NASA Aeronautics Sustainable Aviation Strategy

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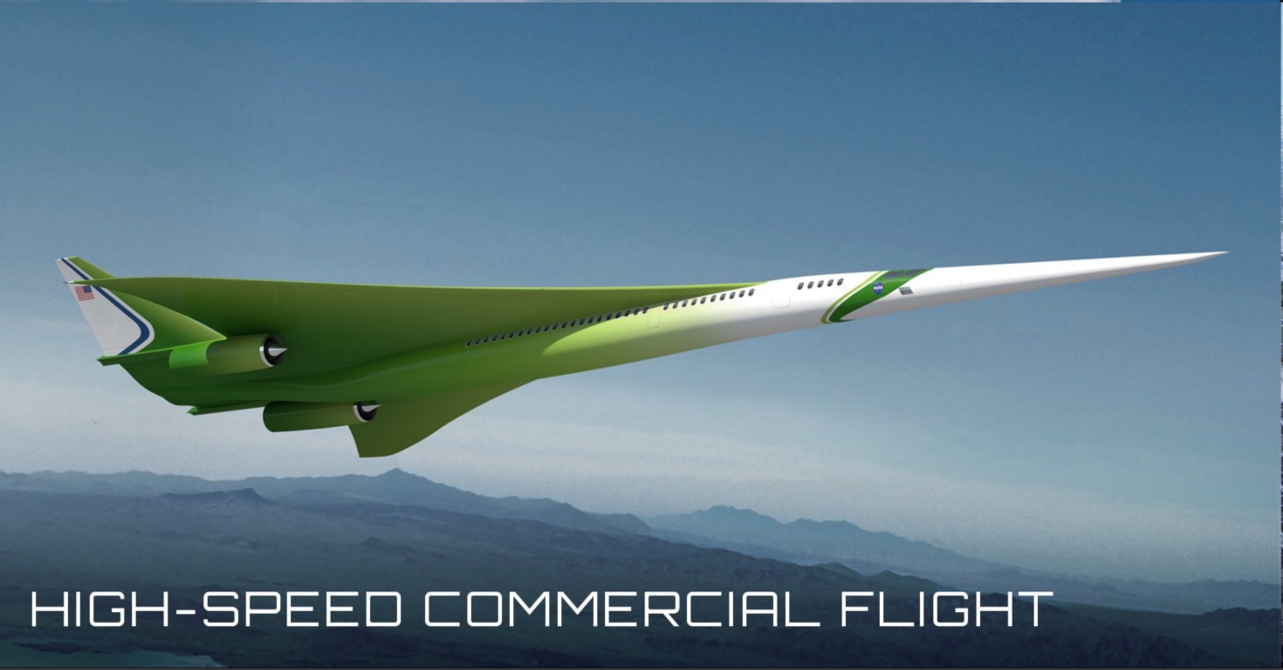
NASA Aeronautics – Vision for Aviation in the 21st Century

