National Aeronautics and Space Administration

NASA AATT Project Overview

Cliff Brown

Acoustics Technical Working Group

October 18, 2022

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Current AATT Project Organization (October 2022)

Project Manager *Dale Van Zante (Acting)*

Deputy Project Manager *Melinda Cagle*

Chief Technologists *Scott Anders (Airframe)*
Julia Stephens (Acting,Propulsion)

Flight Test Advisor *Randy Thompson*

Business Manager *Mark Monaco*

Center Integration Managers
Bruce Storms (ARC) *Sam Simpliciano (AFRC)*
John Mudry (GRC) *Marisol Garcia (LaRC)*

Center Resource Analysts
Eric Lee (ARC) *Alejandra Pacheco (AFRC)*
Mark Monaco (GRC) *vacant (LaRC)*

Project Coordinator *Keshia Newsome*
Config. and Data Mgr. *Mike Rogers*
Risk Facilitator *Stephan Manchir*
Scheduler *Leslie Letzinger*

Systems Analysis & Integration
Jesse Quinlan, Lead
Eric Hendricks, Co-Lead

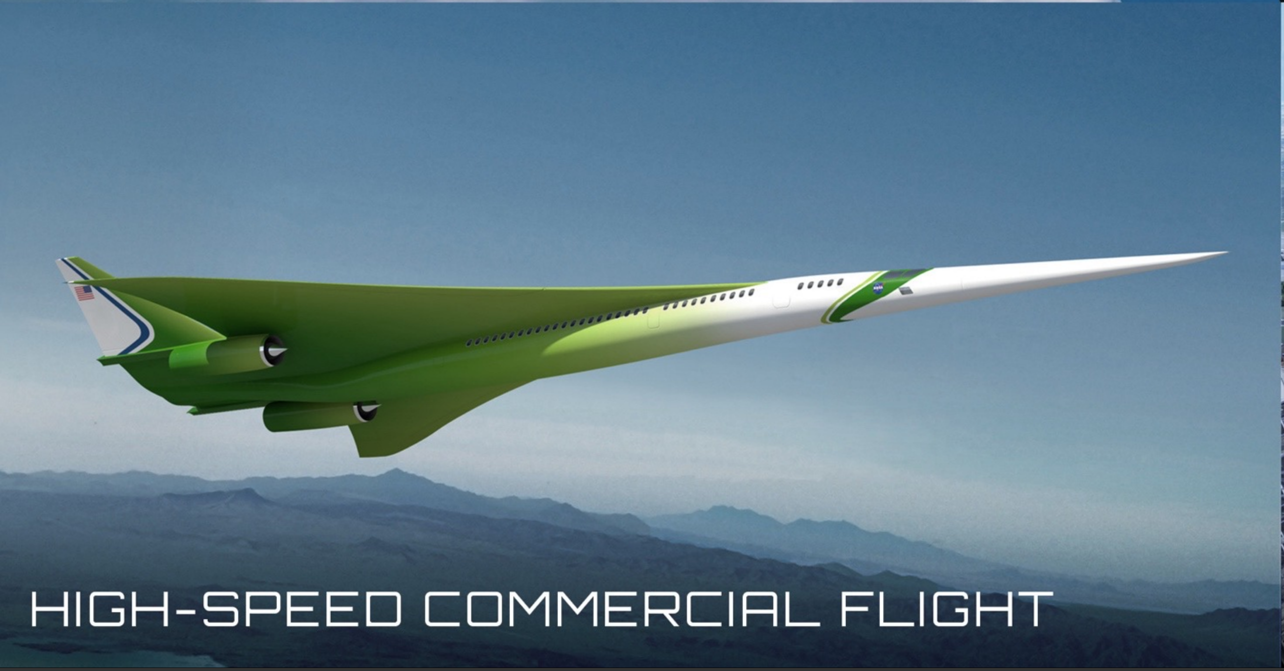
Propulsion and Power (P&P) Subproject
Amy Jankovsky, SPM
Jessica Reinert, DSPM

Technical Leads:
Cliff Brown, Rodger Dyson, Jennifer Klettlinger, Peter Struck, Andy Woodworth, Brian Howerton, Ezra McNichols

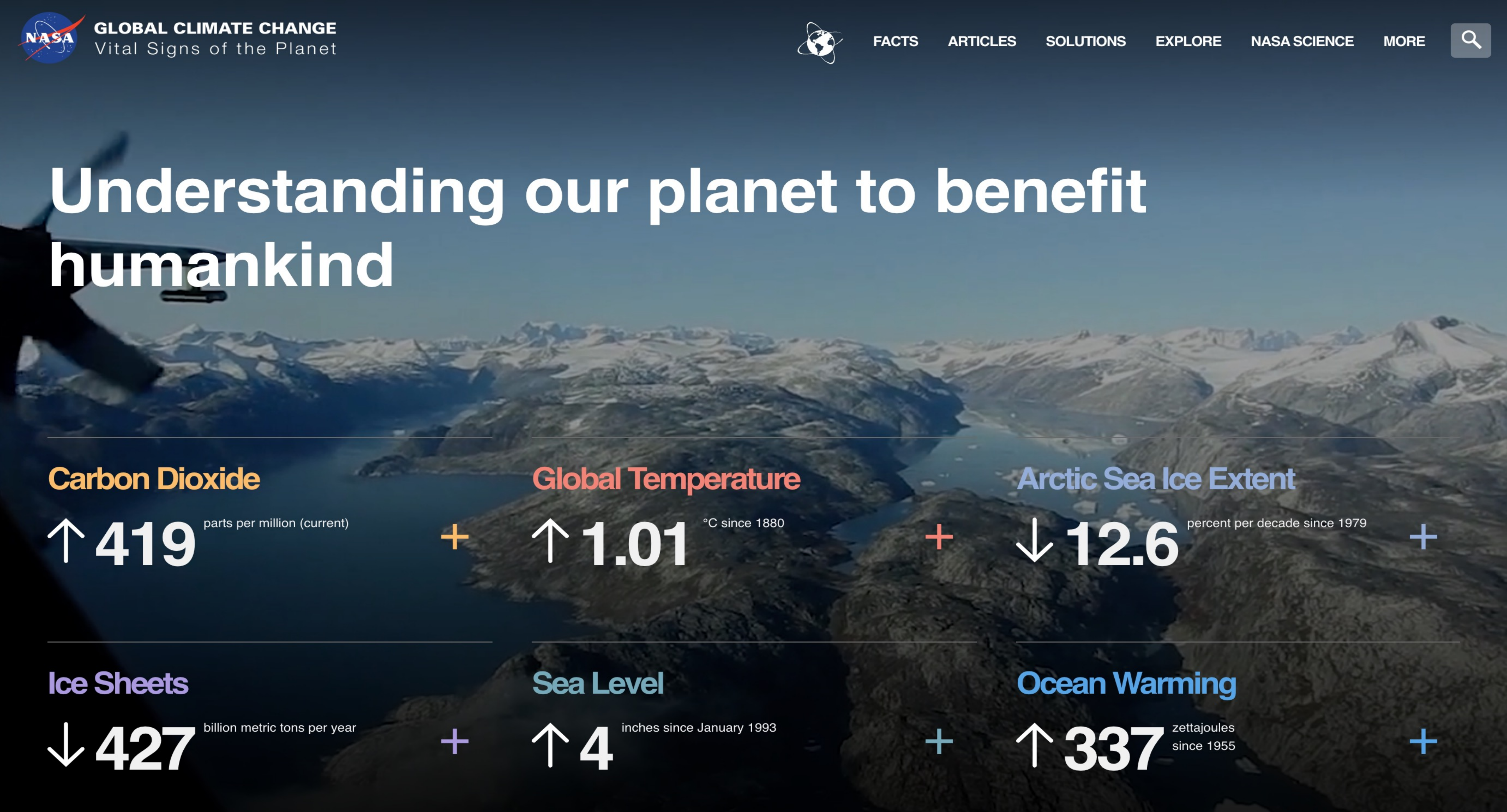
Vehicle Systems Integration (VSI) Subproject
Susan Wilz, SPM
Jim Moore, DSPM
Marisol Garcia, DSPM

Technical Leads:
Andy Broeren, David Chan, Latunia Melton, William Milholen, Shishir Pandya, Julia Stephens, Karen Taminger, Florence Hutcheson

