Environment & Energy Research Portfolio Overview

Presented to: REDAC E&E Subcommittee

By: Dr. James I. Hileman Chief Scientific and Technical Advisor for Environment and Energy Office of Environment and Energy Federal Aviation Administration

Date: September 16, 2020



Presentation Outline

- Office of Environment and Energy Background
- E&E Research Portfolio Overview
- ASCENT COE Summary
- Budget Profile for E&E Portfolio
- Summary



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FAA Organizational Structure



Office of Environment and Energy (AEE)



Office of Environment and Energy (AEE)





Environmental & Energy Strategy





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Environment and Energy (E&E) Research Programs



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



ASCENT Center of Excellence (COE)

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



Additional Efforts

- Commercial Aviation Alternative Fuels Initiative (CAAFI)
- Contract mechanisms (e.g., PEARS-II, EMARIS (tbd))
- Volpe Transportation Center



Efforts Relating to Aircraft Noise

Understanding Noise

- Improving modeling capabilities
- Examining relationship between noise and annoyance, sleep, cardiovascular health and children's learning
- Evaluating current aircraft, helicopters, commercial supersonic aircraft, unmanned aerial systems, and commercial space vehicles

Outreach

- Enhanced community involvement
- Increase public understanding

Reducing Noise at the Source

- Aircraft technologies and architecture
- Noise standards

Mitigation

- Optimized operations and procedures
- Sound insulation program



For more information:

Aircraft noise: www.faa.gov/go/aviationnoise/ MITRE: v

ASCENT: www.ascent.aero

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

/ MITRE: www.mitre.org/

Volpe: www.volpe.dot.gov/



Federal Aviation Administration

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, and commercial space vehicles

Reducing Emissions at the Source

- Aircraft technologies and architecture
- Modifications to fuel composition
- Vehicle operations
- Engine standard (NO_X, CO₂, and PM standards)
- Future trends analysis

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/



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Efforts Relating to Sustainable Aviation Fuels

Testing

- Support Certification/Qualification testing to ensure fuels are safe for use
- Improve Certification/Qualification process to reduce the time and resources required to ensure fuels are safe for use

Analysis

- Environmental sustainability to ensure fuels are properly credited under the ICAO Carbon Offsetting and Reduction Scheme (CORSIA)
- Techno-economic analysis to understand how to reduce costs
- Future scenarios

Coordination

- Interagency
- Public-Private
- State & Regional
- International



For more information: ASCENT: www.ascent.aero/ CAAFI: www.caafi.org/

CLEEN: www.faa.gov/go/cleen/ Volpe: www.volpe.dot.gov/



Efforts Relating to Aircraft Technology

Continuous Lower Energy, Emissions & Noise (CLEEN) Program

- FAA partnership with industry 100% industry cost share
- Focus on aircraft and engine technologies (CLEEN Phases I-III) and development of high performance fuels (CLEEN Phase III)
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies
- Mature technologies from TRL 3-5 to TRL 5-7
- Individual companies use knowledge gained to improve their design methods

ASCENT COE Efforts on Innovation and Technology

- FAA partnership with academia 100% in-kind cost share
- Focus on broad range of innovation solutions (technology, fuels, ops, etc.)
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies
- Advance technologies at any TRL, but with understanding that FAA has a focus on applied R&D
- Universities use knowledge gained to improve knowledge broadly, but there are opportunities to examine specific technologies under NDAs



For more information: ASCENT: www.ascent.aero/

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



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

- Current version of tool, AEDT3c, has enhanced performance and dispersion
- Laying ground work for AEDT4 with a planned 2023 release
- Developing noise screening tool to support NEPA process



Highlights of Ongoing R&D Efforts (E&E Portfolio)

- Development of innovation portfolio within ASCENT
- Renewed efforts on impacts evaluation within ASCENT
- Much effort on supersonic aircraft across R&D portfolio
- Starting efforts on UAS and UAM within ASCENT
- Work on helicopter noise is making good progress
- Exploring low noise operational procedures and means to improve communication among affected communities
- Released AEDT3c executing long term vision for AEDT
- Sustainable aviation fuels: CORSIA, CAAFI, and ASTM
- Technology maturation in CLEEN continues and we are close to making awards for 3rd Phase of CLEEN
- Commercial space noise and emissions on the radar



Outreach Materials

Continuing to maintain/update materials:

- Environment and Energy Tri-Fold
- FAA Environment and Energy Website (faa.gov/go/environment)
- Noise Website (faa.gov/noise)
- CLEEN Website (faa.gov/go/cleen)
- ASCENT Website (ascent.aero)
- CAAFI Website (caafi.org)



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FAA Centers of Excellence (COE)

For 15 years, FAA Office of Environment and Energy has relied on university centers of excellence to:

- Provide knowledge to inform decision making on environment and energy matters;
- Enable the introduction of innovative solutions to cost-effectively mitigate the environmental impacts of aviation; and
- Support the instruction of hundreds of professionals with knowledge of the environmental challenges facing aviation.