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



Four Transformations for Sustainability, Greater Mobility, and Economic Growth

The Aviation Carbon Reduction Challenge

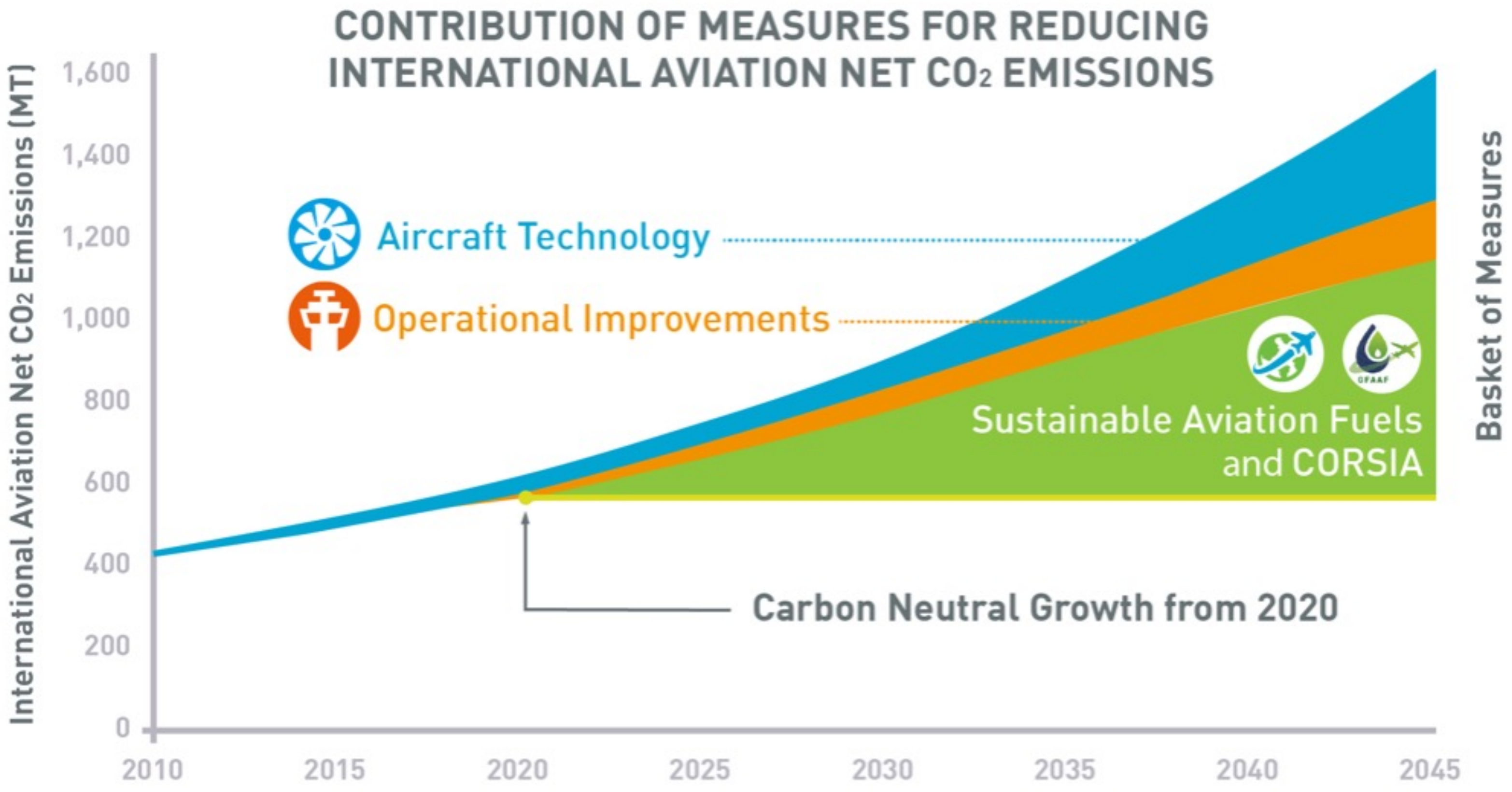
- By 2050, an estimated 10 billion passengers will fly each year a distance of 20 trillion revenue passenger kilometres.
- With today's fleet and operational efficiency, this activity would require over 570 Mt of fuel and generate some 1,800 megatonnes (Mt) of CO_2.
- Imagine enabling the same level of demand while reducing CO_2 by 82% to 325 Mt or less by 2050, and potentially zero by 2060.

Aviation must rise to the environmental challenge
to continue connecting people around the world.

Global Context for Green Aviation

International Civil Aviation Organization (ICAO) Goals

To meet the global aviation industry's goal of 50% reduction in carbon emissions by 2050, ICAO members collectively are pursuing a basket of measures.



ICAO Adopted Aviation Carbon Reduction Goals (ICAO Resolution A40-18)

Aviation emitted 90 grams of CO_2 per passenger-kilometer in 2019, a decrease of 2% from 2018 and of 12% from 2013. Airlines are on track to meet the goal to improve fuel efficiency by 2% per year – but improved aircraft, operations and fuels will be required to maintain this pace.

Aviation Industry Pillars for a Sustainable Future

Global Aviation Industry's GOAL: 50% reduction in carbon emissions by 2050 relative to 2005
and **possible net zero emissions by 2060 through these three means**

