecast (2020-2040) [Table 23]
- Detailed analysis of commercial aviation jet fuel emissions based on AEDT analysis
- International jet fuel emissions includes U.S., international, and foreign airspace
Actions to Reduce U.S. Aviation CO₂ Emissions

Working to accelerate industry action to lower CO₂ emissions trajectory

Means to reduce aviation CO₂:

- Replace existing aircraft with more fuel efficient models
- Develop new more fuel efficient aircraft and engine technologies
- Modernize air space and implement new procedures
- Develop and deploy sustainable aviation fuels (SAF)
- Utilize offsets from other sectors

NOTE: Graphic developed by Philippe Bonnefoy of Blue Sky based on ongoing analysis efforts supported by the FAA Office of Environment & Energy (AEE).
ICAO CAEP Long Term Aspirational Goal (LTAG) Support

• FAA providing staffing and researchers to support CAEP exploration of feasibility of a long term aspirational goal for CO$_2$ emissions from international aviation

• Engaging directly across all aspects of this work (tech, fuels, operations, scenarios) to support assessment of current, foreseen, innovative measures to contribute to CO$_2$ reduction under various future scenarios

• Leveraging multiple efforts to provide analysis support
  – ASCENT Projects 1 & 52 providing fuel analysis
  – ASCENT Project 64 providing technology
  – Considerable support from other USG agencies, Volpe and Blue Sky
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Rationale for Investing in Aircraft Technology

- Historically, advances in aircraft technology have been the main factor in reducing aviation’s environmental impact
- Manufacturers have limited financial incentive to develop technologies to reduce noise and emissions
- Continued improvements come with large technological risk
- COVID-19 pandemic has hit the aerospace sector particularly hard and the industry has considerably reduced ability to undertake research to advance new technologies
- Government resources help mitigate technological risk and incentivize aviation manufacturers to invest in and develop cleaner, quieter technology
Finding Opportunity in These Challenging Times

Accelerate technology maturation to enable a step change improvement in environmental performance

- R&D since FY10 (NASA, FAA); ~ $2,300M (NASA); $262M (FAA)
- Target 25 to 30% lower GHG re: Best in Class (e.g., A320neo / B737Max)
- Technologies need to be scalable from Single to Twin aisle aircraft
- GHG reductions need to be achieved WITH commensurate reductions in noise and emissions impacting air quality
- NASA / FAA Partnership for Flight Demo key for tech maturation

“Clean sheet” *Single Aisle* Aircraft focus for Flight Demo

- 55% of Global Market Value ($)
- 40% of CO2 emissions from Global commercial operators
- 61% of US population exposure to significant noise (65 DNL) during CY 2019

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**Global Market Value**

2020-2039 $6.8T

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**Estimated CO₂ Emissions from Global Commercial Operators**

(2018)

- Regional: 9%
- Single Aisle: 46%
- Widebody: 40%
- Freighter: 5%

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**Population Exposed to Significant Noise**

65 DNL, U.S. CY 2019

- 11% of Regional
- 10% of Single Aisle
- 18% of Widebody
- 61% of Freighter

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*boeing.com/commercial/market/commercial-market-outlook/

**Volpe Preliminary Data - used with permission
final data to be published in Chapter 1 of 2022 ICAO Environmental Report

*** F. Grande, AEDT3c, CY 2019 U.S. inventory, 18March2021
Opportunity: Clean Sheet Single Aisle in Early 2030’s

• Market opportunity for next major airplane to be a *Step Change Improvement*, rather than evolutionary.
• Leverage over a decade of closely aligned NASA/FAA/Industry research and development to mature technologies.
• Opportunity to target the dominant aircraft class by number of aircraft, operations, CO$_2$ emissions, and noise.

