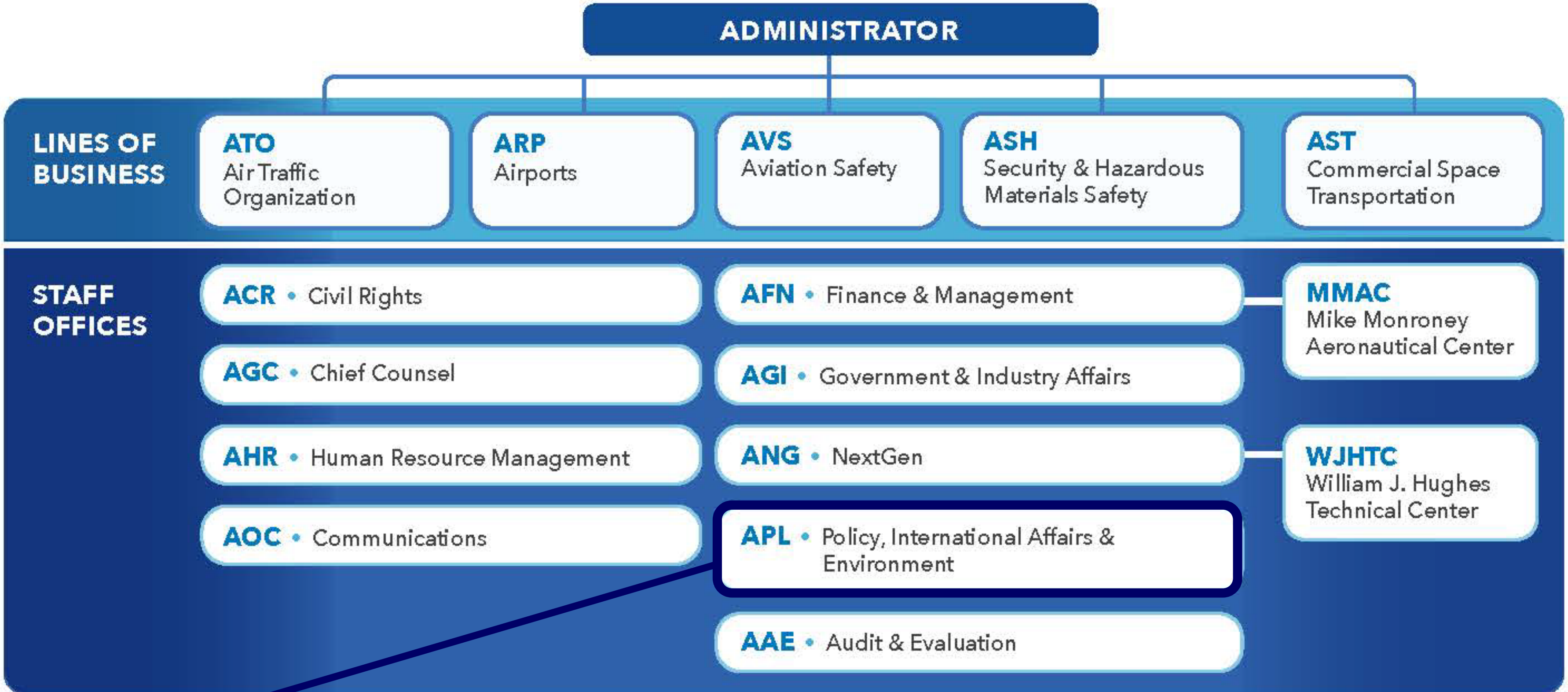
Environment & Energy Research & Development Portfolio Overview

Prepared for: Full REDAC Meeting

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

Date: October 5, 2022

FAA Organizational Structure



Office of Environment and Energy (AEE)

- Office within APL, responsible for broad range of environmental policies
- About 45 staff members *(in process of expanding)*
- *Responsible for roughly 1/3 of FAA RE&D Budget and I.R.A. Programs*

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 Program:

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

POLICY MAKING

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

DEVELOP INNOVATIVE SOLUTIONS TO REDUCE NOISE AND EMISSIONS

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

ASCENT AVIATION SUSTAINABILITY CENTER
www.ascent.aero/

CLEEN — Continuous Lower Energy, Emissions & Noise — Federal Aviation Administration
www.faa.gov/go/cleen/

CAAFI®
www.caafi.org/

the VOLPE center

Noise R&D Overview

Federal Register Notice

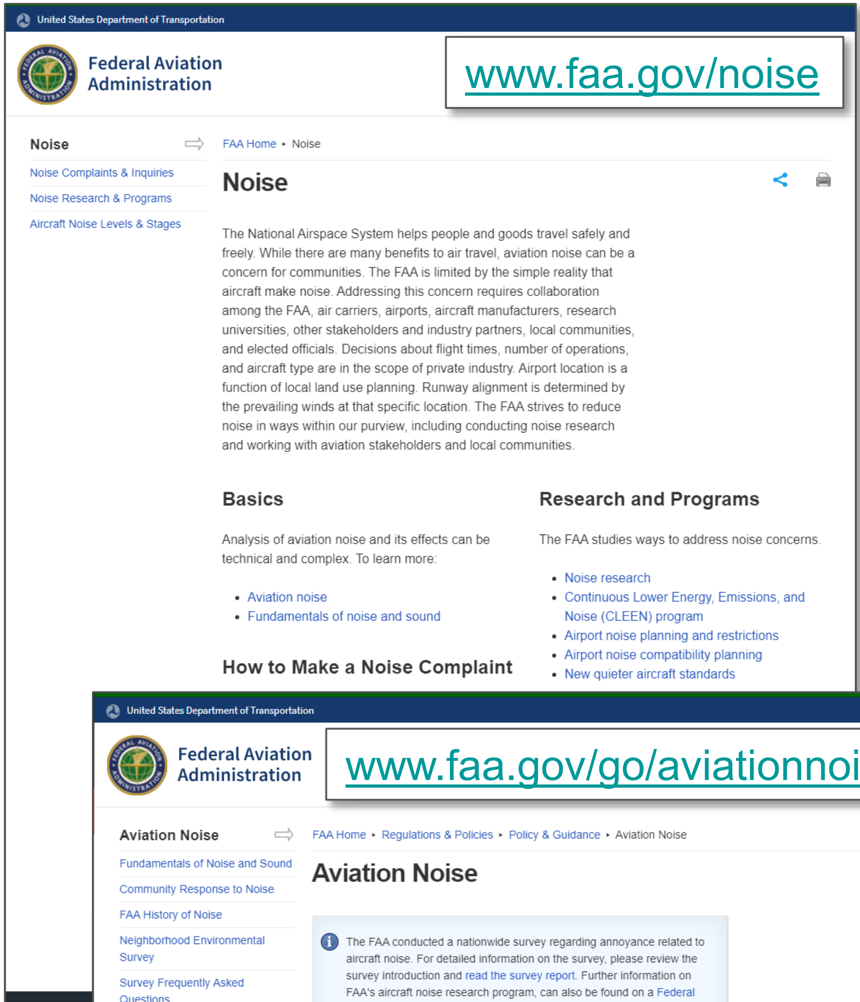
Provides comprehensive overview of FAA R&D efforts on noise

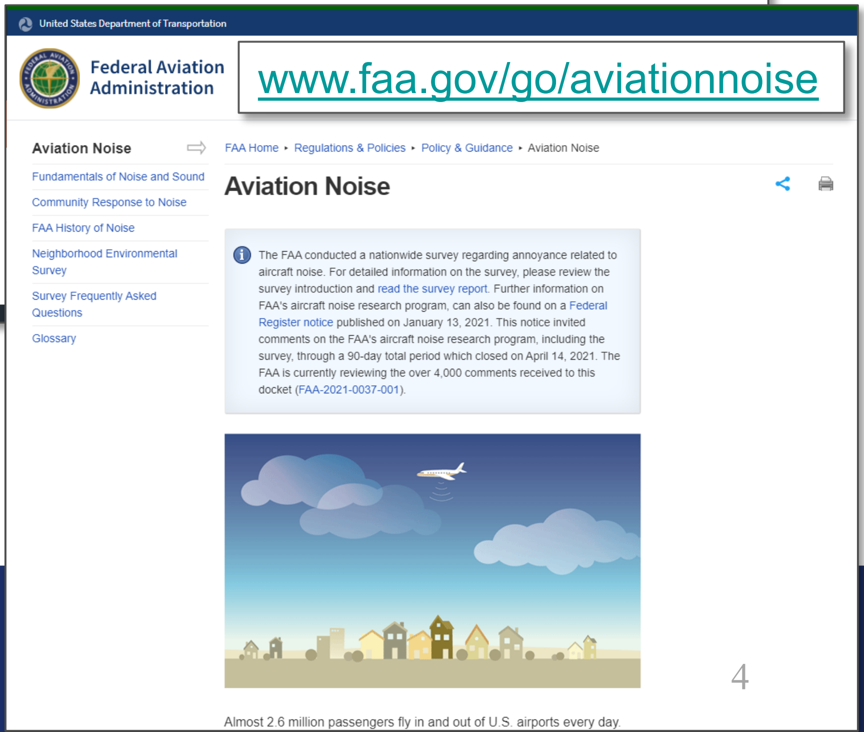
- Effects of Aircraft Noise on Individuals and Communities
- Noise Modeling, Noise Metrics and Environmental Data Visualization
- Reduction, Abatement and Mitigation of Aviation Noise
- Considering all air vehicles