Timeline:

- In 2004, FAA established PARTNER Center of Excellence
- In 2013, FAA established Center of Excellence for Alternative Jet Fuels and Environment, a.k.a. Aviation Sustainability Center or ASCENT, that continues work of PARTNER with expanded efforts on alternative jet fuels R&D
- In 2015, FAA sunsets PARTNER Center of Excellence, which had 48 projects (research efforts shifted to ASCENT)
- Currently have 77 ASCENT Projects (increase of 30 in less than 1 year)



ASCENT COE Details



ASCENT Leadership

- Mike Wolcott of WSU Director
- John Hansman of MIT Co-Director
- Carol Sim of WSU Assistant Director

ASCENT Research Areas

- Noise, Emissions, Tools
- Technology, Operations
- Alternative Jet Fuels

	Report 1*	Report 2	Report 3	Report 4	Report 5
Time period	9/2013 – 9/2015	10/2015 – 9/2016	10/2016 – 9/2017	10/2017 – 9/2018	10/2018 – 9/2019
Research Projects	50	54	43	32	30
Publications, Reports, and Presentations	137	119	110	179	166
Students involved	131	112	105	116	236
Industry partners	63	70	72	72	76

* ASCENT Annual Tech Reports available for download at: https://ascent.aero/resources



ASCENT COE Grant Approval Process





Timeline of Grant Approvals

Action Memo	# of Grants	Total Funds	APL Approval	S-1 Signature		
FY2018 #1	9	\$2.8M	6/10/18	9/24/18		
FY2019 #1	15	\$3.3M	10/11/18	3/29/18		
FY2019 #2	8	\$2.6M	11/28/18	5/31/19		
FY2019 #3	1	\$1.7M	3/21/19	6/14/19		
Implemented new process and sought new project ideas from ASCENT Community						
FY2020 #1	26	\$12.4M	8/28/19	2/5/20		
FY2020 #2	3	\$2.0M	10/24/19	2/5/20		
FY2020 #3	20	\$4.8M	1/9/20	6/5/20		
FY2020 #4	35	\$14.9M	5/6/20	8/11/20		

In the last year, we sent \$34.1M to support 84 ASCENT grants.

By way of comparison, PARTNER received \$62.8M of grant funding over its entire 10 year span of operations.



ASCENT Research Themes

- Alternative Jet Fuels
- Emissions
- Noise
- Operations
- Tools





ASCENT Alternative Jet Fuels Research Portfolio

https://ascent.aero/topic/alternative-fuels/

Alternative jet fuels have the potential to provide benefits to the aviation industry in terms of energy security and reduction in greenhouse gases. Their production can support rural economic growth and job creation through the development of economically valuable feedstocks and fuel processing facilities.

ASCENT Alternative Jet Fuels Projects

- 001 Alternative Jet Fuel Supply Chain Analysis
- 025-030 & 034 National Jet Fuel Combustion Program
- 031 Alternative Jet Fuels Test and Evaluation
- 032 (COMPLETE) Worldwide LCA of GHG Emissions from Petroleum Jet Fuel
- 033 Alternative Fuels Test Database Library
- 052 (NEW) Comparative Assessment of Electrification Strategies for Aviation
- 065 (NEW) Fuel Testing Approaches for Rapid Jet Fuel Prescreening
- 066 (NEW) Evaluation of High Thermal Stability Fuels
- 067 (NEW) Impact of Fuel Heating on Combustion and Emissions
- 073 (NEW) Combustor Durability with Alternative Fuel Use



ASCENT Emissions Research Portfolio

https://ascent.aero/topic/emissions/

Demand for air transportation, both for passenger and cargo service, has been increasing and airports are expanding to accommodate it. This growth is accompanied by an increase of emissions from aircraft, ground services equipment and vehicle traffic on and near airports. All this activity impacts the local air quality around airports and human health.