Success will reduce environmental impacts for decades to come
Complementary NASA & FAA Technology Maturation

- NASA and FAA have pursued a consistent and complementary strategy for over a decade of research, concept and technology development, and Government-Industry Partnership.
- NASA and FAA work feeds focused Technology Maturation of key technologies using Sustainable Flight National Partnership (SFNP). SFNP includes several Flight, Static and Mfg TRL6 Demonstrations.
- In parallel, FAA CLEEN Programs continue to provide near term wins for environmental technology implementation in industry.
Critical to establish the new “S Curve” for the next 50 years of transports
Demonstrate a ‘step change reduction’ in GHG emissions relative to best in class aircraft

- Transonic Truss-Braced Wing
  - 5-10% fuel burn benefit

- Small Core Gas Turbine
  - 5-10% fuel burn benefit

- Electrified Aircraft Propulsion
  - ~5% fuel burn and maintenance benefit

- High-Rate Composite Manufacturing
  - 4x-6x manufacturing rate increase
Press Release and Website
www.faa.gov/go/CLEEN

Press release on Phase 3 was released on Sept 10, 2021

Comprehensive report on CLEEN Program accomplishments has been uploaded as an FAA Fact Sheet

Website: https://www.faa.gov/newsroom/continuous-lower-energy-emissions-and-noise-cleen-program?newsId=22534

Materials should aid communications about the CLEEN Program

Website: https://www.faa.gov/newsroom/continuous-lower-energy-emissions-and-noise-cleen-program?newsId=22534
CLEEN Phase III Technologies

**Engine Core**
- GE: Compact Core – Low Emissions Combustor
- GE: Advanced Thermal Management
- GE: Hybrid Electric Integrated Generation
- Honeywell: Efficient Green High Pressure Core
- Honeywell: Compact High Work High Lift Low Pressure Turbine (LPT)
- Pratt & Whitney: TALON X+ Combustor

**Airframe**
- Boeing: Quiet Landing Gear
- Boeing: Quiet High-Lift System

**Aircraft Systems**
- GE: MESTANG III
- Boeing: Intelligent Operations

**Sustainable Aviation Fuels**
- Boeing: Higher Blend SAF Qualification
- GE: Higher Blend SAF Qualification

**Nacelle, Fan, and Bypass**
- America’s Phenix: Erosion-Resistant Fan Blade Coating
- Boeing: Advanced Nacelle Next Generation Inlet
- Collins: Large Cell Exhaust Acoustic Technology
- GE: Open Fan
- GE: Advanced Acoustics
- Honeywell: Highly Efficient Fan Module
- Pratt & Whitney: Ultra-Quiet Reduced-Loss Fan Stage

**Fuel**
**Emissions**
**Noise**
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The SAF Grand Challenge
U.S. government-wide effort to reduce the cost, enhance the sustainability, and expand the production and use of Sustainable Aviation Fuel (SAF) to meet 100% of aviation fuel demand by 2050

- Establishes SAF as a key priority in a broader set of actions by the U.S. Government and the private sector to reduce the aviation sector’s emissions in a manner consistent with the goal of net-zero emissions

- Sets an ambitious vision and affirm to industry that the USG is committed to SAF research, development, and deployment

- Announcement and signing with White House and agency Secretaries on September 9, 2021

- Memorandum Of Understanding (MOU) among DOE, DOT and USDA to jointly lead the initiative and commit resources to research, development, and deployment
SAF Grand Challenge Goals Relative to Projected Demand

Volume of Jet Fuel (in billion gallons)

Geographic Scope: Legend:

- International outside the US* (US Operators)
- International Arrivals (US Operators)
- International Departures (US Operators)
- International Departures (Foreign Operators)†
- Domestic Passenger
- Domestic Cargo
- Domestic General Aviation

Jet Fuel Uplift within the United States

Data Sources and Assumptions:

2019: BTS T-2 (International operations reported by US carriers)

2019: EPA GHG Inventory, international departures by foreign operators scaled based on 2019 traffic mix (FAA Data)
2030-2050: FAA Modeling based on EPA GHG Inventory (Domestic) scope. CO₂ emissions based on FAA Aerospace traffic Forecast, after technology and operations improvements.