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

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

Public webinar on FRN on February 22, 2021
https://www.youtube.com/watch?v=Mku13gL0xGc





Emissions R&D Overview

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 (jet fuel and aviation gasoline)
- Vehicle operations
- Engine standard (NO_X, CO_2, 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/

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

- ***Published U.S. Aviation Climate Action Plan to address CO_2 emissions – E&E R&D featured prominently throughout***
- ***Leading the development of the SAF Grand Challenge Roadmap with E&E R&D being a key component***
- ***E&E R&D is at the core of the ICAO CAEP Long Term Aspirational Goal (LTAG) for international aviation CO_2 emissions***
- ***Laying ground work to address non-CO_2 aviation climate impacts***

- R&D Portfolio is expanding (ASCENT COE and CLEEN)
- Research efforts continue to inform decision making on many fronts
- Released AEDT3e - executing long term vision for Aviation Environmental Design Tool (AEDT)[1]
- Rotorcraft noise research efforts continue: helicopters, drones and advanced air mobility
- Continuing wide-ranging portfolio on supersonic aircraft

1. For more information on AEDT or to download it, please visit: https://aedt.faa.gov/

Overseeing Rapid Growth

- **FY10-FY21 Enacted Budgets**: ~45 staff and annual budget that varied from $40M to $52M for R&D efforts
- **FY19-FY21 Pres Budgets**: Operated under possibility of reduced budget (FY19, FY20, and FY21 Pres Budgets - $19M, $27M, and $27M (initial))

- **FY22 Enacted Budget**: R&D funding increased to $89.5M
- **FY23 Pres Budget and House/Senate Reports:** further increase to between $92M and $99M
- **Substantial R&D support for decision-making:** both domestic policy and in ICAO Committee on Aviation Environmental Protection (CAEP)

- **Inflation Reduction Act** (signed in August 2022)
  - New SAF and Tech Grant Program - $297M
  - SAF Blenders Tax Credit (Sections 13203 and 13704)

White House Sustainable Aviation Event

On September 9, 2021, government and industry leaders met to discuss actions and make new announcements regarding efforts to address aviation and climate change in the near-term, with a view to long-term ambition.

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;
- 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.

"…the Administration also plans to release an aviation climate action plan in the coming months, which will set forth a comprehensive plan for aviation."

THE WHITE HOUSE

MENU

BRIEFING ROOM

FACT SHEET: Biden Administration Advances the Future of Sustainable Fuels in American Aviation

SEPTEMBER 09, 2021 • STATEMENTS AND RELEASES

New Actions Aim to Produce Three Billion Gallons of Sustainable Fuel, Reduce Aviation Emissions by 20% by 2030, and Grow Good-Paying, Union Jobs

Today, President Biden is taking steps to coordinate leadership and innovation across the federal government, aircraft manufacturers, airlines, fuel producers, airports, and non-governmental organizations to advance the use of cleaner and more sustainable fuels in American aviation.

Share

. Today's announcements build upon this proposal through a whole-of-government effort to advance cleaner aviation, as well as work in concert with bold actions taken by the aviation-related industries. 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.

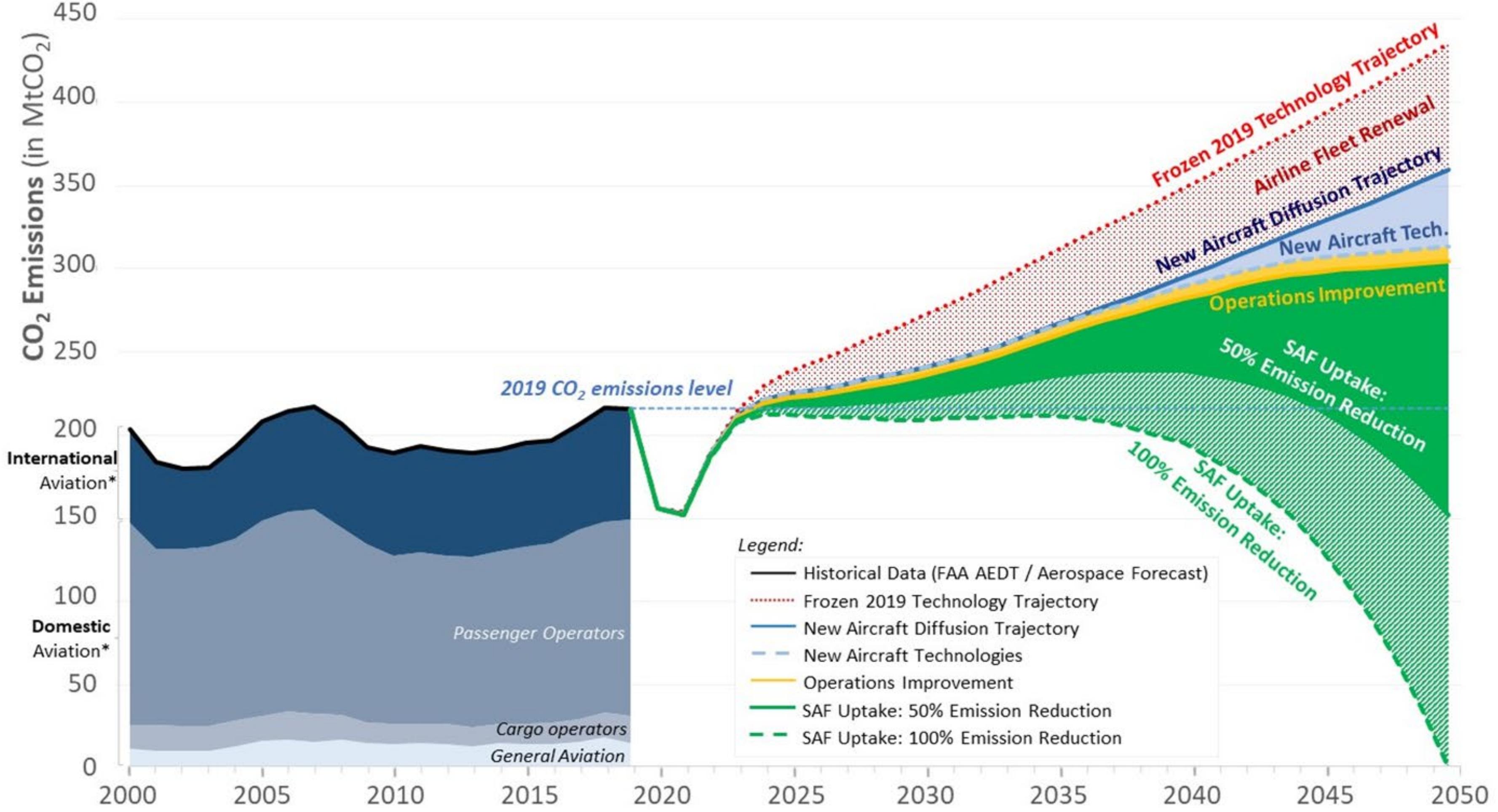
Building on today's announcements, the Administration also plans to release an aviation climate action plan in the coming months, which will set forth a comprehensive plan for aviation.

Aviation Climate Action Plan

- International Civil Aviation Organization (ICAO) – “State Action Plans”
- Plan builds on ongoing FAA Environment & Energy Program – long-term focus on reducing climate impacts of aviation
- Administration focus on climate – Achieving net zero emissions economy-wide by 2050

- Climate Action Plan Press Release:
  https://www.faa.gov/newsroom/us-releases-first-ever-comprehensive-aviation-climate-action-plan-achieve-net-zero
- Climate Action Plan Document:
  https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

Analysis of Future Domestic and International Aviation CO_2 Emissions



* Note: Domestic aviation from U.S. and Foreign Carriers. International aviation from U.S. Carriers.

NOTE: Analysis conducted by BlueSky leveraging FAA Aerospace Forecast and R&D efforts from the FAA Office of Environment & Energy (AEE) regarding CO2 emissions contributions from aircraft technology, operational improvements, and SAF

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Aviation Climate Action Plan – Contents

https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

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Technology R&D Overview

Through the Continuous Lower Energy, Emissions, and Noise (CLEEN) Program, FAA are working in a public-private partnership with industry to accelerate maturation of certifiable aircraft and engine technologies.