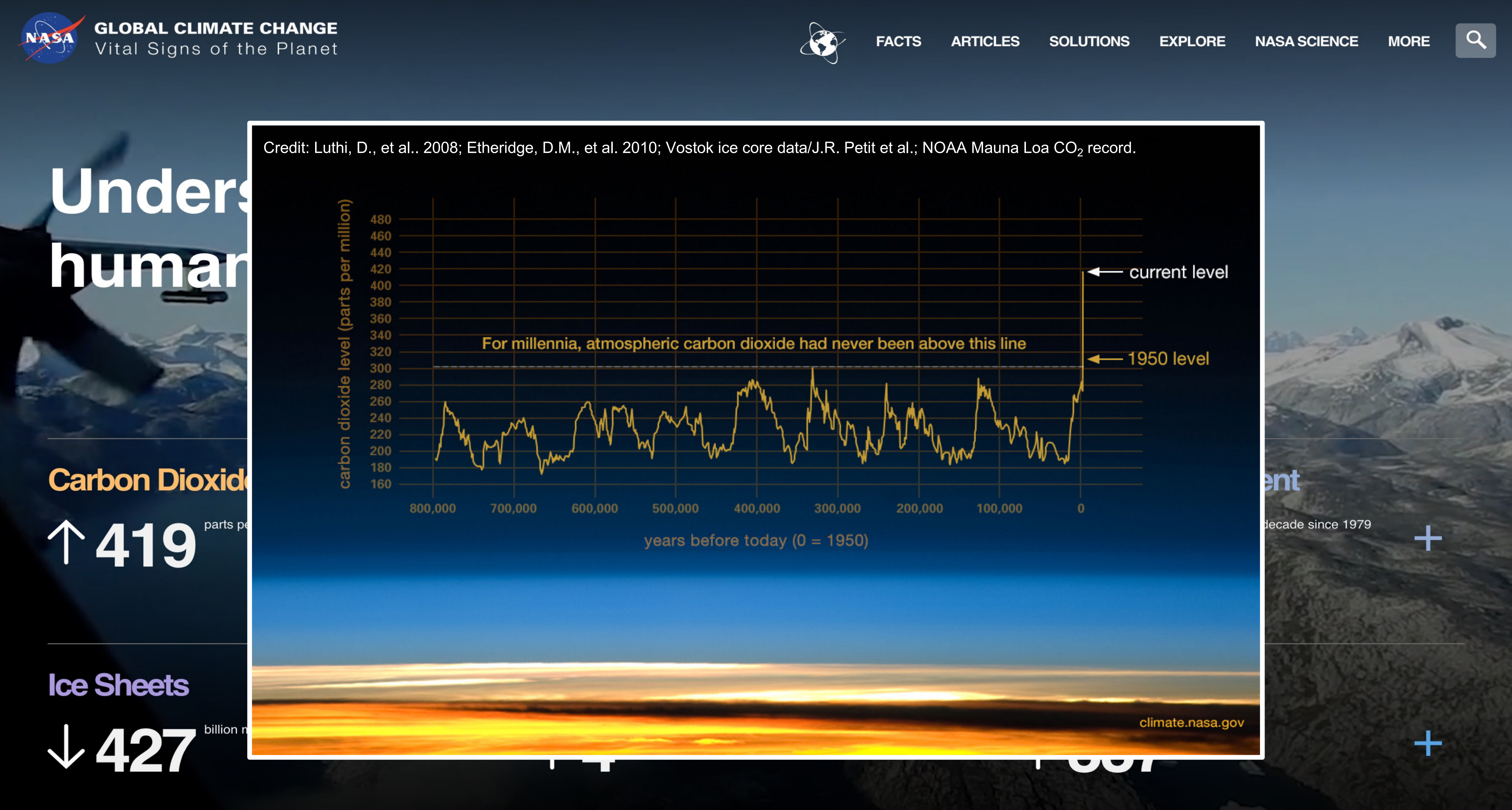
Names shown in red new since last year



Four Transformations for Sustainability, Greater Mobility, and Economic Growth

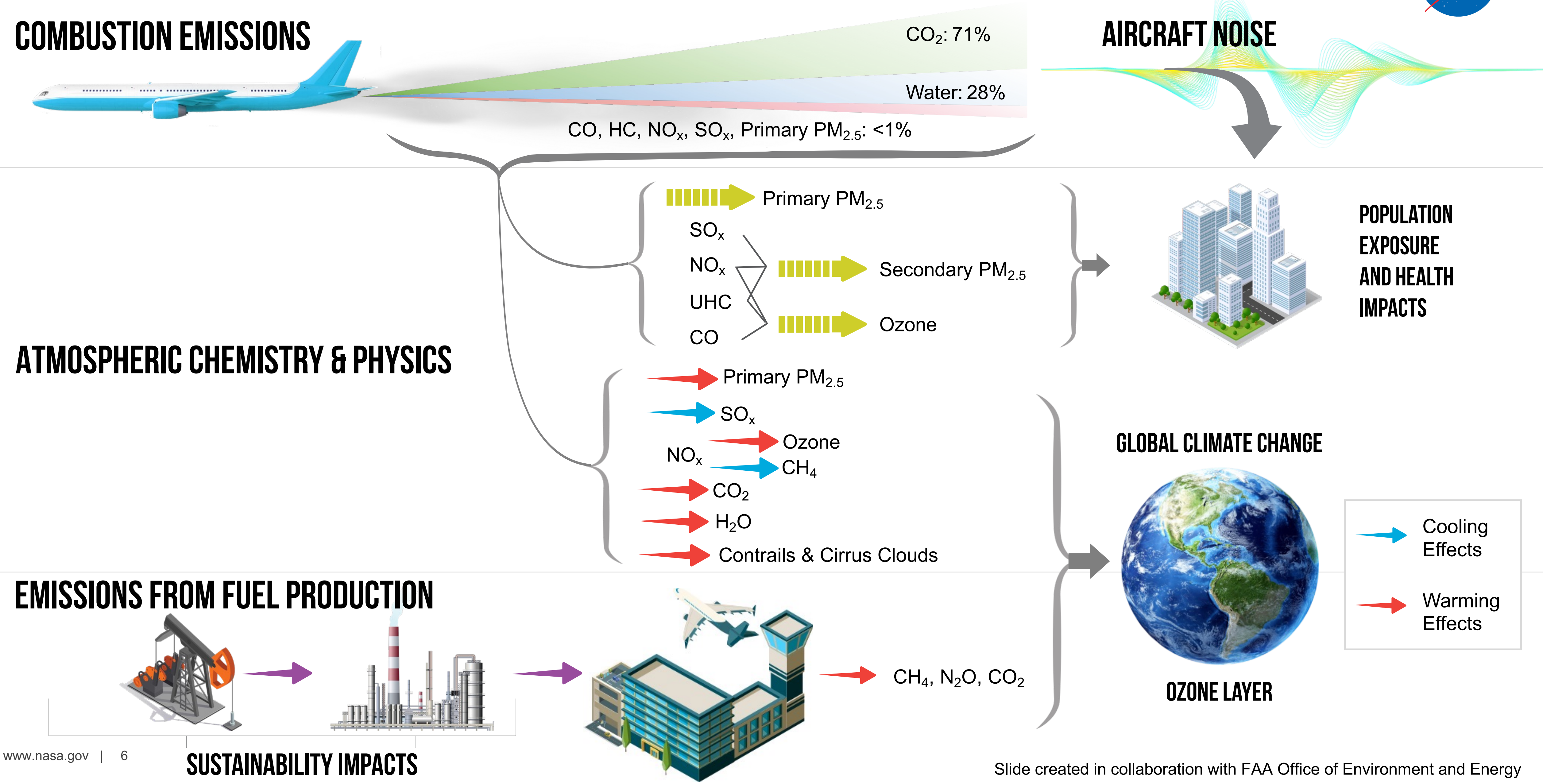


Source: climate.nasa.gov on Sept. 24, 2022



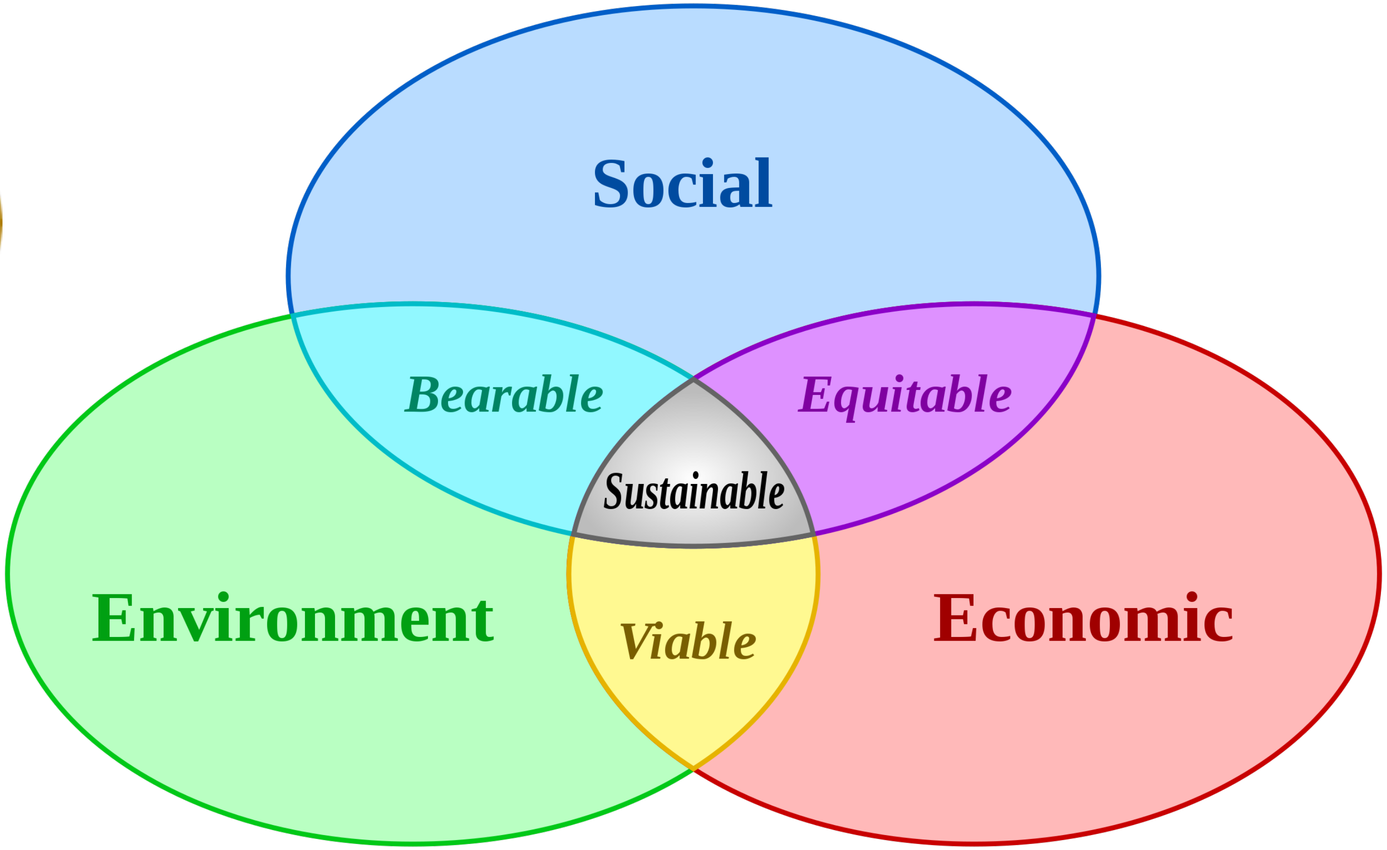
Source: climate.nasa.gov on Sept. 24, 2022