TECHNOLOGY

NASA = Primary Role

SUSTAINABLE AVIATION FUEL

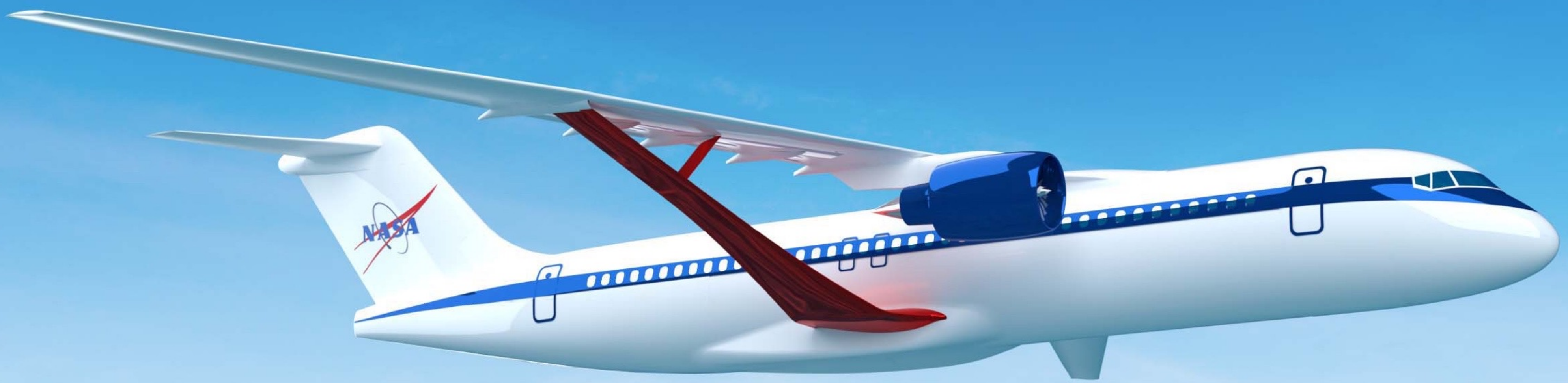
NASA = Supporting Role

OPERATIONS AND INFRASTRUCTURE

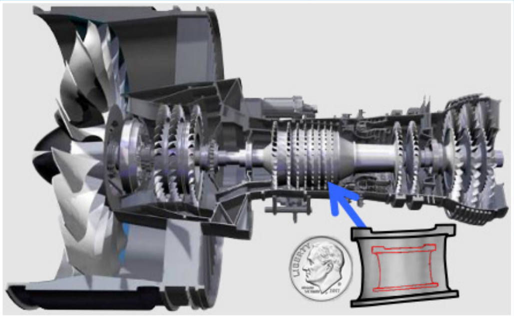
NASA = Primary Role

Subsonic Transport Technologies

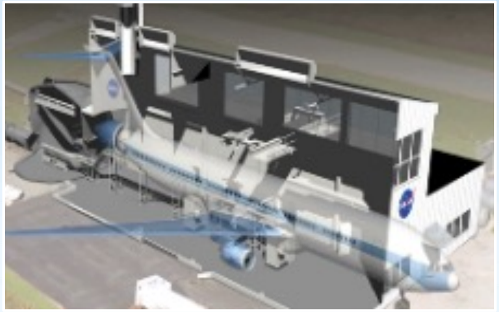
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports



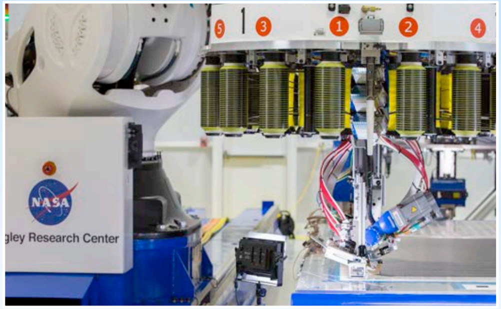
Transonic Truss-Braced Wing
5-10% fuel burn benefit