- Technological innovation will be essential to enable environmentally sustainable growth and maintain U.S. global leadership.

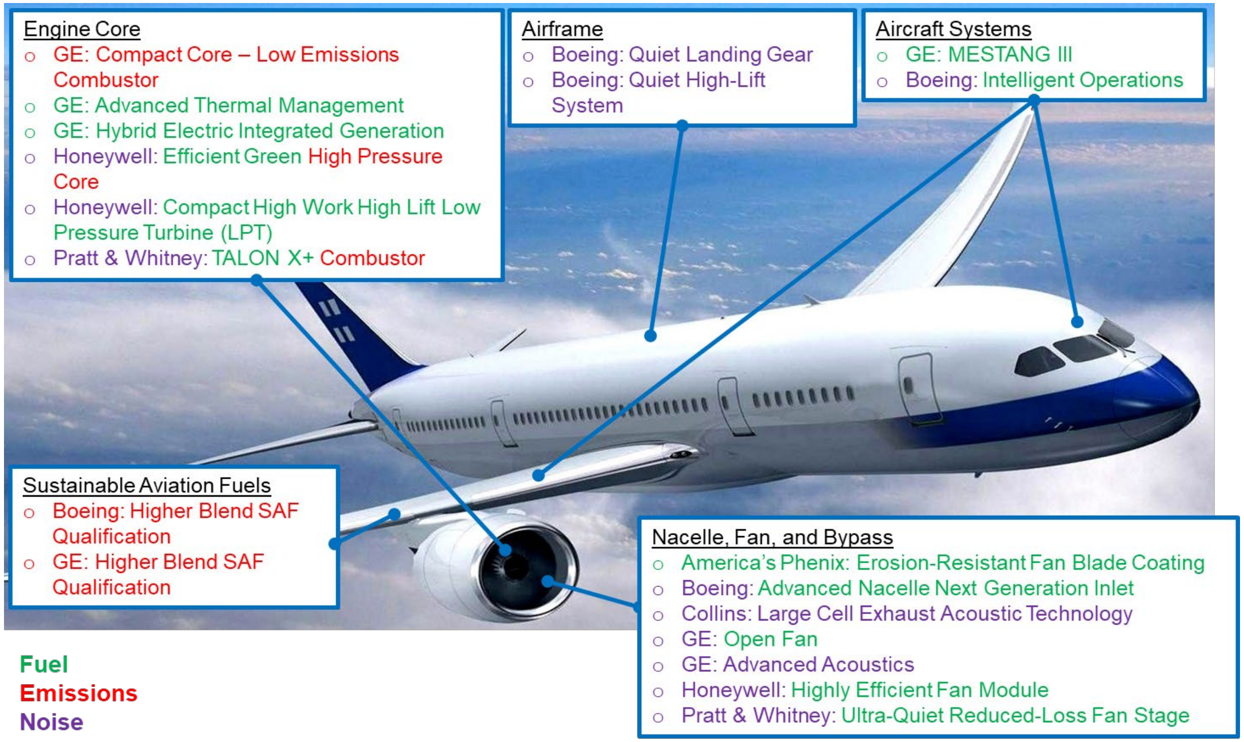
- FAA have been operating CLEEN Program since 2010 (initially set up during Bush administration)

- FAA announced CLEEN Phase III on Sept 9, 2021

- Summary of CLEEN accomplishments over first two phases (10+ years) available online

- Complementary ASCENT technology project portfolio

CLEEN Phase III Technologies



Fuel
Emissions
Noise

For more information on CLEEN program: http://www.faa.gov/go/cleen

For the CLEEN Phase 3 Press Release:
https://www.faa.gov/newsroom/faa-awards-100m-develop-next-generation-sustainable-aircraft-technology

For a summary of CLEEN Accomplishment:
https://www.faa.gov/newsroom/continuous-lower-energy-emissions-and-noise-cleen-program?newsId=22534

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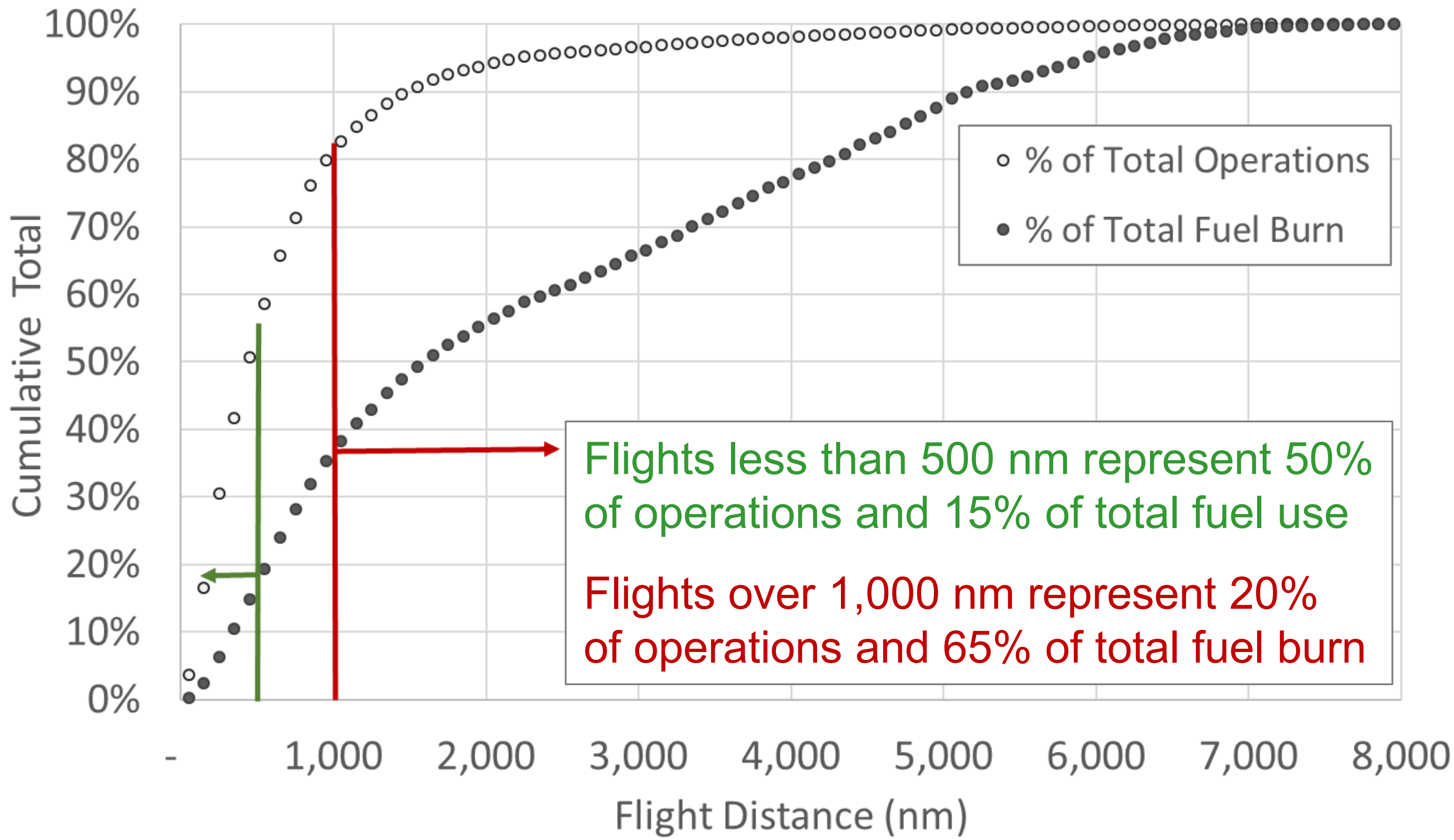
Jet Fuel

- Jet fuel is a critical component of the safe, reliable, and efficient global air transportation system
- Jet fuel provides a unique combination of properties that enable aircraft to safely carry hundreds of passengers and tons of freight for thousands of miles at high speed
  - Remains a liquid at very low temperatures of flight
  - Does not vaporize at low atmospheric pressures experienced in the upper atmosphere during cruise flight
  - Tolerates relatively high engine temperatures without breaking down and clogging fuel lines
  - Provides considerable energy both in terms of energy per unit mass and per unit volume
- While these properties play a key role in enabling today's aviation system, they also make it a difficult sector to decarbonize because they are hard to replace

Global Jet Fuel Use

- Global jet fuel use is driven by long-haul aviation
- SAF only option through 2050 for long distances



Data analysis conducted by the U.S. DOT Volpe Center using the Aviation Environmental Design Tool (AEDT)