Environmental Impacts of Aviation



Slide created in collaboration with FAA Office of Environment and Energy

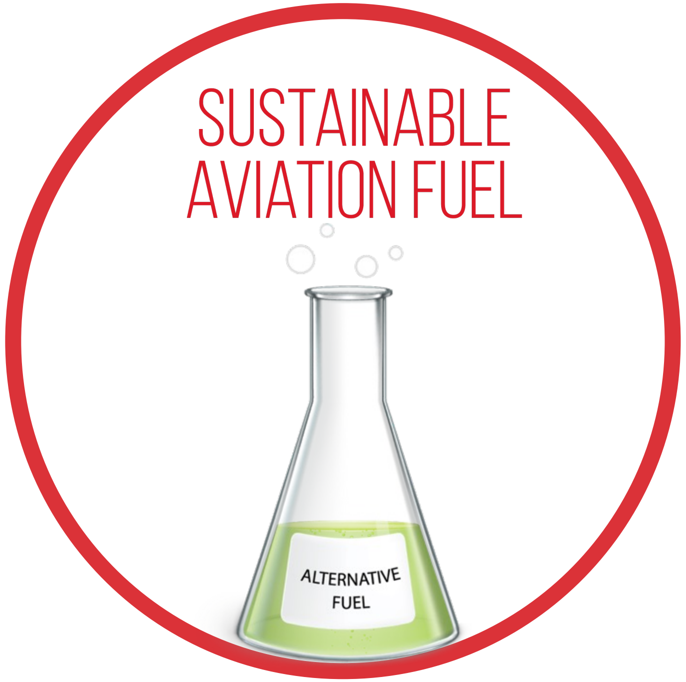
Sustainable Flight National Partnership (SFNP)



Sustainability is more than aircraft emissions;
it is at the intersection between environmental, social, and economic factors.

Aviation Pillars for a Sustainable Future

NASA = Primary Role



NASA = Supporting Role

NASA = Primary Role

Achieve net-zero greenhouse emissions by 2050 through 25-30% energy efficiency improvements in next-generation transports, 100% sustainable aviation fuel, and optimal trajectories

Sustainable Flight National Partnership Benefits

Small Core Gas Turbine for 5%-10% fuel burn benefit
(HyTEC Project)

Electrified Aircraft Propulsion for ~5% fuel burn and maintenance benefit
(EPFD & AATT Projects)

Sustainable Aviation Fuels for reduced lifecycle carbon emissions
(AATT Project)

Transonic Truss-Braced Wing for 5%-10% fuel burn benefit
(AATT Project)

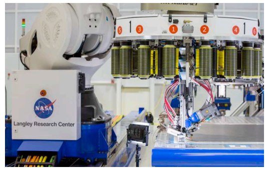
High-Rate Composites for 4-6x manufacturing rate increase
(HiCAM Project)

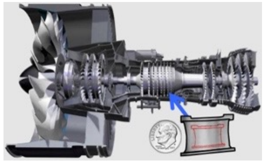
Integrated Trajectory Optimization for 1%-2% reduction in fuel required and minimization of contrail formation
(ATM-X Project)

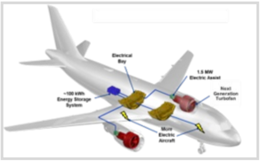
Achieve 25-30% energy efficiency improvements and 10-15 dB noise reduction in next-generation transports*

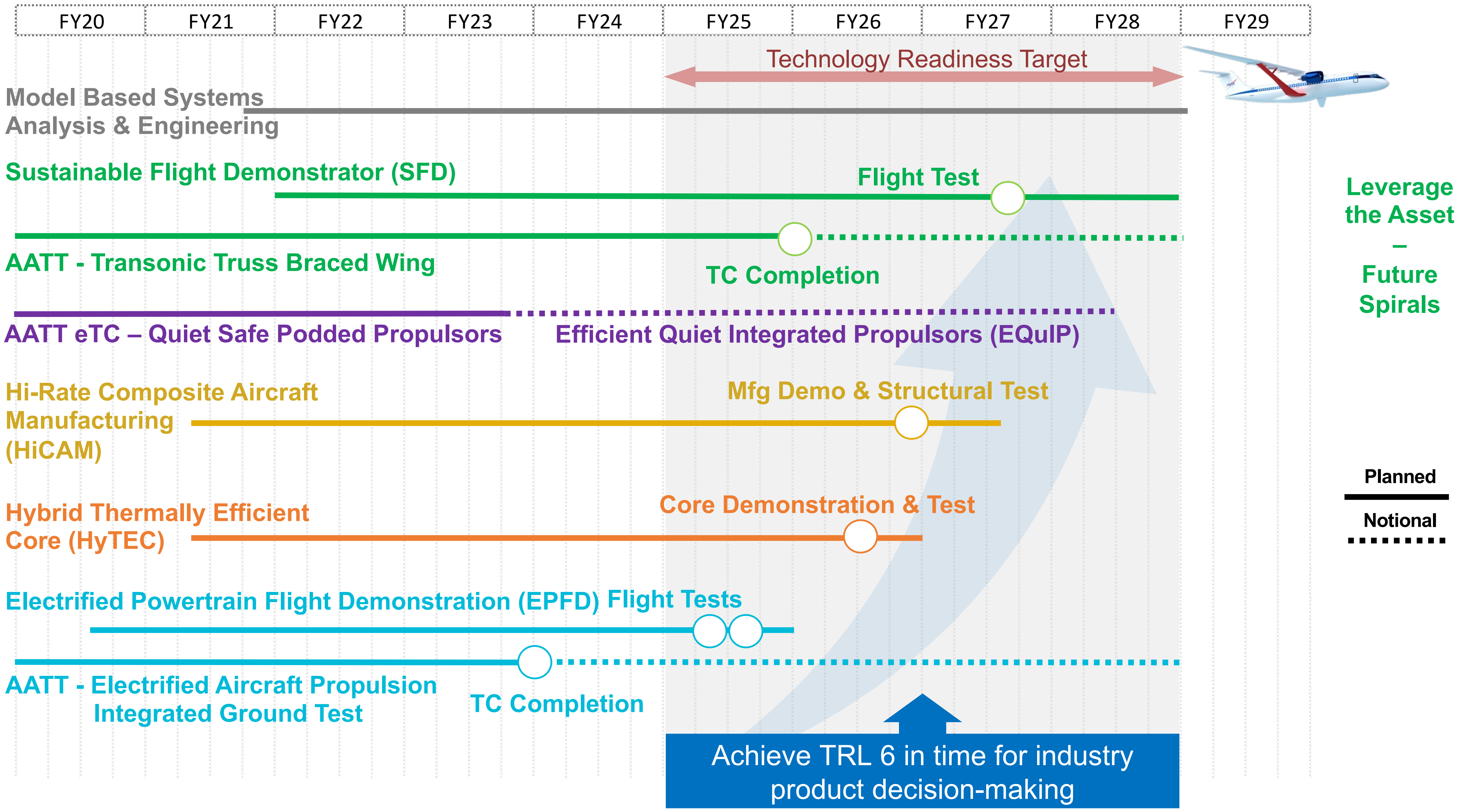
* U.S. Aviation Climate Action Plan

Subsonic Transports: Integrated Technology Development



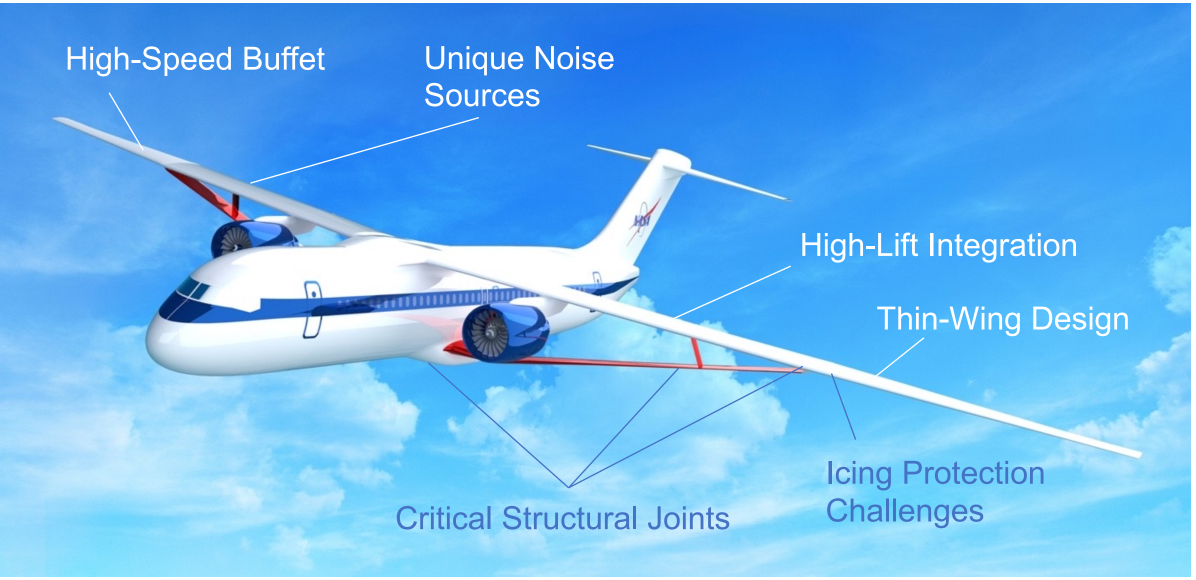






Transonic Truss-Braced Wing Technology Maturation

Increase confidence in technology to be robustly integrated in the aircraft system