Small Core Gas Turbine
5-10% fuel burn benefit

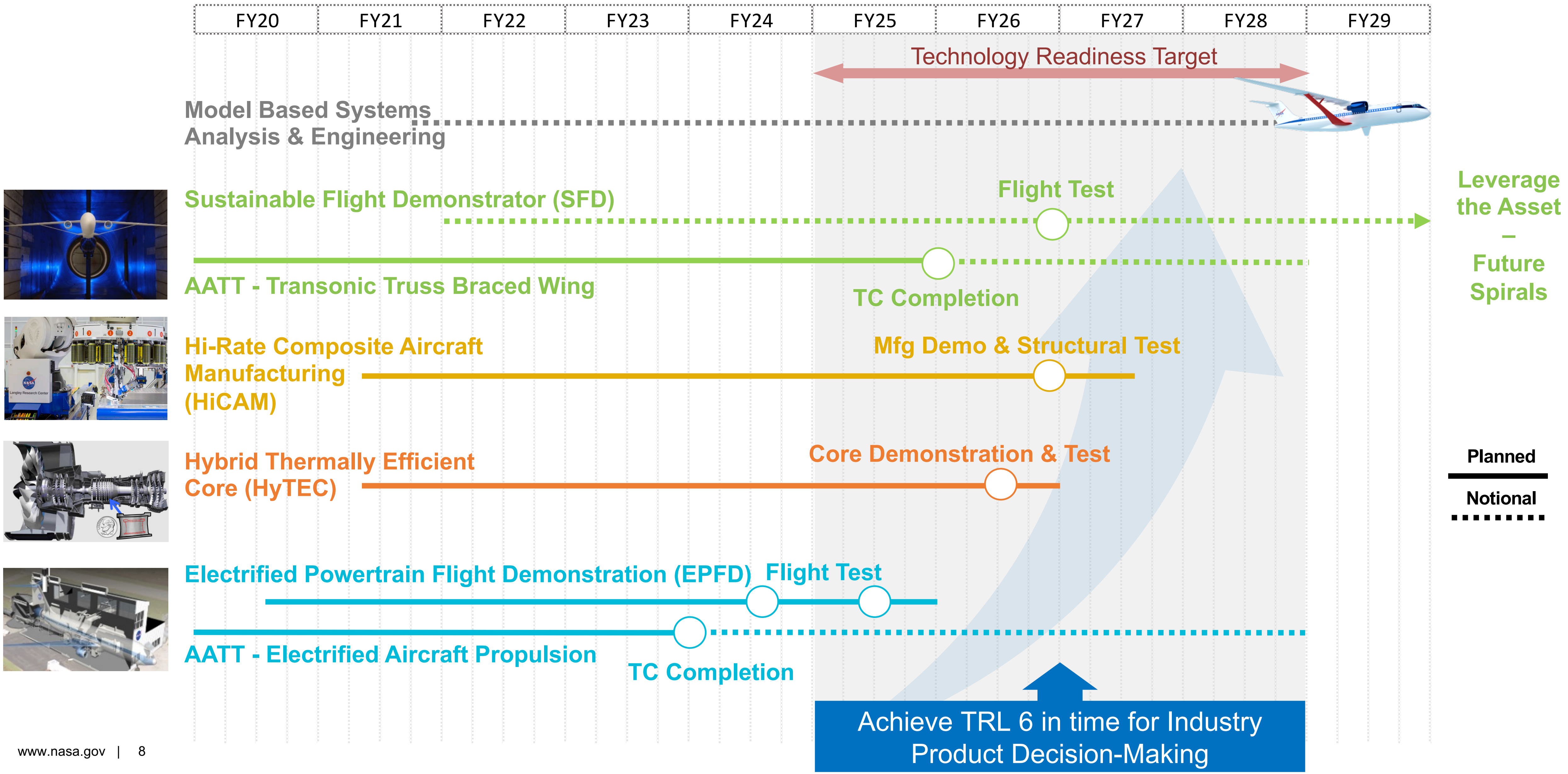


Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit



High-Rate Composite Manufacturing
4x-6x manufacturing rate increase

Subsonic Transports: Integrated Technology Development



Sustainable Flight Demonstrator

Demonstrate integrated technologies in flight

Scope

- Develop and fly an integrated multi-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

- Currently in early planning stages
- Request for information in November 2020
- December 2020 industry day to discuss ideas

DISCUSSIONS INITIATED WITH INDUSTRY

Transonic Truss-Braced Wing Technology Maturation

Increase confidence in technology to be 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 design/unique joints