ASCENT Emissions Projects

- 002 Ambient Conditions Corrections for Non-Volatile PM Emissions Measurements
- 013 (COMPLETE) Micro-Physical Modeling & Analysis of ACCESS 2 Aviation Exhaust Observations
- 014 (COMPLETE) Analysis to Support the Development of an Aircraft CO2 Standard
- 018 Community Measurement of Aviation Emission Contribution of Ambient Air Quality
- 019 Development of Improved Aviation Emissions Dispersion Capabilities for AEDT
- 020 (COMPLETE) Development of NAS wide and Global Rapid Aviation Air Quality
- 021 (COMPLETE) Improving Climate Policy Analysis Tools
- 024 (COMPLETE) Emissions Data Analysis for CLEEN, ACCESS, and Other Recent Tests
- 022 Evaluation of FAA Climate Tools
- 039 Naphthalene Removal Assessment
- 047 Clean Sheet Supersonic Aircraft Engine Design and Performance
- 048 Analysis to Support the Development of an Engine nvPM Emissions Standard
- 051 (NEW) Combustion concepts for next-generation aircraft engines to reduce fuel burn and emissions
- 052 (NEW) Comparative Assessment of Electrification Strategies for Aviation
- 058 (NEW) Improving Policy Analysis Tools to Evaluate Aircraft Operations in the Stratosphere
- 064 (NEW) Alternative Design Configurations to Meet Future Demand
- 067 (NEW) Impact of Fuel Heating on Combustion and Emissions
- 068 (NEW) Combustor Wall Cooling Concepts for Dirt Mitigation
- 069 (NEW) Transitioning a research nvPM mass calibration procedure to operations
- 070 (NEW) Reduction of nvPM emissions via innovation in aero-engine fuel injector design
- 071 (NEW) Predictive Simulation of Soot Emission in Aircraft combustors
- 074 (NEW) Low Emissions Pre-Mixed Combustion Technology for Supersonic Civil Transport



ASCENT Noise Research Portfolio

https://ascent.aero/topic/noise/

The growth in demand for passenger and cargo air transportation has pushed operators to increase the number and frequency of their scheduled flights. The expansion in operations and the changes to the airspace aimed at accommodating it have resulted in renewed public concern.

ASCENT Noise Projects

- 003 Cardiovascular Disease and Aircraft Noise Exposure
- 004 (COMPLETE) Estimate of Noise Level Reduction
- 005 (COMPLETE) Noise Emission and Propagation Modeling
- 007 (COMPLETE) Civil, Supersonic Over Flight, Sonic Boom (Noise) Standards Development
- 008 Noise Outreach
- 009 (NEW) Geospatially driven noise estimation module
- 017 Pilot Study on Aircraft Noise and Sleep Disturbance
- 038 Rotorcraft Noise Abatement Procedures Development
- 040 (COMPLETE) Quantifying Uncertainties in Predicting Noise in Real-world Situations
- 041 Identification of Noise Acceptance Onset for Noise Certification Standards of Supersonic Airplanes
- 042 Acoustical Model of Mach Cut-off
- 043 Noise Power Distance Re-Evaluation
- 044 Aircraft Noise Abatement Procedure Modeling and Validation
- 049 (NEW) Urban Air Mobility Noise Reduction Modeling
- 050 (NEW) Over-Wing Engine Placement Evaluation
- 053 (NEW) Validation of Low-Exposure Noise Modeling by Open-Source Data Mgmt and Visualization Systems Integrated w/ AEDT
- 055 (NEW) Noise Generation and Propagation from Advanced Combustors
- 057 (NEW) Support for Supersonic Aircraft Noise Efforts in ICAO CAEP
- 059 (NEW) Jet Noise Modeling to Support Low Noise Supersonic Aircraft Technology Development
- 061 (NEW) Noise Certification Streamlining
- 062 (NEW) Noise Model Validation for AEDT
- 063 (NEW) Parametric Noise Modeling For Boundary Layer Ingesting Propulsors
- 072 (NEW) Aircraft noise exposure and market outcomes in the US
- 075 (NEW) Improved Engine Fan Broadband Noise Prediction Capabilities
- 076 (NEW) Improved Open Rotor Noise Prediction Capabilities
- O77 (NEW) Measurements to Support Noise Certification for UAS/UAM Vehicles and Identify Noise Reduction Opportunities



ASCENT Operations Research Portfolio https://ascent.aero/topic/operations/

Aviation operations at an airport can affect local communities in ways that are dependent on how and where aircraft are flown. Aviation operations can be optimized to reduce the amount of noise and emissions generated by these operations while still maintaining the efficiency of the airport system.