Scope

- Mature and reduce risk of Transonic Truss-Braced Wing (TTBW) technology, focused on:
  - Buffet boundary prediction
  - Stall characteristics
  - High-lift system integration
  - Acoustic assessment
  - Icing impact
  - Thin wing structural design
  - Unique structural joints

Benefit

- Achieve 5-10% reduction in fuel burn through reduced drag

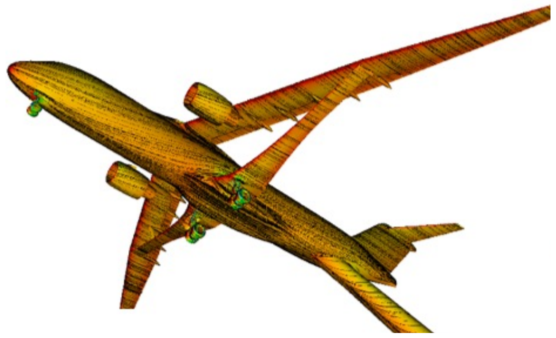
Approach

- Concept studies through scale model testing
- Perform high-fidelity prediction, testing and validation to increase confidence in fuel burn benefit

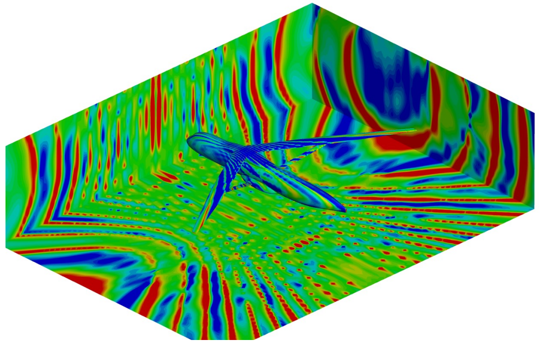
Design/Analysis/CFD studies and wind-tunnel tests are underway

TTBW Acoustic Research, Predictions, and Assessment

- Steady CFD simulations of the TTBW in-progress – results being validated against wind tunnel test data and used for system-noise assessments
- Noise scattering tests on-going in the NASA LaRC Quiet Flow Facility
- High resolution unsteady numerical simulations to predict noise and guide the improvement of system level prediction tools **(NASA/3DS/AVEC)**
- Development of computational tools to predict and assess the effects of scattering by the TTBW airframe **(Old Dominion University)**
- Modeling and testing of Slat Gap Filler (SGF) devices for low-noise leading-edge designs applicable to TTBW **(NASA & Texas A&M)**
- Assess noise contribution of Krueger flap bracket to TTBW system noise via testing in Florida State University's hybrid wind tunnel **(FSU)**.



PowerFlow Unsteady CFD Simulation

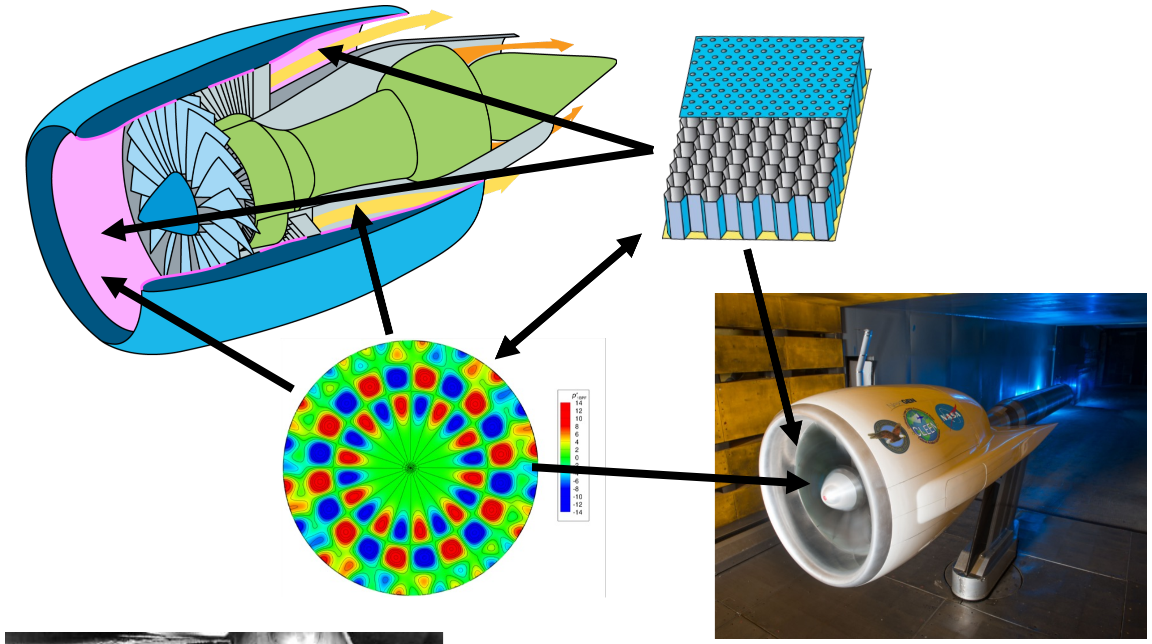


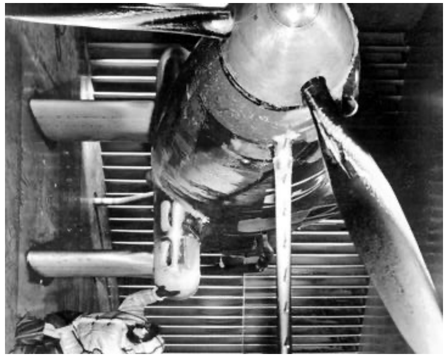
TTBW Noise Scattering Prediction

Computational and experimental work in progress to: support TTBW system noise assessments; reduce uncertainty; and assess potential noise reduction technologies

Quiet Safe Podded Propulsors (QESPP) eTC

Support MBSA&E and industry develop and assess next-generation propulsor technology





Scope
- Assess, model, and predict noise from advanced propulsors, develop source and liner noise mitigation technologies, evaluate aerodynamic performance, and assess icing and aeromechanics risks

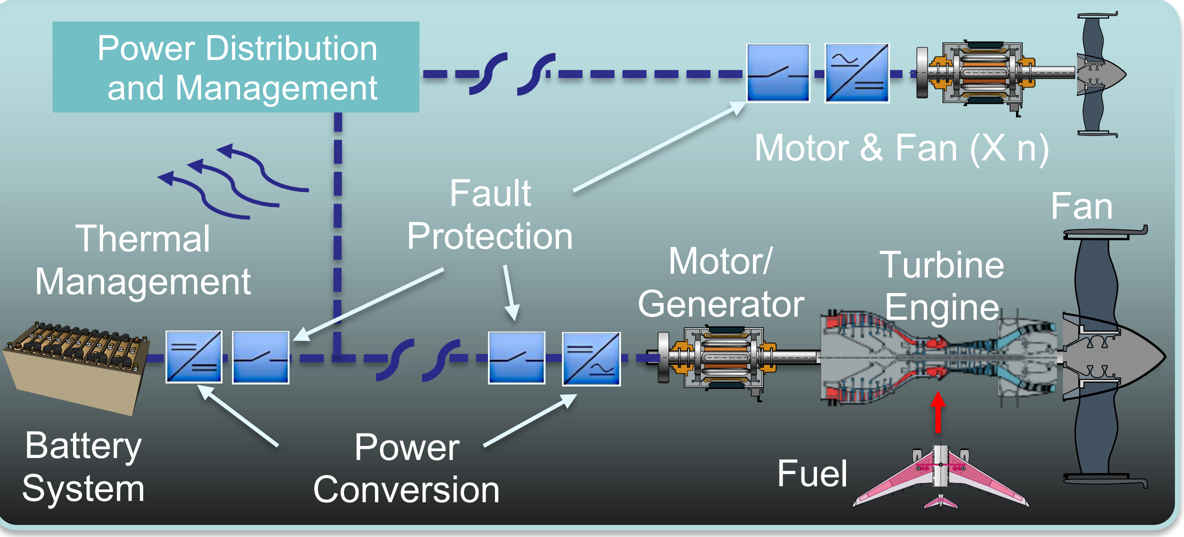
Benefit
- Accelerate next-generation propulsor development for 5-10% fuel burn reduction and Chapter 14 noise with margin
- Support MBSA&E efforts with validated models and predictions in relevant time