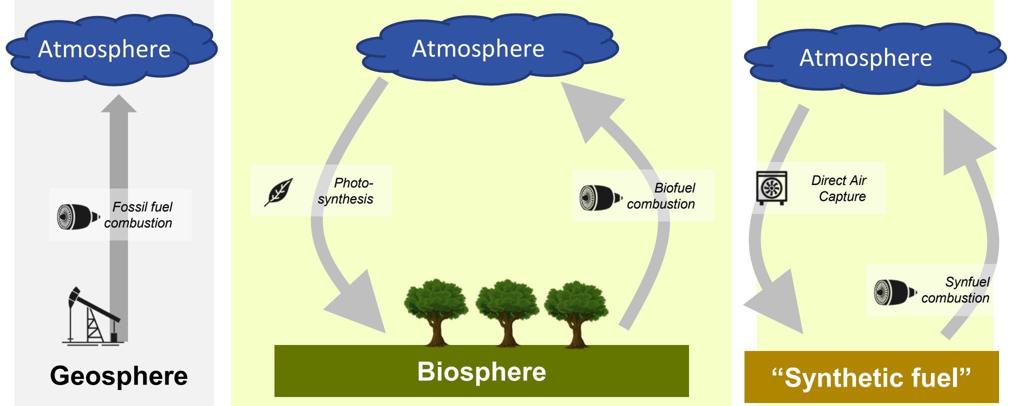
Aircraft Fueling Options

- Utilizing R&D program to understand full range of options for powering aircraft
  - ASCENT Project 1 Alternative Jet Fuel Supply Chain Analysis
  - ASCENT Project 52 Comparative Assessment of Electrification Strategies for Aviation
  - ASCENT Project 80 Hydrogen and Power to Liquid (PtL) Concepts for SAF Production

- Looking both at near term and much further into future
- Carefully considering electricity, cryogenic hydrogen, and power-to-liquid fuels – in addition to SAF
- Ensuring that research findings are shared broadly with aerospace and energy communities

Energy Carriers for Aviation – A Typology

	Fossil Jet-A	Waste- and biomass-based SAF	Power-and-biomass-to-Liquid (PBtL)	Power-to-Liquid	Hydrogen	Battery ?
H source	*Fossil H_2*	*Biomass and wastes; currently supplemented by H_2 produced from SMR*	*Biomass feedstock and H_2 produced from renewable electricity*	*H_2 produced from low-carbon electricity*	*H_2 produced from low-carbon electricity or SMR with CCS*	
C source & C balance	*Fossil carbon*	*Biomass and waste streams**	*Biomass*	*Atmospheric CO_2 or waste CO_2 streams*	--	



* Using carbon from waste streams provides a carbon benefit if the carbon content of the waste stream would have been released to the atmosphere anyways.

Substantial Low Carbon Electricity Required for Hydrogen Production

Slide adapted from MIT LAE (Project 52/80), courtesy Florian Allroggen

Aircraft Energy

- To enable long distance transport, aircraft need considerable energy storage while also producing considerable power
- To produce this power, an aviation fuel needs large energy per unit mass and volume
- Aviation also has stringent safety requirements – see ASTM D1655 & D7566 for jet fuel

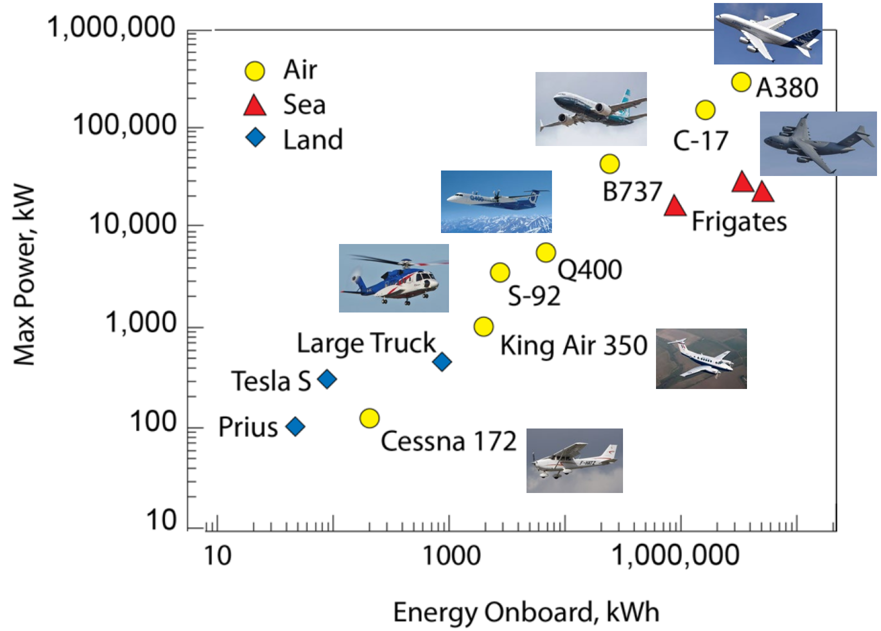
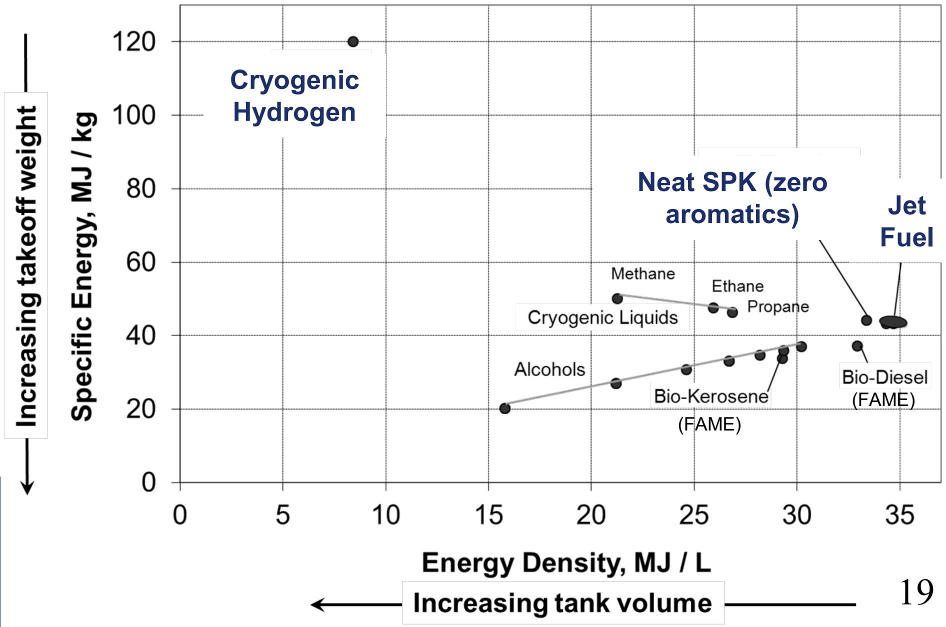


FIGURE 2.1 Power and energy required for vehicles ranging from small cars to large commercial aircraft. SOURCE: A.H. Epstein, 2014, Aeropropulsion for commercial aviation in the twenty-first century and research directions needed, *AIAA Journal* 52(5):901-911, doi:10.2514/1.J052713. Reproduced by permission of United Technologies Corporation, Pratt & Whitney.

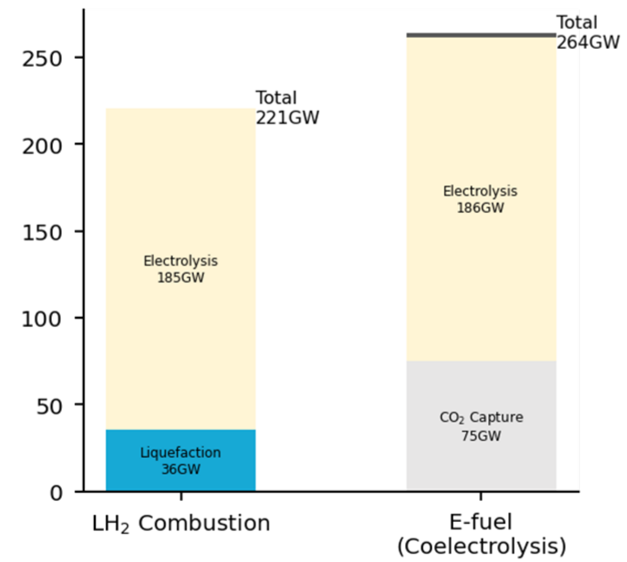


Upper graphic from 2016 National Academies report, "Commercial Aircraft Propulsion and Energy Systems Research: Reducing Global Carbon Emissions."