Benefit

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

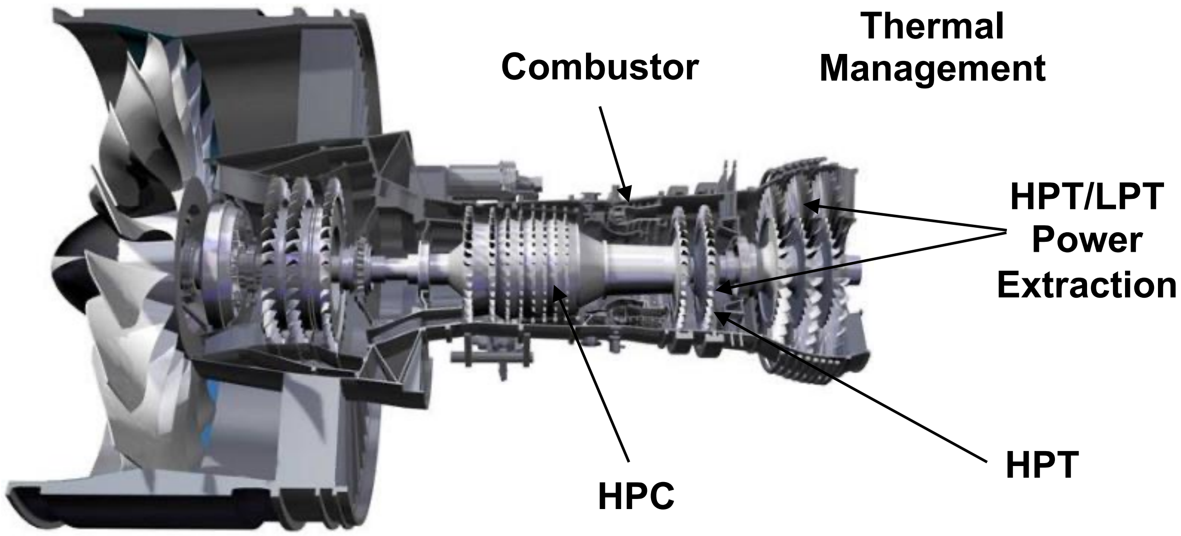
Approach

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

TECHNOLOGY CHALLENGE UNDERWAY

Hybrid Thermally Efficient Core

Accelerate development and demonstration of advanced turbine engine technologies



HyTEC
Hybrid Thermally Efficient Core

Scope

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

Benefit

- Achieve a **5 to 10% fuel burn reduction** versus 2020 best in class
- Achieve **up to 20% power extraction** (2 to 4 times current state of the art) at altitude to optimize propulsion system performance and enable hybridization

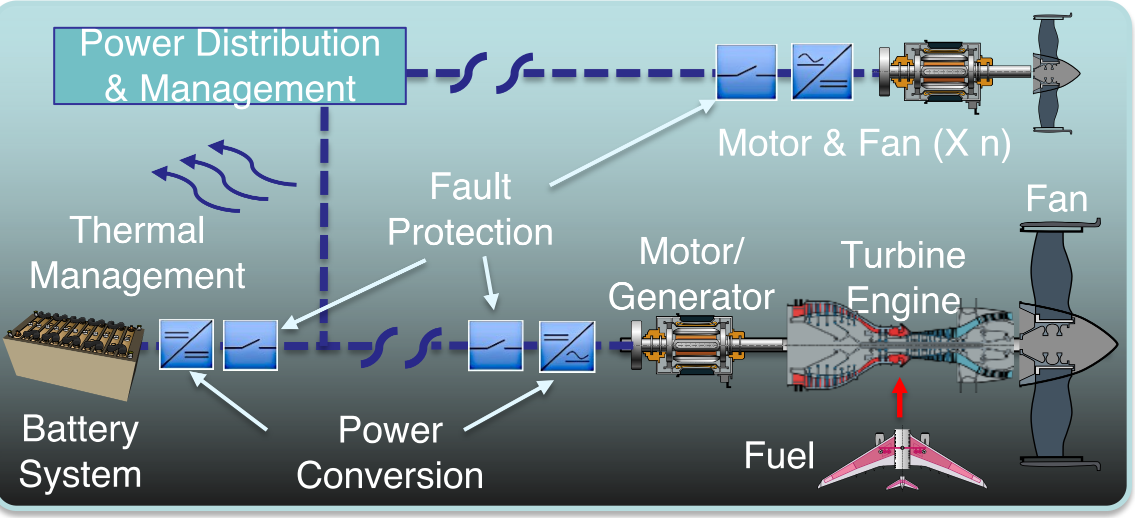
Approach

- Partner with industry to mature and demonstrate promising technologies

HyTEC PROJECT IN FORMULATION PHASE

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 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 Electrified Aircraft Propulsion (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