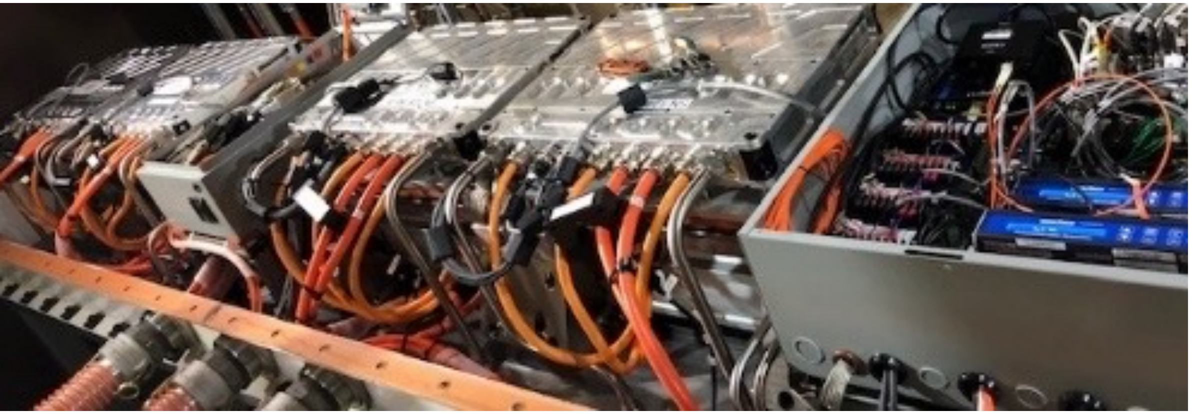
Approach
- Partner with industry and FAA CLEEN to mature and demonstrate promising technologies

Modern high bypass ratio propulsors are a dominant aircraft noise source with potential for significant efficiency gains regardless of power source

Focused Technologies for Electrified Aircraft Propulsion

Retire barrier technical and integration risks for megawatt-class electrified aircraft propulsion systems





Scope

- Address critical challenges for electrified aircraft propulsion by maturing and reducing risk for Electrified Aircraft Propulsion (EAP) technology, focused on:
  - Mass and weight reduction
  - Electrical losses
  - Reliability
  - EMI, power quality, dynamic stability
  - Limits on DC voltage levels
  - System design and integration

Benefit

- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft.
- Reduce key risks for a range of future applications and help enable new standards that are needed for EAP-based aircraft certification

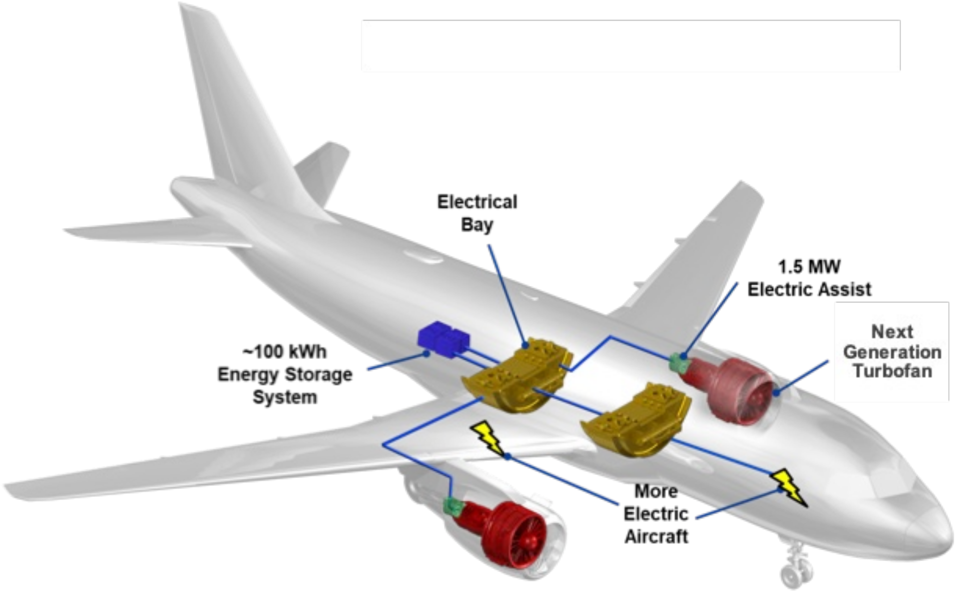
Approach

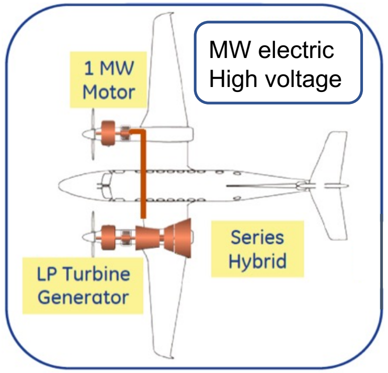
- Conduct technology-focused integrated ground tests
- Partner with industry on testing of electrified propulsion architectures and component technologies
- Leverage prior electric aircraft propulsion advances (TRL ~4)

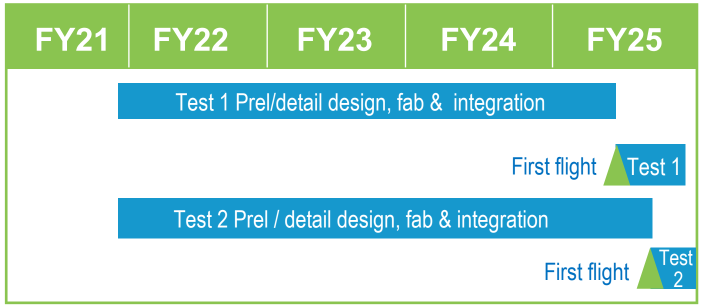
Architecture development and
high-power component tests are underway.

Electrified Powertrain Flight Demonstration

Demonstrate integrated electrified powertrains in flight using industry platforms







Scope

- Demonstrate practical vehicle-level integration of megawatt-class electrified aircraft propulsion systems, leveraging advanced airframe systems to reinvigorate the regional and emerging smaller aircraft markets and strengthen the single aisle aircraft market.
- Assess gaps in regulations/standards to support future Electrified Aircraft Propulsion (EAP) certification requirements.

Benefit

- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft.
- Enable new standards that are needed for EAP-based aircraft certification.

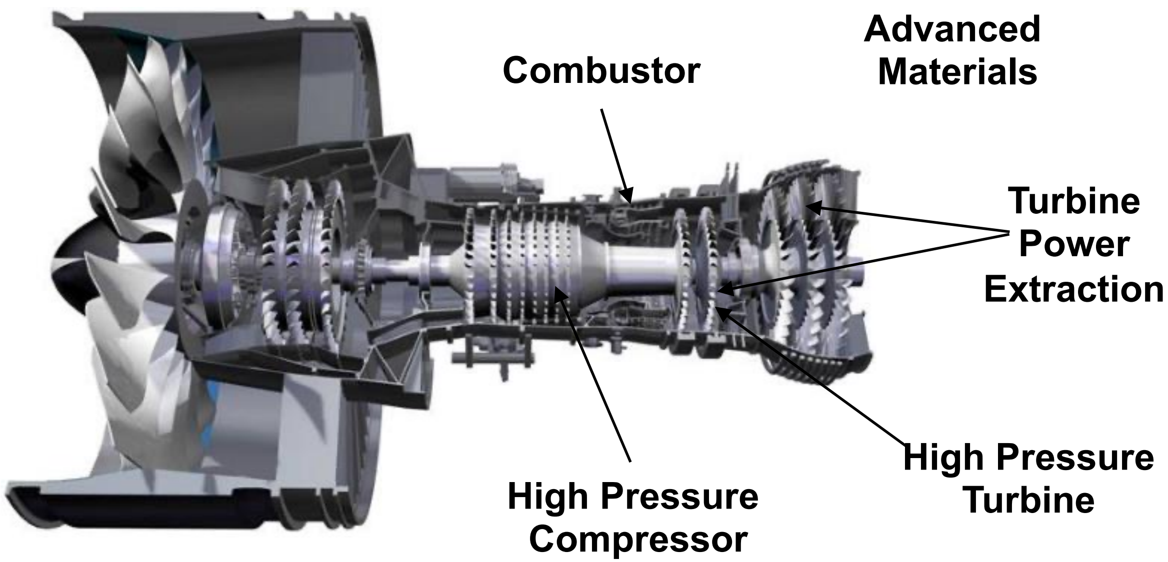
Approach

- Engage with U.S. industry to integrate and demonstrate megawatt-class EAP machines in flight.
- Engage with the FAA, SAE, ASTM, etc. to contribute data that inform EAP standards and regulations.