Airports as Energy Hubs: Global picture

- Replacing jet fuel with cryogenic hydrogen would require considerable electricity to electrolyze water and compress it to a cryogenic state
- Power-to-liquids would require comparable energy as cryogenic hydrogen, but without requiring infrastructure changes

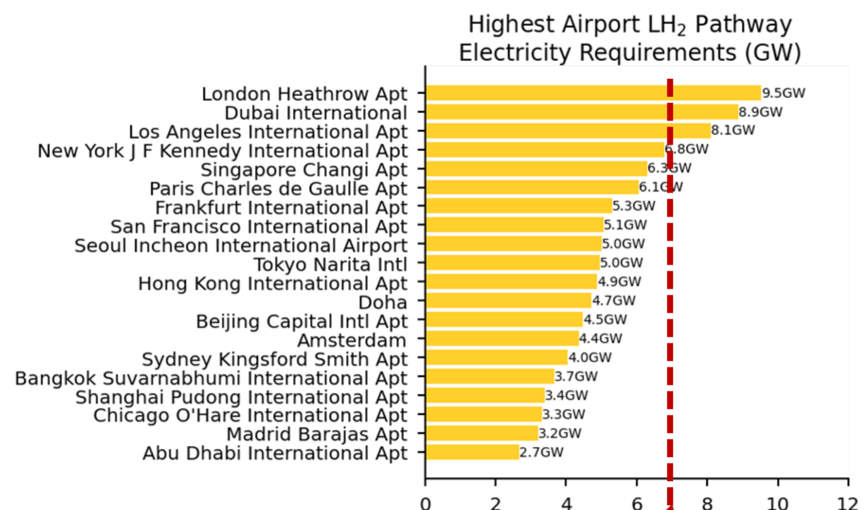
Electric power consumption of fuel production[1]
broken down by process step, in GW



[1] Values are annual average power demand.

For comparison:
U.S. power generation capacity (2019): 1.2 TW
Cumulative global PV capacity (2019): 627 GW

Electric energy consumption of fuel production
in GW, by airport



Preliminary Results from Ongoing Research in ASCENT Project 52 for flights greater than 1,000 km

Graphic and data courtesy of MIT from ASCENT Project 52
See https://ascent.aero/project/comparative-assessment-of-electrification-strategies-for-aviation/

Federal Aviation Administration

Aircraft Energy Sources – Multiple Fuel Option

Fundamental question: how to do we replace petroleum with low carbon energy sources?

Energy Source		Conversion		Finished Fuel
• Petroleum	→	• Refining	→	• **Hydrocarbons (aka jet fuel)**
• Biomass • Residues • Wastes	→	• Chemical, biological, and thermochemical processes	→	• **Hydrocarbons (aka SAF)**

Today's Infrastructure and Fleet of Aircraft

Energy Source		Conversion		Finished Fuel
• Solar • Wind • Hydro • Nuclear	→	• Electricity generation • Electrolysis	→	• **Electricity for Batteries** • **Hydrogen**

New Infrastructure and Future Aircraft

Aircraft Energy Sources – Single Fuel Option

Fundamental question: how to do we replace petroleum with low carbon energy sources?

Energy Source
- Petroleum

Conversion
- Refining

Finished Fuel
- **Hydrocarbons (aka jet fuel)**

Energy Source
- Biomass
- Residues
- Wastes

Conversion
- Chemical, biological, and thermochemical processes

Finished Fuel
- **Hydrocarbons (aka SAF)**

Energy Source
- Solar
- Wind
- Hydro
- Nuclear

Conversion

Today's Infrastructure and Fleet of Aircraft

Sustainable Aviation Fuels (SAF)

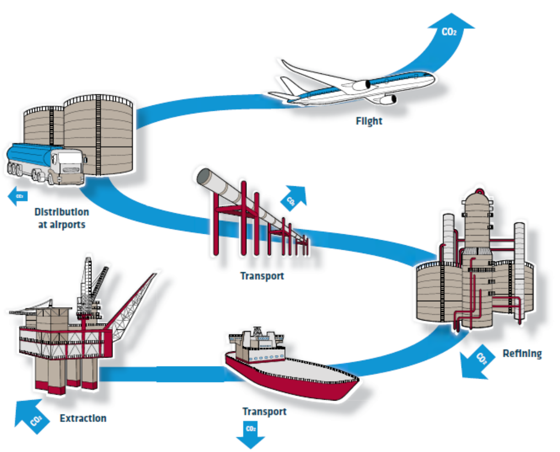
- SAF are "drop-in" liquid hydrocarbon fuels with the same performance and safety as conventional jet fuels produced from petroleum
- SAF are fully fungible with the existing fuel supply and can be used in the same infrastructure, engines, and aircraft
- SAF can be produced from renewable feedstocks, waste materials, and industrial waste gases
- Some types of SAF reduce emissions that impact air quality and contribute to the formation of contrails, which also impacts climate change

Image courtesy of Anna Oldani from Frankfurt Intl Airport

Sustainable Aviation Fuels – Life Cycle Benefit

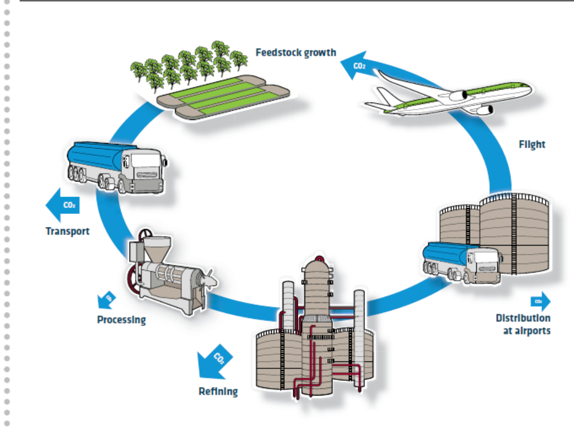
The extent to which any particular SAF provides a climate benefit depends on SAF’s life cycle emissions profile, taking into account the production, transportation, and combustion of the SAF, as well as indirect effects.

Carbon lifecycle diagram: fossil fuels



At each stage in the distribution chain, carbon dioxide is emitted through energy use by extraction, transport, etc.

Carbon lifecycle diagram: Sustainable aviation fuel



Carbon dioxide will be reabsorbed as the next generation of feedstock is grown.
Note: *the diagram above does not demonstrate the lifecycle process of SAF derived from municipal waste.*

FAA have extensive research that have supported development of rigorous life cycle accounting methods over the last decade:

- Argonne National Labs GREET Model
- ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)
- SAF Blenders Tax Credit (I.R.A. Sections 13203 and 13704)

Diagram from ATAG Beginner’s Guide to SAF, which is available at: https://aviationbenefits.org/downloads/beginners-guide-to-sustainable-aviation-fuel/

Federal Aviation Administration

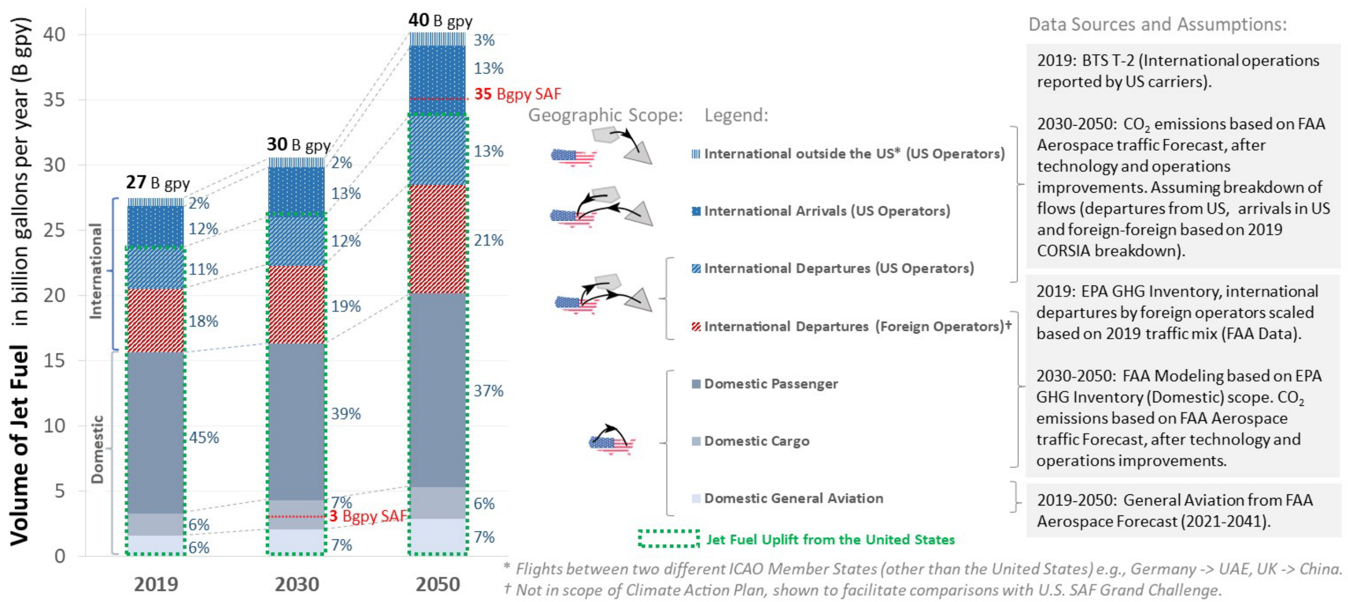
SAF Grand Challenge

https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge

The US Government has identified the development and deployment of SAF as a key aviation climate priority. The USG has established a multi-agency effort led by the DOT, DOE, and USDA to implement the "SAF Grand Challenge" to reduce cost, enhance sustainability, and expand production and use of SAF that achieves a minimum of a 50% reduction in life cycle GHGs compared to conventional fuel.