ASCENT Operations Projects

- 006 (COMPLETE) Rotorcraft Noise Abatement Operating Conditions Modeling
- 015 (COMPLETE) Cruise Altitude and Speed Optimization
- 016 (COMPLETE) Airport Surface Movement Optimization
- 023 Analytical Approach for Quantifying Noise from Advanced Operational Procedures
- 038 Rotorcraft Noise Abatement Procedures Development
- 044 Aircraft Noise Abatement Procedure Modeling and Validation
- 053 (NEW) Validation of Low-Exposure Noise Modeling by Open-Source Data Management and Visualization Systems Integrated with AEDT



ASCENT Tools Research Portfolio

https://ascent.aero/topic/tools/

The aviation system operation involves the complex interactions between many different components and understanding how to optimize its activities requires advanced modeling tools. The FAA suite of tools has been developed to provide the ability to characterize and quantify the interdependences of aviation-related noise and emissions, impacts on health and welfare, and industry and consumer costs under different policy, technology, operational and market scenarios.

ASCENT Tools Projects

- 009 (NEW) Geospatially driven noise estimation module
- 010 Aircraft Technology Modeling and Assessment
- 011 (COMPLETE) Rapid Fleet-wide Environmental Assessment Capability
- 012 (COMPLETE) Aircraft Design and Performance Assessment Tool Enhancement
- 035 (COMPLETE) Airline Flight Data Examination to Improve flight Performance Modeling
- 036 (COMPLETE) Parametric Uncertainty Assessment for AEDT2b
- 037 CLEEN II System Level Assessment
- 040 (COMPLETE) Quantifying Uncertainties in Predicting Aircraft Noise in Real-world Situations
- 043 Noise Power Distance Re-Evaluation (NPD+C) to Include Airframe Noise in AEDT
- 045 Takeoff/Climb Analysis to Support AEDT APM Development
- 046 Surface Analysis to support AEDT APM Development
- 049 (NEW) Urban Air Mobility Noise Reduction Modeling
- 053 (NEW) Validation of low exposure noise modeling by open source data management and visualization systems integrated with AEDT
- 054 (NEW) AEDT Evaluation and Development Support
- 058 (NEW) Improving Policy Analysis Tools to Evaluate Aircraft Operations in the Stratosphere
- 060 (NEW) Analytical Methods for Expanding the AEDT Aircraft Fleet Database
- 062 (NEW) Noise Model Validation for AEDT
- 064 (NEW) Alternative Design Configurations to meet Future Demand



A Cross-Cutting Research Example: Supersonics

https://ascent.aero/topic/supersonics/

Multiple ASCENT Projects support technology analysis for ICAO/CAEP rulemaking activity and development of new technologies for the next generation of supersonic aircraft.



ASCENT Supersonics Related Projects

- 007 (COMPLETE) Civil, Supersonic Over Flight, Sonic Boom (Noise) Standards Development
- 010- Aircraft Technology Modeling and Assessment
- 022 Evaluation of FAA Climate Tools
- 041 Identification of Noise Acceptance Onset for Noise Certification Standards of Supersonic Airplanes
- 042 Acoustical Model of Mach Cut-off
- 047 Clean Sheet Supersonic Aircraft Engine Design and Performance
- 057 (NEW) Support for Supersonic Aircraft Noise Efforts in ICAO CAEP
- 058 (NEW) Improving Policy Analysis Tools to Evaluate Aircraft Operations in the Stratosphere
- 059 (NEW) Jet Noise Modeling to Support Low Noise Supersonic Aircraft Technology Development
- 074 (NEW) Low Emissions Pre-Mixed Combustion Technology for Supersonic Civil Transport



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E&E R&D Budget Profile – FY17-FY21



FY2021 President Budget for FAA (see pages 475-482 for E&E Portfolio): https://www.transportation.gov/mission/budget/faa-cj-fy-2021-estimates



Environment & Energy R&D Portfolio – FY21 **RE&D A.s: Environment & Energy**

Major Activities and Accomplishments Planned in FY 2021 Include:

- Using advances in scientific understanding, enhance the aviation environmental tool suite to improve our ability to calculate environmental consequences and impacts of aviation.
- Develop innovative, cost-effective solutions to reduce noise, fuel use, and emissions for both fixed wing and vertical takeoff and landing vehicles through technology and operational procedure concepts.
- Conduct analyses to inform decision making on operational procedure concepts, policy measures, and standards that could reduce noise, fuel use, and emissions.
- Develop improved measurement capabilities and airworthiness certification methods for both noise and emissions, for both existing air vehicles and new entrants.
- Conduct analyses and gather data to inform the development of noise and emissions standards to enable the introduction of new entrants, such as Unmanned Aerial Systems, Urban Air Mobility vehicles, and civil supersonic aircraft.