Two Flight Demonstration Contracts Awarded in September 2021

Hybrid Thermally Efficient Core

Accelerate development and demonstration of advanced turbine engine technologies



Scope

- Develop and demonstrate in integrated ground tests engine core technologies to Increase thermal efficiency, reduce engine core size and facilitate hybridization

Benefit

- Achieve **5-10% fuel burn reduction** versus 2020 best in class
- Achieve **up to 20% power extraction** (4 times current state of the art) at altitude to optimize propulsion system performance and enable hybridization

Approach

- Partner with industry to mature and demonstrate promising technologies

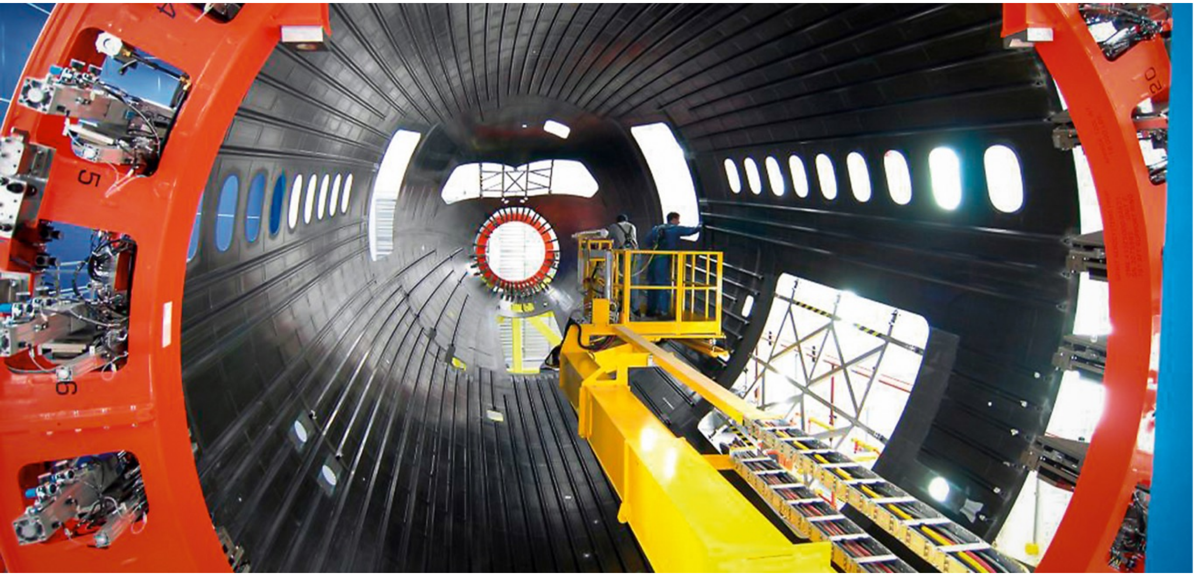
Small-core turbofan technology contract awards were made in September 2021.

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

4–6x production rate increase without cost or weight penalty

Production Rate per Month

• Metals	SOA:	60
• Composites	SOA:	10-15
	Target:	80-100



Scope

- Explore and advance high-rate composite manufacturing and assembly technologies
  - Evolving State-of-Art (SOA) thermosets, thermoplastics, resin transfer molding
  - Materials, processes, and architectures
  - Develop model-based engineering tools for high-rate manufacturing concepts

Benefit

- Increased manufacturing rates for composite aircraft structures to meet future production requirements and enable market penetration for lightweight composite materials

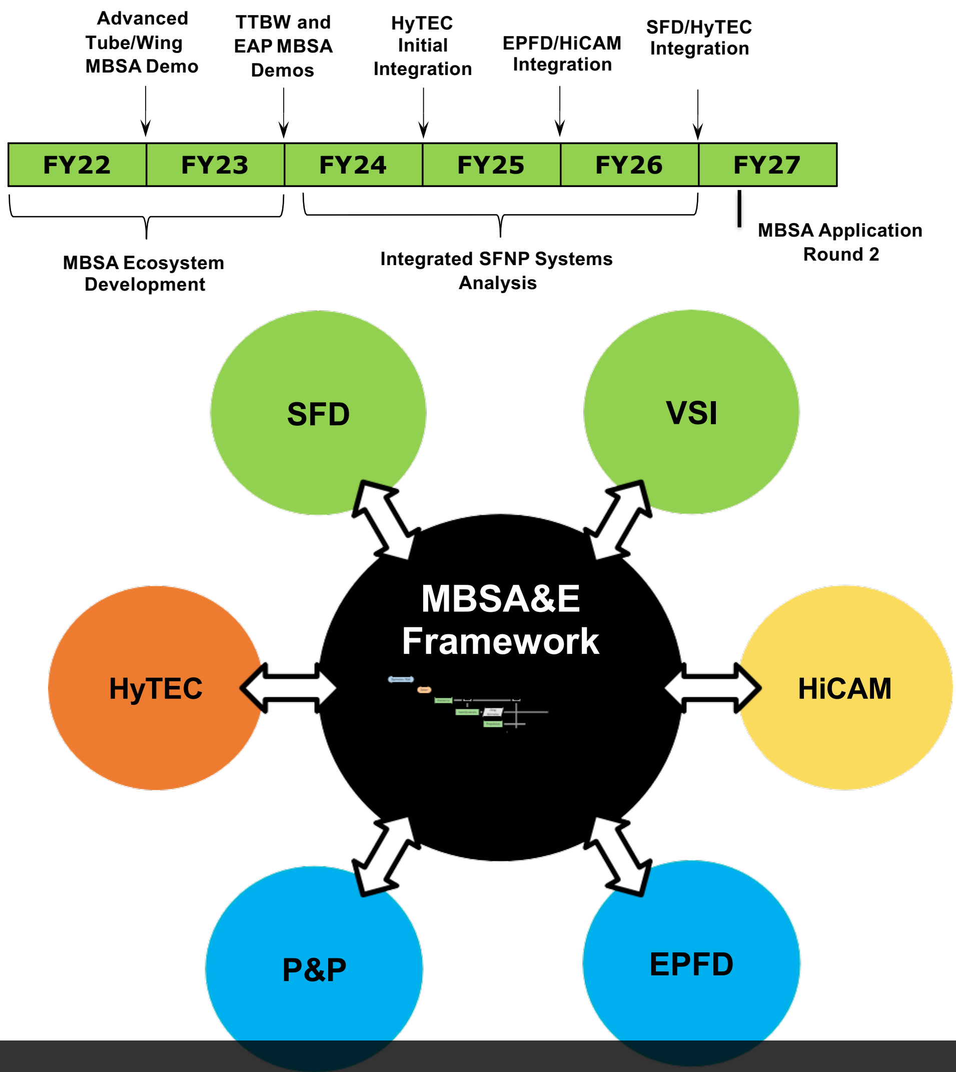
Approach

- Leverage advances in simulation including methods from Advanced Composites project
- Partner with industry for rapid prototype and evaluation of manufacturing concepts
- Demonstrate technologies in large structural ground tests

12 Cooperative Tasks Awarded to Inform HiCAM Plans

Model Based Systems Analysis and Engineering (MBSA&E)

- Objective: Assess system-level benefits over a broad portfolio of sustainable aircraft technologies in relevant time
- Approach: Develop an open cross-program MBSA&E capability for system analysis and benefit assessments
- Anticipated Results:
  - Component-level research and demonstration teams will provide relevant models appropriate for the MBSA&E framework
  - MBSA&E framework will be used to digitally integrate SFNP technologies and vision concepts and assess the collective impacts of broader, component-level research



MBSA&E will provide traceable, integrated, system-level benefit assessments of vision vehicle concepts informed by SME’s, demonstrations, and external partnerships

NASA AACES 2050 Studies

Advanced Aircraft Concepts for Environmental Sustainability

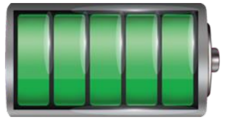
2008-2019 | 2020-2029 | 2030 - 2039 | 2040 - 2050

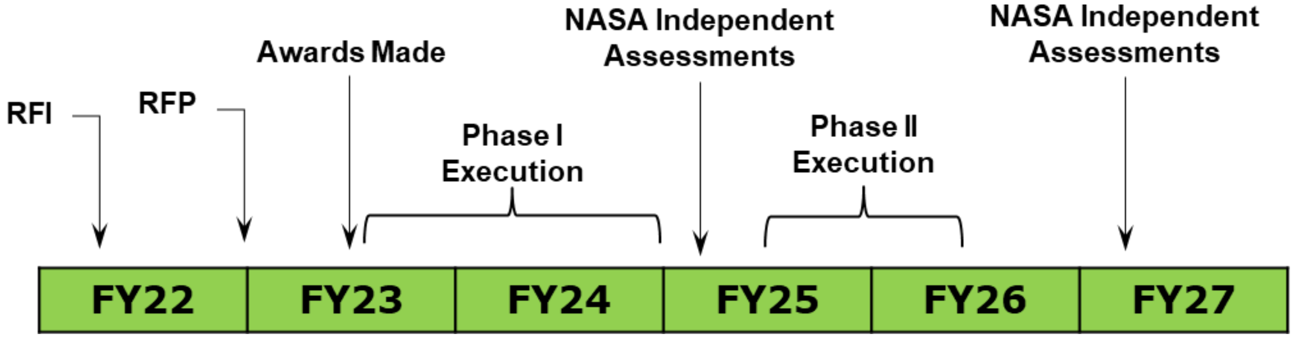
FY10-15 ERA N+2 for the 2020s Impact

FY09 N+3 Adv Concept Studies Target 2030-35 Impact

FY23 “N+4” AACES Studies - Explore 2020s, Demo 2030s, Impact 2040s

- *2040s Marketplace (payload/range/speed), 2050 Environmental Goals*
- *Alternative Energy Scenarios (LH2, LNG, Increased Electrification, 100% SAF)*
- *Advanced Airframes (clean energy compatible, shielding, adaptive, unconventional structures)*
- *Alternative propulsion (clean energy compatible, BLI, distributed propulsion, hybrid electric)*
- *Tools & Methods for Reduced Lifecycle Cost & Environmental Impact*