SAF Grand Challenge will include development of a multi-agency roadmap in order to:

- Reduce the cost of SAF
- Enhance sustainability of SAF
- Expand SAF supply and end use



Potential demand for jet fuel in gallons per year (gpy) across domestic operations (by U.S. and Foreign Carriers).

Federal Aviation Administration

SAF Grand Challenge Roles (in MOU[1])

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
- R&D aimed at creating new pathways toward higher SAF production
- Advance environmental analysis of SAF
- Collaborate with EPA to expedite regulatory approvals of SAF with significant life-cycle GHG reductions

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.
- Collaborate with EPA to expedite regulatory approvals of SAF with significant life-cycle GHG reductions

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
- Provide outreach & technology transfer to producers, processors and communities to accelerate adoption and participation
- Commercialization support
- Collaborate with EPA to expedite regulatory approvals of SAF with significant life-cycle GHG reductions

1. SAF Grand Challenge MOU available at: https://www.energy.gov/sites/default/files/2021-09/S1-Signed-SAF-MOU-9-08-21_0.pdf

SAF Grand Challenge Roadmap[1]

Feedstock Innovation – sustainable supply system innovations across SAF relevant feedstocks: reduce cost, reduce technology uncertainty and risk, increase yield and sustainability, and optimize SAF precursors.

Conversion Technology Innovation – conversion technology pipeline: reduce production cost, increase conversion efficiency, sustainability, and fuel volumes

Building Regional SAF Supply Chains – regional supply chains ensuring R&D transitions, field validation, demonstration projects, supply chain logistics, public-private partnerships, bankable business model development, and collaboration with regional, state and local stakeholders

Enabling End Use (e.g. Fuel Testing and Certification & Qualification) – enable efficient evaluation of fuel performance and safety, data analysis, address blend limits and understand combustion emissions and impacts

Policy and Valuation Analysis – support policy decisions and maximize social, economic, and environmental value of SAF including alignment of existing and new policies

Communicating Progress & Building Support – monitor and measure progress against SAF GC goals and communicate the public benefits of the SAF GC to critical stakeholders

1. SAF Grand Challenge Roadmap is available at: https://www.energy.gov/eere/bioenergy/articles/sustainable-aviation-fuel-grand-challenge-roadmap-flight-plan-sustainable

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Efforts to Support Decision-Making

- FAA working with NASA, EPA, Volpe Center, and ASCENT Center of Excellence universities to develop tools and conduct analysis of a wide range of economic and environmental impacts that could result from changes to aviation noise, emissions, and energy policy.

- R&D efforts informing decision making:

  NO_X Metric System (NEW)

  Dual Noise/CO_2 stringency (NEW)

  Long Term Aspirational Goal (ongoing)

  Supersonic Aircraft Noise (ongoing)

  Fuel Composition (ongoing)

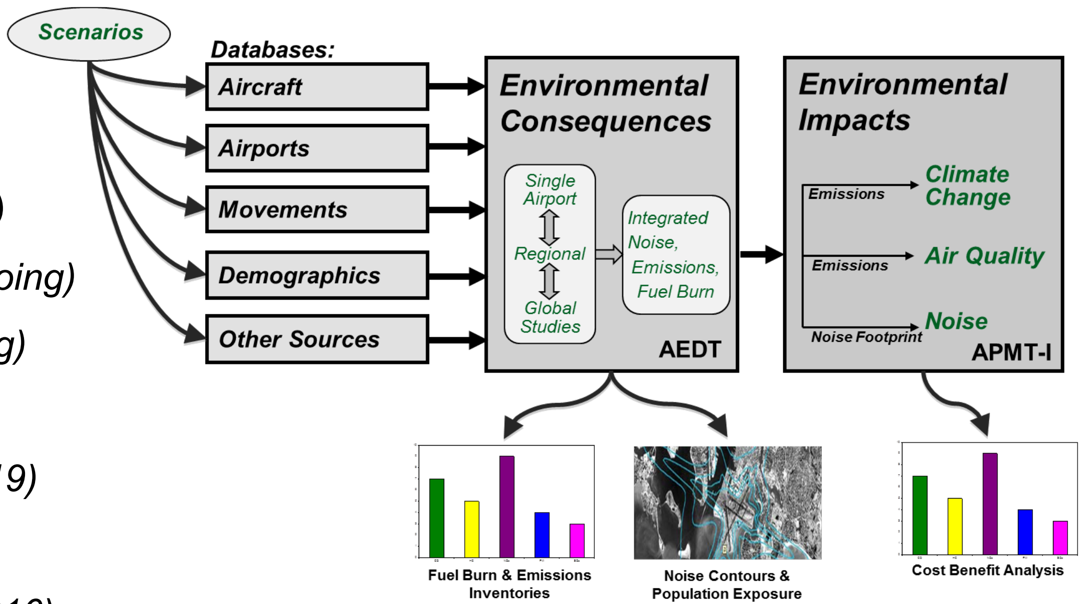
  ICAO CAEP/11 PM Standard (2019)

  ICAO CORSIA (2019)

  ICAO CAEP/10 CO_2 Standard (2016)

  ICAO CAEP/9 Noise Standard (2013)

  ICAO CAEP/8 NOx Standard (2010)

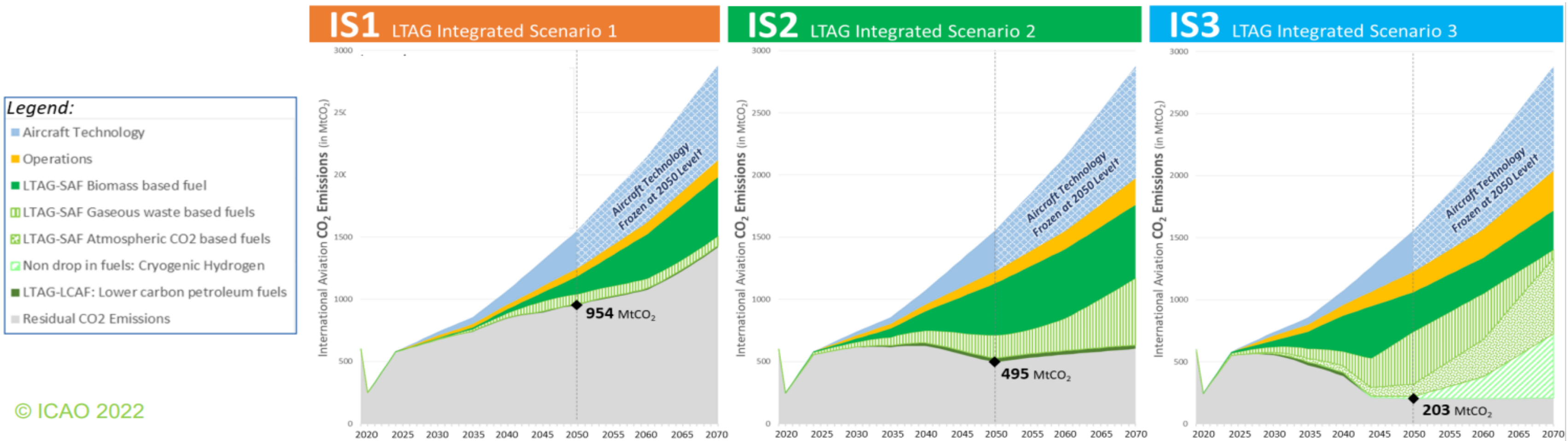


ICAO CAEP Long Term Aspirational Goal (LTAG) Support

- In 2020, the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) undertook an effort to assess the feasibility of a long term aspirational goal (LTAG) for CO2 emissions from international aviation.
- FAA led most aspects of the work to develop scenarios of future global aviation CO_2 emissions growth (accounting for growth, technology, fuels, operations)
- Utilized multiple FAA RE&D E&E supported efforts to provide analysis support:
  - ASCENT Projects 1 & 52 and DOE Argonne National Lab provided fuel analysis
  - NASA and ASCENT Project 64 provided technology analysis
  - Volpe Center conducted integrated analysis
  - Blue Sky consultancy provided costing and supported integrated analysis
  - FAA coordinated considerable support from across U.S. government
- In March 2022, the final report of the LTAG task group was approved for release by the ICAO Council for use in informing decision making leading up to the 41st ICAO Assembly