* Flights between two different ICAO Member States (other than the United States) e.g., Germany -> UAE, UK -> China.
† Not in scope of Climate Action Plan, shown to facilitate comparisons for SAF Grand Challenge.
## SAF Grand Challenge Roles (in MOU)

### DOE
- Continue investments and develop expertise in sustainable technologies to develop cost effective low carbon liquid fuels and enabling coproducts from renewable biomass and waste feedstocks.
- Continue a significant multi-year SAF scale-up strategy committed to in FY21.
- Conduct R&D aimed at creating new pathways toward higher specificity of SAF Production.

### DOT/FAA
- Develop overall strategy to decarbonize aviation
- Coordinate ongoing SAF testing and analysis
- Work with standards organizations to ensure safety and sustainability of SAF
- Continue International technical leadership
- Promote end use of SAF
- Support infrastructure and transportation systems that connect SAF feedstock producers, SAF refiners, and aviation end users.

### USDA
- Continue investments and build expertise in sustainable biomass production systems
- Decarbonize supply chains
- Invest in bio-manufacturing capability
- Workforce development
- Community and individual education
- Extension/outreach/technology transfer
- Commercialization support

Next Step: Develop SAF Grand Challenge Roadmap (details in Fuels Briefing)
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FY22 Funding

• Operating under budget uncertainty

• Expect to use any funding increases to:
  – Expand efforts on aircraft technology maturation in CLEEN and ASCENT
  – Develop SAF that could be used in jet engines without blending with conventional petroleum-based jet fuel
  – Evaluate aviation fuel supply chains to reduce the cost to produce SAF and maximize environmental benefits
  – Obtain the data and develop the analytical tools to support evaluation and certification of new vehicle types
Recent Successes - Capabilities and Solutions Helping Today

Informing Decision Making to Support U.S. Leadership on International Aviation Climate Issues

- Research team at forefront of informing the development of a *long term aspirational goal for international aviation CO₂ emissions* within International Civil Aviation Organization (ICAO).
- Provided critical support to development of *Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*.
- Analytical tools and data provided foundation for ICAO CAEP *Aircraft CO₂ Standard* being promulgated domestically.
- Measurement technique and data provided foundation for new ICAO CAEP *non-volatile particular matter engine standard* that will replace the existing smoke number standard in 2023.

Supporting the Development of Sustainable Aviation Fuels (SAF)

- *Certification of seven alternative jet fuel pathways and two co-processing pathways* enabling multiple airlines to use SAF in LAX, SFO, and elsewhere. Efforts have also *significantly reduced fuel volumes required for new approvals*.
- Research efforts were critical for the *inclusion of sustainable aviation fuels within CORSIA*.

Accelerating Technological Innovation and the Development of Improved Operational Procedures

- *CLEEN aircraft and engine technologies appearing in new aircraft* with some technologies retrofitted into today’s fleet. These technologies and knowledge gained by industry will reduce noise, emissions, and fuel use for decades to come.
- Research efforts are supporting the *introduction of unmanned aircraft systems, advanced air mobility vehicles, and supersonic aircraft* into the air space.
- Developing operational procedure concepts and communication tools at Boston Logan that could *help address noise concerns nationwide*.

Advancing Our Understanding of Noise, Emissions, and their Impacts

- Released *Federal Register Notice on noise research portfolio* with comprehensive community noise annoyance survey quantifying community perceptions on noise. Work is ongoing to understand *impacts of noise on sleep and health*.
- Researchers are advancing our understanding of the impacts of aviation emissions on human health and welfare via *air quality, global climate change, and changes to the ozone layer*.
- Aviation Environmental Design Tool (AEDT) is being used extensively globally to quantify aviation noise and emissions.
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Office of Environment and Energy
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