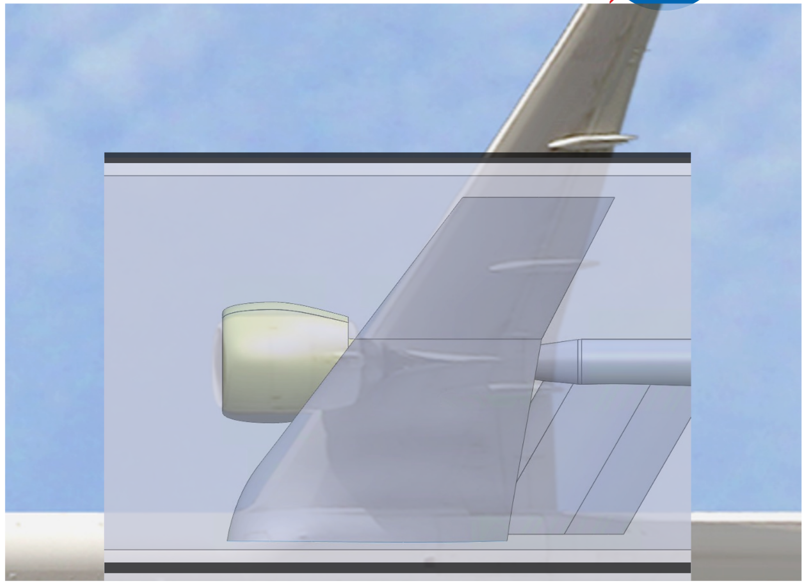


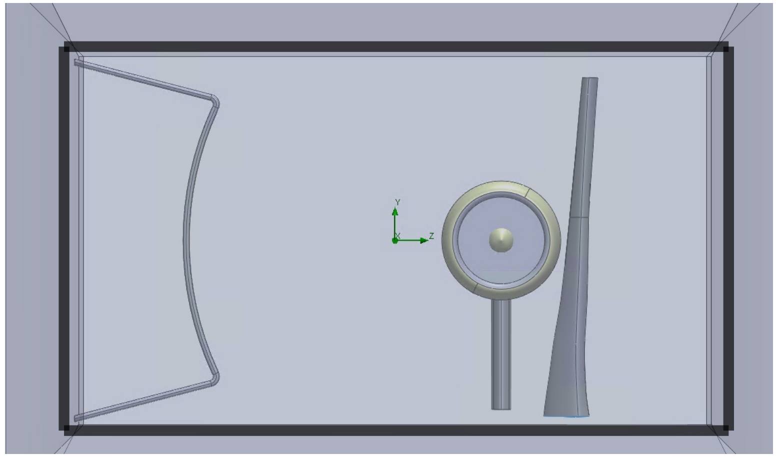


RFI Released 5/19/22, RFP Fall 2022, Awards Early CY23

Efficient Quiet Integrated Propulsors (EQuIP) Proposal

- Objective:
  - Assessment and risk mitigation of integrated propulsors to meet noise and efficiency goals for the next-generation single-aisle aircraft in the 2030's.
  - Provide noise and performance models with integration effects to support MBSA&E and AACES studies
- Approach: Include wing section in NASA's 9x15 Low Speed Wind Tunnel for integrated propulsor testing
- Status:
  - CFD to demonstrate feasibility, provide aerodynamic loading on wing, angle of attack limitations
  - Mechanical design feasibility study





Modern propulsors are closely coupled to the airframe; we must account for the effect of engine-airframe integration on noise and efficiency in our models and assessments

Educational Outreach: NASA Advanced Noise Control Fan

- Objective:
  - Advance noise source reduction and acoustic/thermal management liner technologies
  - Prepare the next generation of engineers
- Approach: Partner with University of Notre Dame to operate the ANCF as a low-TRL, low-cost concept evaluation test rig
- Results (2022):
  - 12 students from 4 universities gained hands-on experience using the ANCF for undergraduate and graduate research
  - Lab and research capabilities improved at UND, WSU, NCAT

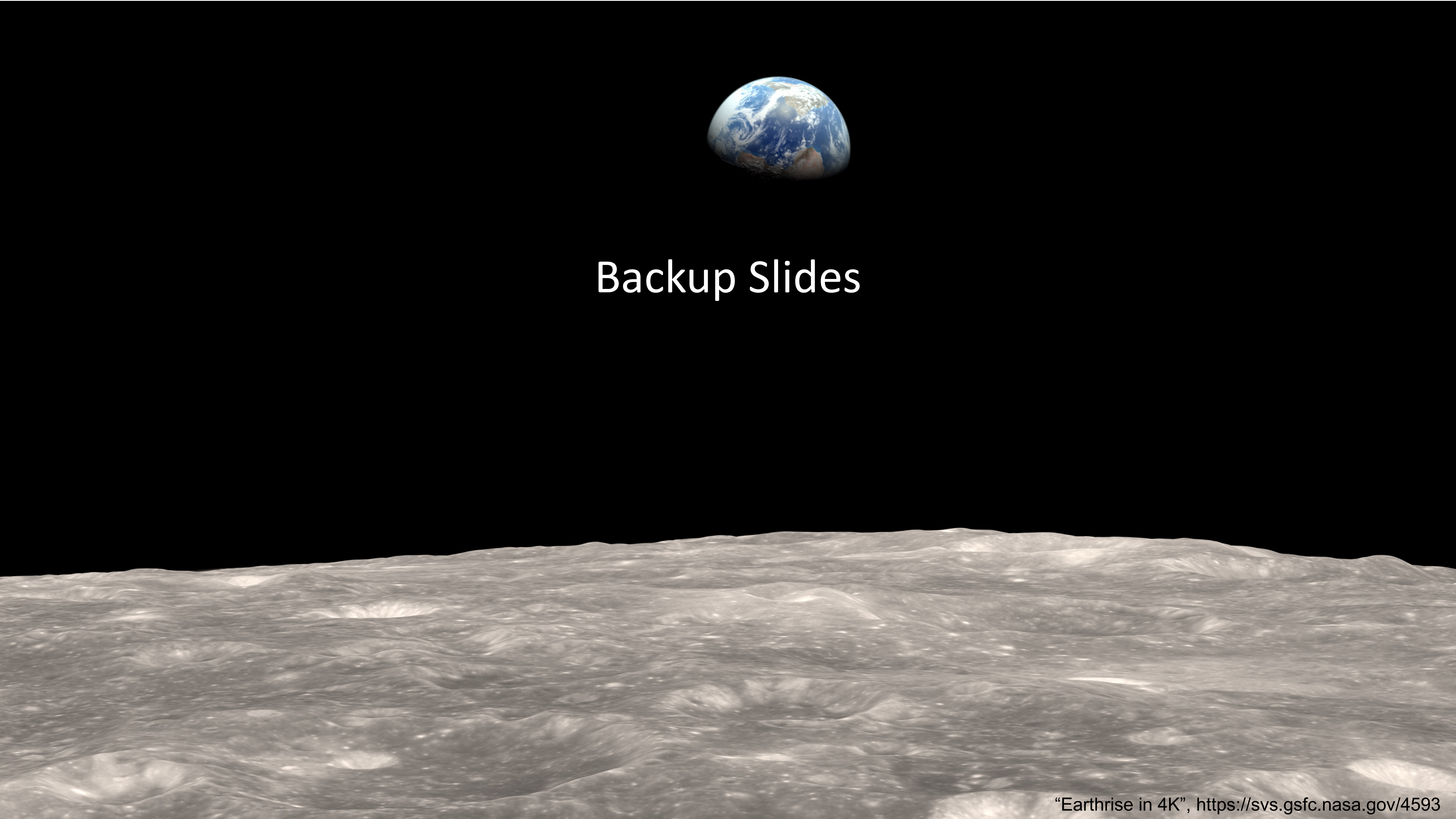
Meeting the sustainability challenge requires meeting the needs of society in the present while *preparing the next generation to meet their own needs*

Sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainability "does imply limits – not absolute limits but limits imposed by the present state of technology"; but technology can be "improved to make way for a new era of economic growth."

-- U.N. Commission on Environment and Development, "Our Common Cause", 1987

"Earthrise in 4K", https://svs.gsfc.nasa.gov/4593

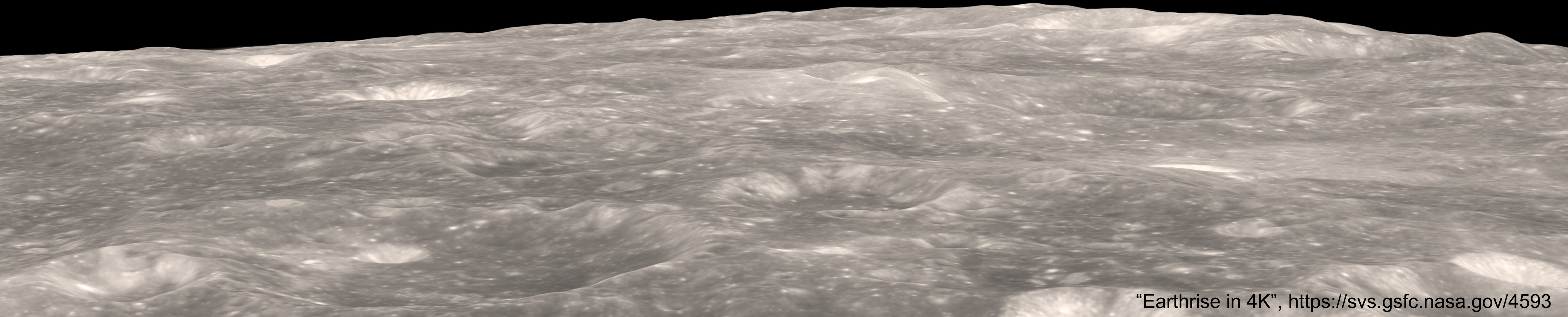
Backup Slides



“Earthrise in 4K”, https://svs.gsfc.nasa.gov/4593

"Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth."