Full report: https://www.icao.int/environmental-protection/LTAG/Pages/LTAGreport.aspx

High Level Results



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Metrics	IS1	IS2	IS3
CO_2 Emissions in 2050 after Reductions	**≈950 $MtCO_2$** in 2050 *(160% of 2019 CO_2 emissions)*	**≈500 $MtCO_2$** in 2050 *(80% of 2019 CO_2 emissions)*	**≈200 $MtCO_2$** in 2050 *(35% of 2019 CO_2 emissions)*
Reduction in 2050 from the Baseline	**39% total** through: Technologies - 20%, Operations - 4%, Fuels - 15%	**68% total** through: Technologies - 21%, Operations - 6%, Fuels - 41%)	**87% total** through: Technologies - 21%, Operations - 11%, Fuels - 55%
Cumulative residual Emissions from 2020 to 2070	23 $GtCO_2$ (2020 to 2050) 23 $GtCO_2$ (2051 to 2070)	17 $GtCO_2$ (2020 to 2050) 11 $GtCO_2$ (2051 to 2070)	12 $GtCO_2$ (2020 to 2050) 4 $GtCO_2$ (2051 to 2070)

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- Scenarios show potential for substantial CO_2 reductions
- Drop-in fuel, and SAF in particular, plays largest role in reducing CO_2 for in-sector measures considered, followed by aircraft technology, and operations
- Will need CCS w/SAF, DAC, and/or out of sector offsets to get to zero
- Next Step: 41st ICAO Assembly in September

Full report: https://www.icao.int/environmental-protection/LTAG/Pages/LTAGreport.aspx

Aviation Climate Action Plan – Contents

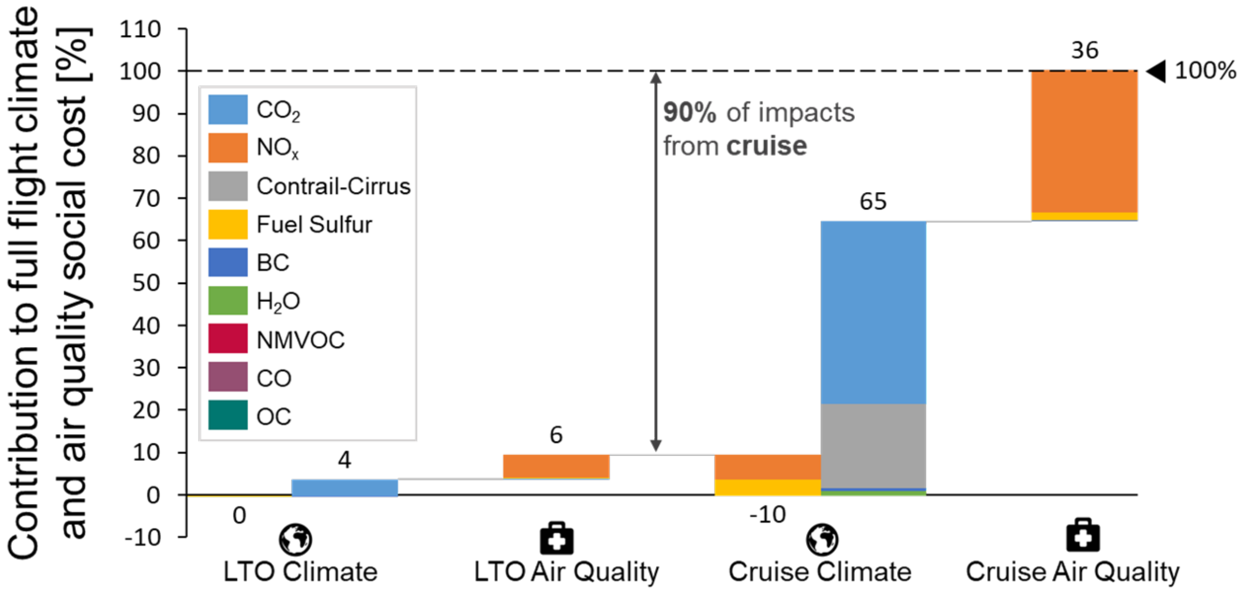
https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

- Introduction
- Climate Goals and Approach
- Aircraft and Engine Technology Development
- Operational Improvements
- Sustainable Aviation Fuels
- International Leadership and Initiatives
- Airport Initiatives
- FAA Leadership on Climate, Sustainability and Resilience
- **Non-CO_2 Impacts of Aviation on Climate**
- Policy and Measures to Close the Gap

Impacts of Aviation Emissions

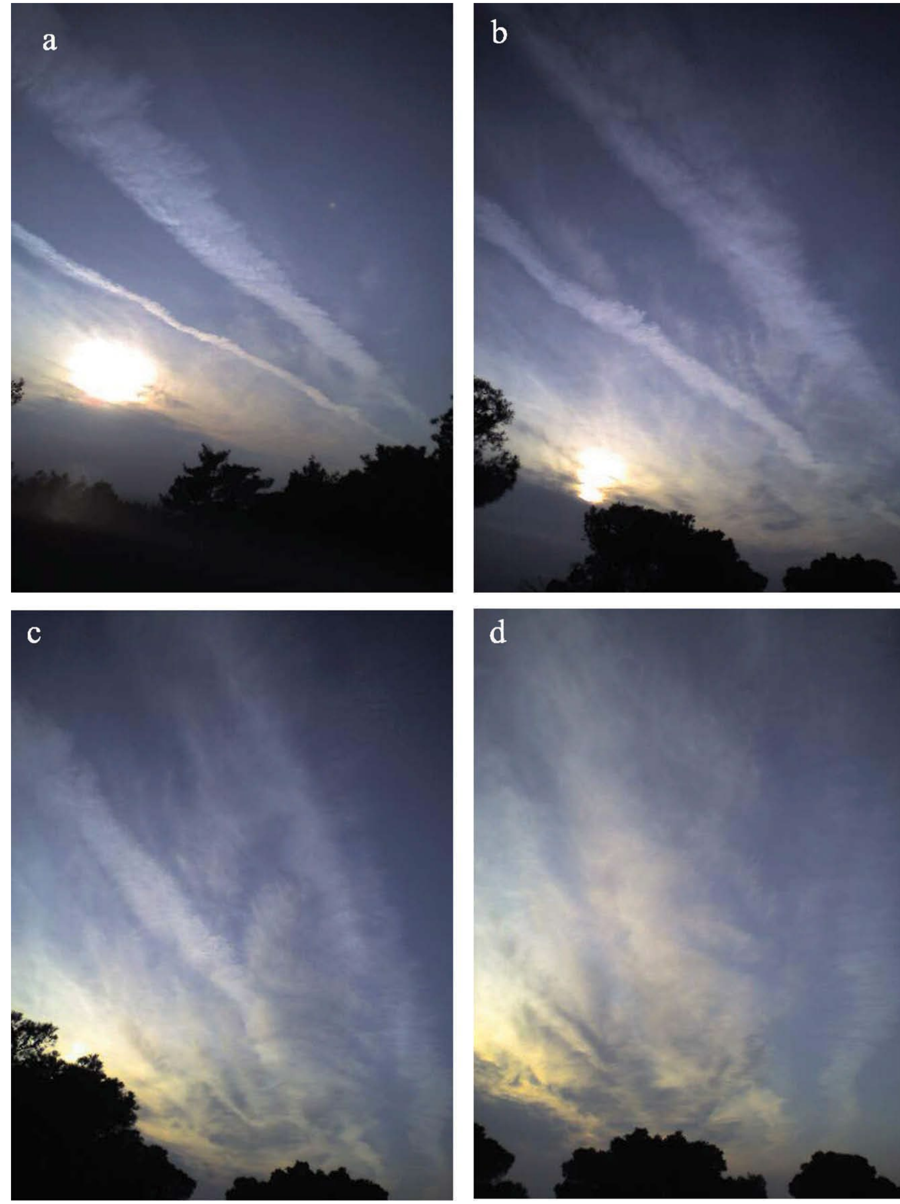
Impacts of Full Flight Emissions on Air Quality, Climate, and Ozone

- Project continues long-standing FAA-funded effort at MIT to use analytical tools to model global movement and transformation of aircraft emissions as well as their impacts on surface air quality, global climate change, and the ozone layer
- Team have found that globally, impacts of cruise emissions on surface air quality are larger than those attributed to landing and takeoff (~16,000 premature mortalities[1] or 0.2% of the 9 million premature mortalities from combustion emissions globally[2])
- However, the results have considerable uncertainty and we continue to do work to better understand the impacts of cruise emissions on surface air quality



1. *Grobler et al, Environmental Research Letters 2019. Data updated with more recent social cost of carbon, 3% discount rate; Country specific VSL.*
2. *Landrigan et al., The Lancet 2017*

Aviation Induced Cloudiness



Photographs of contrail spreading into cirrus taken from Athens, Greece, on 14 Apr 2007 at 1900, 1909, 1913, and 1920 local time (from top left to bottom right). Courtesy of Kostas Eleftheratos, University of Athens, Greece.