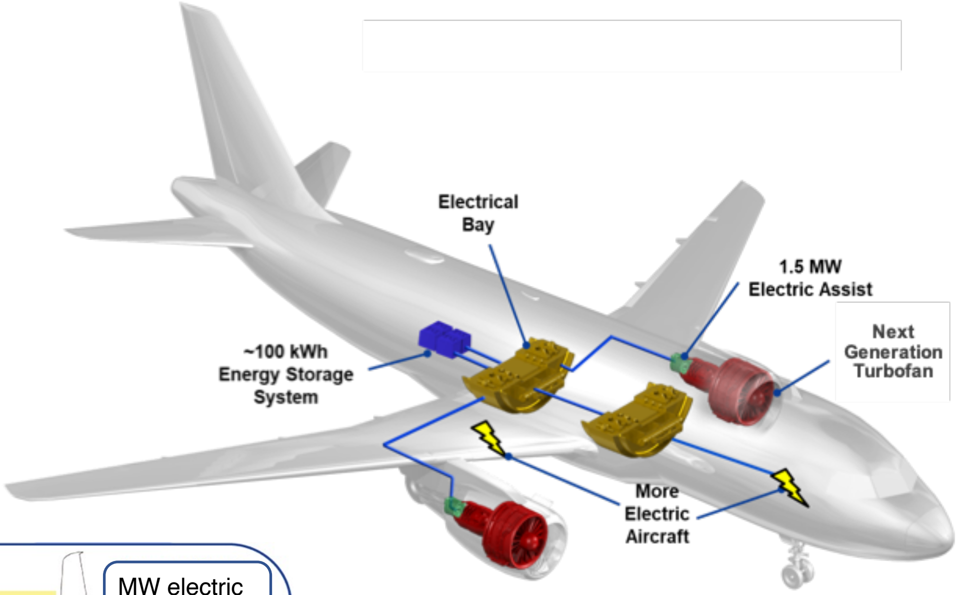
Approach

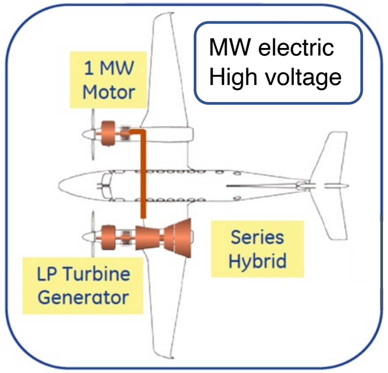
- Conduct technology-focused integrated ground tests
- Partner with industry on testing of electrified propulsion architectures and component technologies
- Leverage prior electric aircraft propulsion advances (TRL ~4)

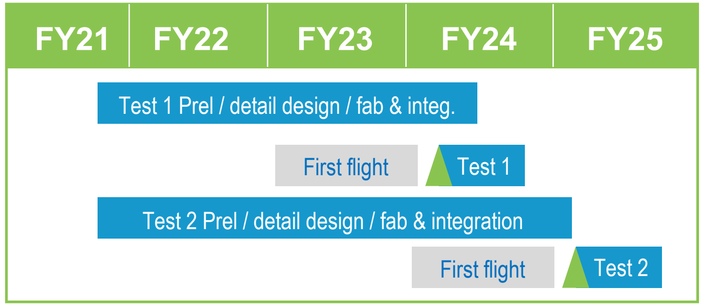
TECHNOLOGY CHALLENGES UNDERWAY

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 Electrified Aircraft Propulsion (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.

SOLICITATION RELEASED FEBRUARY 2021

NASA X-57 Maxwell All-Electric Flight Demonstrator

Mod II

Validates Cruise Motors & Subsystems

Ground and flight test validation of electric motors, battery, and instrumentation.

Mod III

Achieves High-Speed Objectives

Flight test electric motors relocated to wingtips on newly developed & fabricated DEP wing.

Mod IV

Achieves Low-Speed Objectives

Flight test with integrated DEP motors and folding props (cruise motors remain in wing-tips).