Environment & Energy R&D Portfolio – FY21 RE&D A.s: Environment & Energy

Goals for FY 2021 Funding:

- By 2022, complete analyses to quantify the potential health impacts of aircraft noise.
- By 2022, release noise screening tool to streamline environmental approval process and improve communication on noise matters with communities.
- By 2022, conduct measurements and complete analyses to inform the development of noise standards for unmanned aerial systems and urban air mobility vehicles.
- By 2023, release AEDT Version 4 with improved characterization at lower noise levels where some communities are expressing concerns as well as to include supersonic aircraft.
- Through 2025, complete analyses to support the development of new international standards for supersonic transport aircraft and engines in ICAO CAEP.



Environment & Energy R&D Portfolio – FY21 RE&D A.t: NextGen – Environmental Research – Aircraft Technology and Fuels

Major Activities and Accomplishments Planned in FY 2021 Include:

- Develop aircraft and engine technologies, as well as novel drop-in fuels, for both subsonic and supersonic aircraft, that reduce noise and emissions while increasing fuel efficiency through the CLEEN Program.
- Evaluate innovative technological solutions to reduce noise, emissions and fuel burn from both subsonic and supersonic aircraft through ASCENT.
- Support the approval of novel jet fuel pathways within the American Society of Testing and Materials (ASTM) International certification process via testing and coordination to ensure these fuels are safe for use.
- Support the inclusion of sustainable aviation fuels, created from waste and biomass feedstocks, and lower carbon aviation fuels, created from fossil feedstocks, within the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).



Environment & Energy R&D Portfolio – FY21 RE&D A.t: NextGen – Environmental Research – Aircraft Technology and Fuels

Goals for FY 2021 Funding:

- By 2022, develop lifecycle greenhouse gas emissions values and sustainability criteria for use in CORSIA.
- By 2022, identify innovative solutions to reduce noise, emissions, and fuel burn through the university research of ASCENT.
- Through 2025, continue activities within the third phase of CLEEN to demonstrate technologies that can reduce energy use, emissions, and noise for both subsonic and supersonic aircraft.
- Through 2025, conduct testing to support the approval of at least one alternative jet fuel type per year and to streamline the ASTM certification process to reduce the time and cost of certification.
- By 2025, assess the benefits of the technologies matured under the third phase of the CLEEN Program.



Environment and Energy Funding (FY18/19 A13.a/A13.b; FY20 A12.a/A12.b; FY21 A.s/A.t)



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Recent Successes

capabilities and solutions that are helping today

- Leveraging operational procedure development work at Boston Logan to evaluate communication tools, develop additional concepts, and evaluate potential for broader use. Concept with noise reduction potential flown by Boeing 777 ecoDemonstrator at ACY
- Noise research continues. Community noise survey under review. Starting work on national sleep study. Resumed work to understand potential health impacts of noise.
- Aviation Environmental Design Tool (AEDT) being upgraded to better capture actual operations and is being used extensively.
- Measurement technique and data provided foundation for new ICAO CAEP nvPM engine standard that will replace the existing smoke number standard in 2023.
- Analytical tools provided foundation for ICAO CAEP Independent Expert review of aircraft technologies for the purpose of setting goals for noise, fuel burn, and NO_X emissions.
- Provided critical analytical support to the development of Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).
- Research efforts were critical for the inclusion of sustainable aviation fuels within CORSIA.
- Certification of <u>eight</u> alternative jet fuel pathways certification has enabled multiple airlines to buy and use sustainable aviation fuels in LAX and elsewhere.
- CLEEN aircraft and engine technologies appearing in new aircraft with some technologies retrofitted into today's fleet. Will reduce noise, emissions, and fuel use for decades to come.
- Research efforts are paving the way for the re-introduction of supersonic aircraft.



FAA Portion of the Remaining Agenda

Subject	Presenters
Emissions Research	R. Iovinelli & D. Jacob
Supersonic Civil Aircraft Research	D. Scata, R. Iovinelli, et al.
Sustainable Aviation Fuels Research	N. Brown & A. Oldani
Noise Research	D. Scata
Helicopters, UAS, and UAM	E. Elmore et al.
Research on Operational Procedures	C. Dorbian
Aircraft Technology Research	L. Ileri & A. Orton
Analysis & Tool Development	F. Grandi



Questions for Tomorrow:

- Are there R&D areas within the E&E Portfolio that should be lower / higher priority?
- Are there R&D areas that AEE is not examining that should be added to the E&E Portfolio?
- What do you see coming on the horizon regarding E&E that may require future R&D efforts?





Dr. Jim Hileman

Chief Scientific and Technical Advisor for Environment and Energy

Federal Aviation Administration Office of Environment and Energy Email: james.hileman@faa.gov