-- U.N. Commission on Environment and Development, "Our Common Cause", 1987



"Earthrise in 4K", https://svs.gsfc.nasa.gov/4593

U.S. Aviation Climate Action Plan (2021) Goals

Net-Zero GHG Emissions* from the U.S. Aviation Sector** by 2050

* Aviation GHG emissions include life cycle carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) emissions. Aircraft engines produce negligible amounts of nitrous oxides and methane, so this plan has a focus on aviation combustion CO_2 emissions and well-to-tank life cycle GHG emissions (CO_2, N_2O, and CH_4)…

** This U.S. aviation goal encompasses CO_2 emissions from (1) domestic aviation…from U.S. and foreign operators, (2) international aviation (i.e., flights between from two different ICAO Member States) from U.S. operators, and (3) airports located in the United States.

Community Co-Benefits through Improved Air Quality and Reduced Noise

In addition to its impacts on climate change, aircraft operations have impacts on human health and welfare via noise pollution and emissions that degrade air quality. These impacts are felt in communities near airports as well as much further away in the communities that surround our metropolitan areas. The actions outlined in this document will not only put us on a course to achieve net-zero GHG emissions by 2050, but they will also reduce the impacts of noise and air quality on airport communities.

Goals: achieve net-zero CO_2 aircraft and well-to-tank life cycle GHG emissions and 10-15 dB aircraft noise reduction (re. 2021 best in class) by 2050

NASA Aeronautics – Vision for Aviation in the 21st Century

ARMD continues to evolve and execute the Aeronautics Strategy
https://www.nasa.gov/aeroresearch/strategy

6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Safe, Quiet, and Affordable Vertical Lift Air Vehicles
- Innovation in Commercial Supersonic Aircraft
- In-Time System-Wide Safety Assurance
- Ultra-Efficient Subsonic Transports
- Assured Autonomy for Aviation Transformation

U.S. leadership for a new era of flight

Aviation is Vital to our Nation's Economy

Pre-COVID

- $78 billion positive trade balance; the largest positive trade balance of any U.S. manufacturing sector
- $1.8 trillion total U.S. economic activity
- 10.9 million direct/indirect jobs
- 21.3 billion tons of freight transported by U.S. airlines in 2019

The Aviation Carbon Reduction Challenge

- By 2050, an estimated 10 billion passengers will fly each year a distance of 22 trillion revenue passenger kilometres.
- With today's fleet and operational efficiency, this activity would require over 620 megatonnes (Mt) of fuel and generate close to 2000 Mt of CO_2.
- Imagine enabling the same level of demand while reducing net CO_2 emissions to zero by 2050.

Meeting the challenge is the opportunity for the United States to lead the world in innovation and reductions in CO_2 aviation emissions, and to maintain economic competitiveness in a critical export industry ($6 trillion-plus market over the next 20 years).

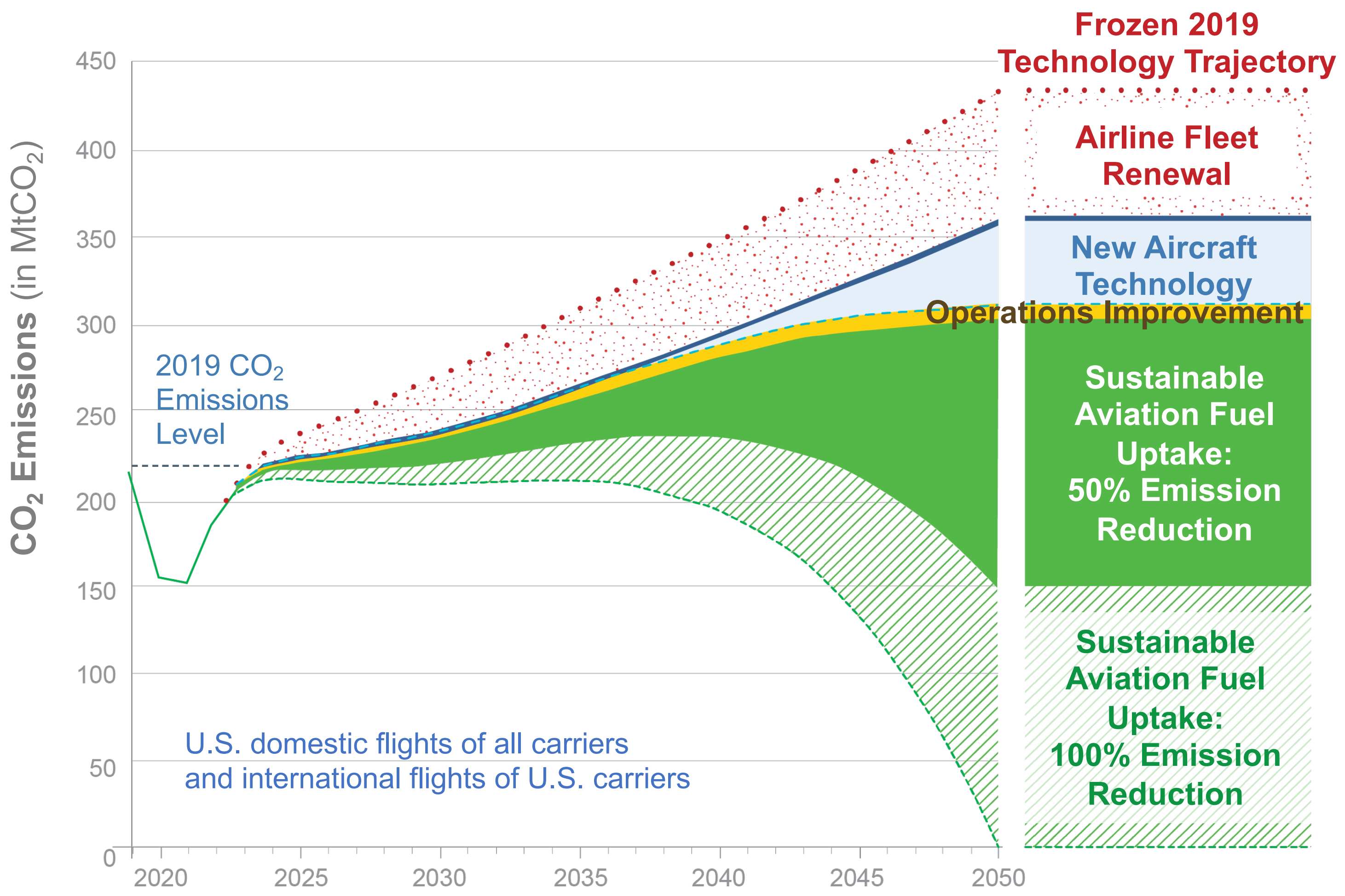
U.S. Aviation Climate Action Plan

Global Context for Sustainable Aviation

U.S. aviation goal is to achieve
net-zero greenhouse gas emissions by 2050.

U.S. Aviation Climate Action Plan is aligned with

- U.S. economy-wide goal
- International Civil Aviation Organization
- Air Transport Action Group



The U.S. is working with the global community to achieve net-zero greenhouse gas emissions by 2050 using a common basket of measures.

Sustainable Flight Demonstrator

Demonstrate integrated airframe-focused technologies in flight

Scope

- Develop and fly integrated airframe-focused technology flight demonstrator with U.S. industry to mature technologies that enable the next-generation single-aisle aircraft in the 2030s.

Benefit

- Validate promising technologies, retire technical risks, and mature to TRL 6 key synergistic commercial transport vehicle technologies. Combined, these technologies could support efficiency and environmental performance goals for the 2030s.

Approach

- Request for Information supporting Project Formulation 2020-21
- Project Formulation and Risk Reduction in 2021-22
- Competitive Request for Proposals in 2022

Risk Reduction Contract Awards Made August 2021
Design/Build Contract Award Anticipated Late 2022

Sustainable Aviation Fuels

Enable the use of 100% sustainable aviation fuels (SAF) and reduce climate impact

Scope

- Support adoption of high-blend ratio sustainable aviation jet fuels

Benefits

- Reduced aviation environmental impact
- Reduced uncertainty for climate impact of aviation-induced cloudiness
- Improved efficiency/emissions with drop-in synthetic and biofuels

Approach

- Characterize high-blend sustainable aviation jet fuel emissions on ground and in flight

Future SAF Research Plans in Development

Long-Term Transport Technology and Innovation

Generational studies to inform future technology investments

2008-2019 | 2020-2029 | 2030 - 2039 | 2040 - 2050

Subsonic Fixed Wing

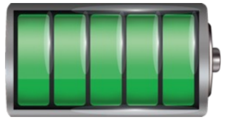
N+2 Studies, ERA for the 2020s Impact

N+3 Advanced Concept Studies SFNP for 2030s Impact

Concept Studies and Technology Development Needed for 2040s Impact

Opportunities to Define
Future Aviation Systems and Concepts

- Advanced Concept Studies for 2040+ EIS
- Net-Zero Emissions Concepts
- Promising Technologies and Architectures
- Support Aviation Community with NASA-unique Contributions



Innovations for 2040s and Beyond

Sustainable Flight National Partnership Benefits

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

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

Sustainable Aviation Fuels for reduced lifecycle carbon emissions

Model-based Systems Analysis & Engineering provides digital integration

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

High-Rate Composites for 4-6x manufacturing rate increase

Integrated Trajectory Optimization for 1%-2% reduction in fuel required and minimization of contrail formation

Sustainable Flight Demonstrator for integrated airframe-focused technology maturation