From: Heymsfield et al. BAMS 2010

Joint EPA-FAA fact sheet on contrails from September 2000:
https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/contrails.pdf

FAA Efforts Related to Aviation Induced Cloudiness (AIC)

FAA supporting research on multiple fronts to examine measures that *could* mitigate aviation's impact on climate change through modification to contrails and aviation induced cloudiness

Potential means of modifying aviation induced cloudiness

- Modify current jet fuel specification
- Sustainable Aviation Fuels (SAF)
- New engines and combustor technology
- Change lateral flight path or flight altitude

Sensor Development

Operational Procedure Modification

No current effort

Decision

Contrail Avoidan
Evaluation (A

Cost Benefit Ana
Composition (A
PARTN

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ment Campaigns
ts 2, 69, 81, 87)

rodyne Research Inc.
ects 24, 39, 48, 70, 71)

Improved Climate Knowledge and Modeling Capabilities

ASCENT Projects 21, 22, and 58

Combustor Technology Development

CLEEN Program

Recent Successes - Capabilities and Solutions Helping Today

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

- Provided analysis at the core of the U.S. Aviation Climate Action Plan
- At forefront of informing the development of a *long term aspirational goal for international aviation CO_2 emissions* within International Civil Aviation Organization (ICAO).
- Providing critical support to development of *Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*.
- Measurement technique and data provided foundation for 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)

- At forefront of informing polices on life cycle analysis of SAF (e.g., IRA SAF Blenders Tax Credit, CORSIA)
- Efforts featured prominently throughout the *SAF Grand Challenge Roadmap*
- *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*.

Accelerating Technological Innovation

- *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.

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. Informing ongoing noise policy review.
- 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.

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

Backup Slides

ASCENT Research

ASCENT Center of Excellence

For 18 years, FAA Office of Environment and Energy has relied on university centers of excellence to:

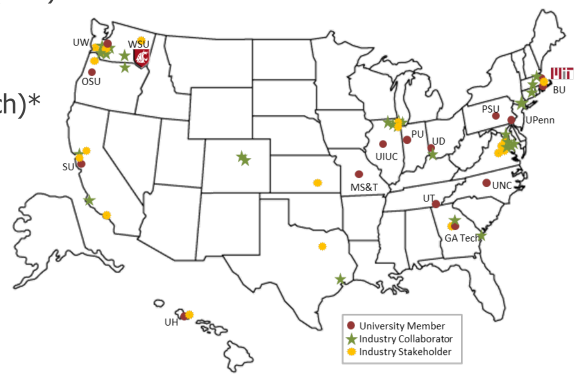
- Provide knowledge to inform decision making on environment and energy matters;
- Enable the introduction of innovative solutions to cost-effectively mitigate the environmental impacts of aviation; and
- Support the instruction of hundreds of professionals with knowledge of the environmental challenges facing aviation (*674 students supported and counting*).

ASCENT Research Portfolio

- In 2013, FAA established ASCENT to conduct research on environment and alternative jet fuels
- Portfolio covers broad range of topics on Alternative Jet Fuels, Emissions, Noise, Operations, and Analytical Tools
- Currently overseeing a large increase in the COE portfolio

Lead Universities:
Washington State University (WSU)
Massachusetts Institute of Technology (MIT)*

Core Universities:
Boston University (BU)*
Georgia Institute of Technology (Ga Tech)*
Missouri University of Science and Technology (MS&T)*
Oregon State University (OSU)
Pennsylvania State University (PSU)*
Purdue University (PU)*
Stanford University (SU)*
University of Dayton (UD)
University of Hawaii (UH)
University of Illinois at Urbana-Champaign (UIUC)*
University of North Carolina at Chapel Hill (UNC)*
University of Pennsylvania (UPenn)*
University of Tennessee (UT)
University of Washington (UW)



Multiple international partners

Advisory Committee (57 orgs)
5 airports
4 airlines
9 NGO/advocacy
8 aviation manufacturers
10 feedstock/fuel manufacturers
21 R&D, service to aviation sector

ASCENT Support

Federal Aviation Administration
Transport Canada
NASA
Environmental Protection Agency
Defense Logistics Agency - Energy
U.S. Dep't of Energy
U.S. Dep't of Agriculture
Air Force Research Laboratory

For more information: https://ascent.aero/

Overview of FY2022 Grant Awards

- In 2018, a grant review and approval process was established wherein Secretary of Transportation approved all grants, including research grants
- Currently working to eliminate this process

- Status of grant awards for FY2022

	Grant Awards	Projects	Value of Awards	OST Approval Date
Memo 1	11	10	$2,580,230	May, 2022
Memo 2	32	26	$13,441,791	Sept, 2022
Memo 3	43	33	$19,463,979	Pending
Total	***86***	***69***	***$35,486,000***	

FY2022 ASCENT – Select Fuels Projects

Project	Title	University
1	Alternative Jet Fuel Supply Chain Analysis	Washington State University Massachusetts Institute of Technology University of Hawaii Pennsylvania State University University of Tennessee Purdue University
31	Alternative Jet Fuels Test and Evaluation	University of Dayton
52	Comparative Assessment of Electrification Strategies for Aviation	Massachusetts Institute of Technology
80	Hydrogen and Power to Liquid (PtL) Concepts for SAF Production	Washington State University Massachusetts Institute of Technology
81	Measurement and Prediction of non-volatile particulate matter size and number emissions from sustainable and conventional aviation fuels	Missouri University of Science and Technology
87	Measurement of nvPM size, number and compositional emissions, for Boeing eco-Demonstrator aircraft burning Sustainable Aviation Fuel	Missouri University of Science and Technology
88	A Method for Rapidly Assessing Jet Fuel Compatibility with non-Metallic Materials	University of Dayton
89	Characterization of Compositional Effects on Dielectric Constant	University of Dayton
90	World Fuel Survey	University of Dayton
93	Collaborative Research Network for Global SAF Supply Chain Development	Massachusetts Institute of Technology University of Hawaii Washington State University

FY2022 ASCENT – Select Emissions Projects

Project	Title	University
78	Contrail Avoidance Decision Support and Evaluation	Massachusetts Institute of Technology
81	Measurement and Prediction of non-volatile particulate matter size and number emissions from sustainable and conventional aviation fuels	University of Missouri
82	Integrated Noise and CO2 Standard Setting Analysis	Georgia Tech Massachusetts Institute of Technology
83	NOx Cruise/Climb Metric System Development	Massachusetts Institute of Technology
84	Noise Modeling of Advanced Air Mobility Flight Vehicles	Massachusetts Institute of Technology
87	Measurement of nvPM size, number and compositional emissions, for Boeing eco-Demonstrator aircraft burning Sustainable Aviation Fuel	University of Missouri
91	Environmental Impacts of High Altitude and Space Vehicle Emissions	Massachusetts Institute of Technology University of Illinois

FY2022 ASCENT – Select Noise Projects

Project	Title	University
3	Cardiovascular Disease and Aircraft Noise Exposure	Boston University
82	Integrated Noise and CO_2 Standard Setting Analysis	Georgia Tech Massachusetts Institute of Technology
84	Noise Modeling of Advanced Air Mobility Flight Vehicles	Massachusetts Institute of Technology
86	Study on the use of broadband sounds to mitigate sleep disruption due to aircraft noise	University of Pennsylvania
94	Probabilistic Unmanned Aircraft Systems (UAS) Trajectory and Noise Estimation Tool	Georgia Tech

FY2022 ASCENT – Select Technology Project

Project	Title	University
79	Novel Noise Liner Development Enabled by Advanced Manufacturing	Pennsylvania State University
92	Advanced Two-Stage Turbine Rig Development	Pennsylvania State University

New ASCENT Projects in FY2022 Memos

Project	Title	University
81	Measurement and Prediction of non-volatile particulate matter size and number emissions from sustainable and conventional aviation fuels	University of Missouri
82	Integrated Noise and CO2 Standard Setting Analysis	Georgia Tech Research Corporation Massachusetts Institute of Technology
83	NOx Cruise/Climb Metric System Development	Massachusetts Institute of Technology
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