FIRST FLIGHT FALL 2021

Hi-Rate Composite Aircraft Manufacturing

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

Production Rate per Month

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

Wing Section Fab

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

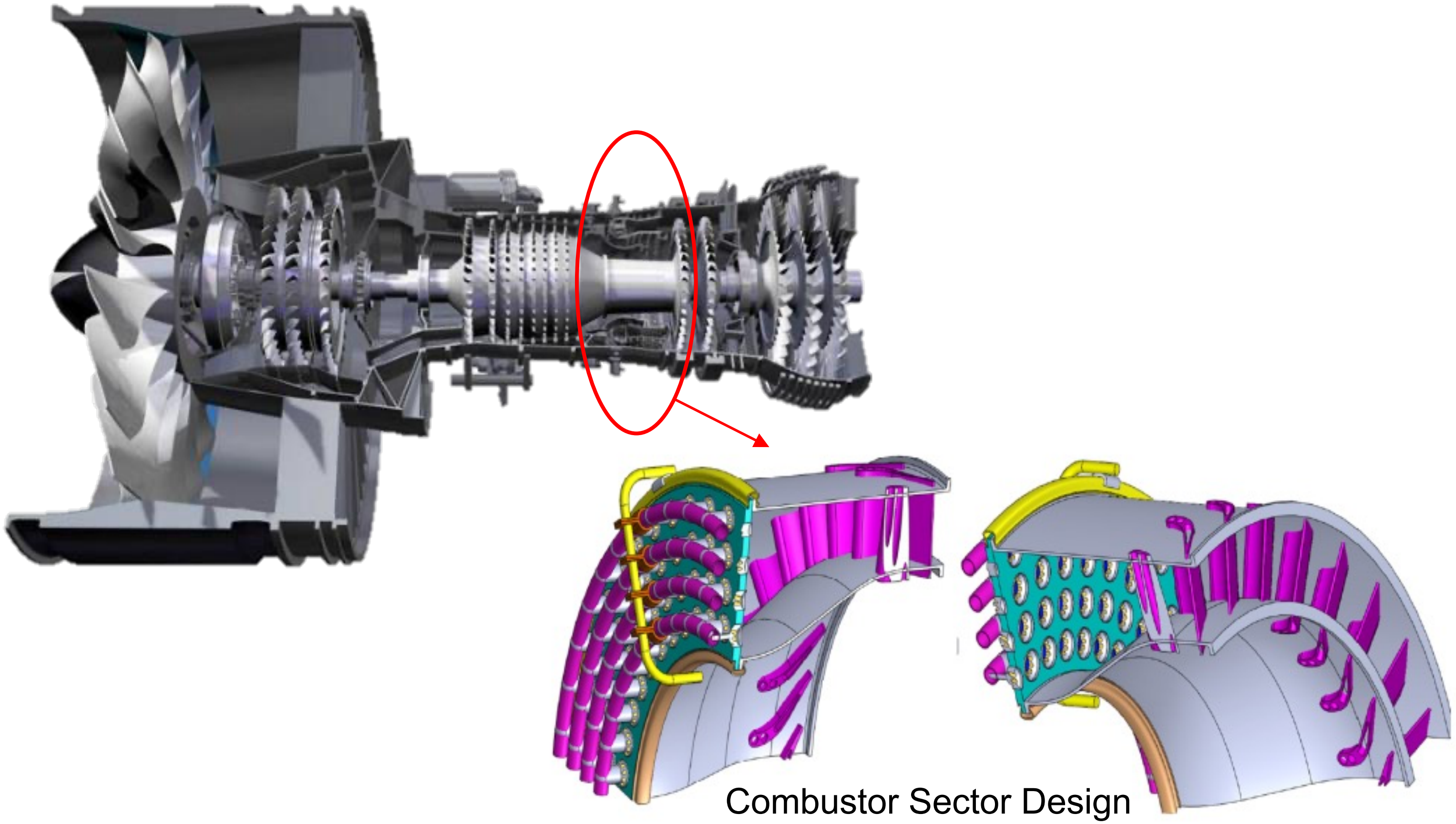
Approach

- 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

HiCAM PROJECT IN FORMULATION PHASE

Sustainable Aviation Fuels

Assess technology needs and impacts

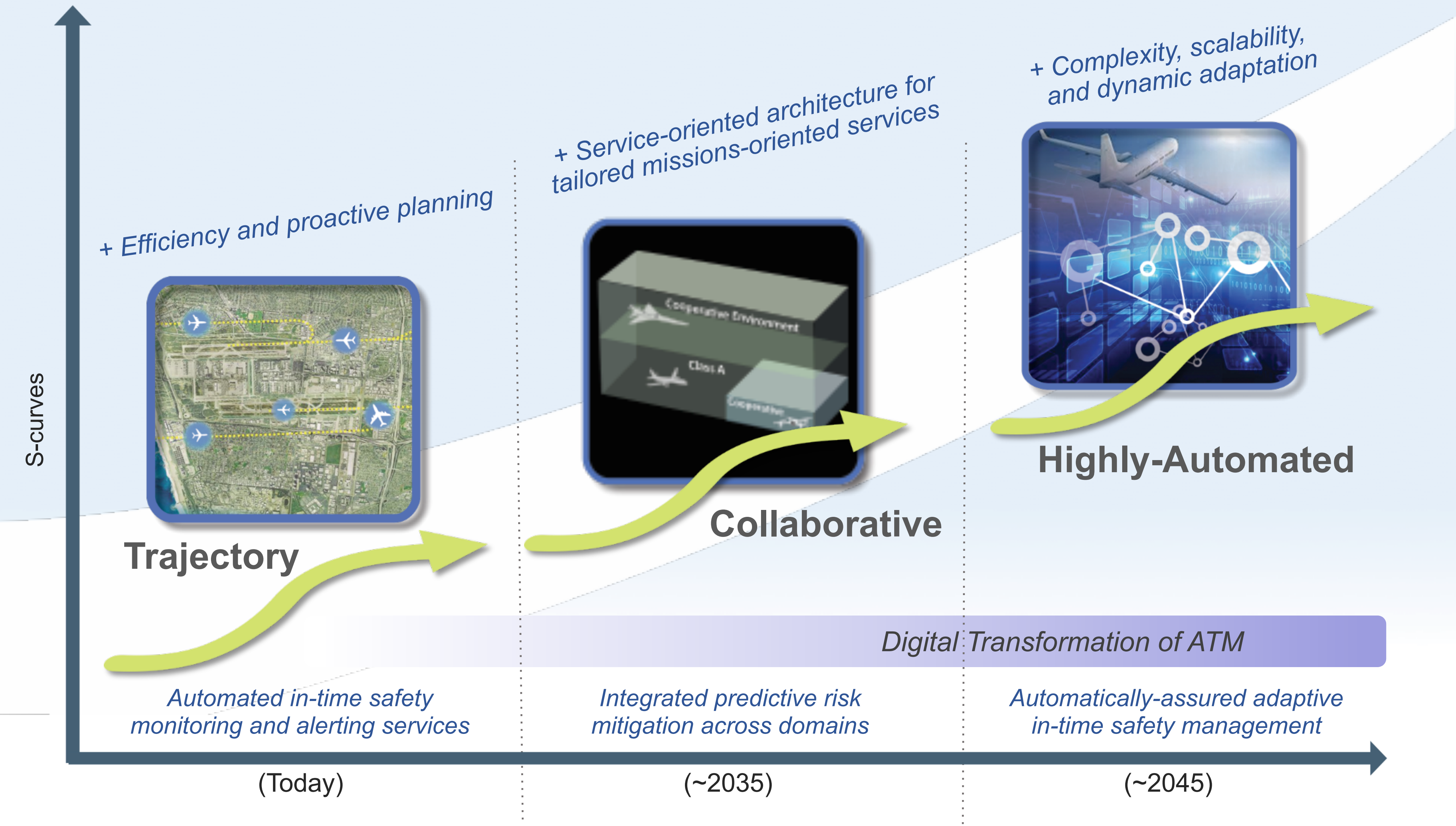


Combustor Sector Design

- Improved efficiency/emissions with drop-in synthetic and biofuels
- Enable adoption of high-blend ratio sustainable alternative jet fuels – advance small core combustor design and address advanced small combustor operability and emissions
- High-blend sustainable alternative jet fuel emissions characterization

FUTURE RESEARCH PLANS IN DEVELOPMENT

Evolution of Airspace Operations and Safety



NASA's Vision for Sustainable Aviation Operations

- Integrated trajectories optimized for environmental benefit
- Advanced flight deck capabilities to operate on those trajectories
- Tailored services that support safe integration of all diverse operations

Airspace Operational Tools Yield Immediate Benefits

Airspace Technology Demonstration (ATD)

Benefits to date from field demonstrations of ATD-2 technologies at the Charlotte Douglas International Airport (29 Sep 2017–30 Apr 2021)

Saved
998,595
gallons of fuel

FUEL

Saved
21,037,598 lbs. of CO_2 = **156,435** urban trees

EMISSIONS

Saved
5,414
hours of engine run time

MAINTENANCE

Reduced delay by 830.3 hours

Saving passengers an estimated **$3,985,599** in value of time and operators an estimated **$1,223,030** in flight crew costs

BENEFITS TODAY

Net Zero Aviation Emissions Innovation

NASA Distributed Propulsion Concept
- Turbo-Electric with superconducting electric drivetrain
- Over 70% reduction in energy use

Examples of current Research at Low TRL

University of Illinois, Urbana-Champagne (NASA ULI) fully electric concept
- Hydrogen fuel cell, superconducting electric drivetrain
- Zero carbon emissions

Foster radical aviation technology advancement – new energy sources, aircraft architectures – necessary for large aircraft with extremely low or zero emissions

Low TRL concepts can be further conceptualized, researched, developed, ground and flight tested and advanced for late 2030s / early 2040s

Recent University Leadership Initiative solicitation (March 2021) included net-zero emissions topics

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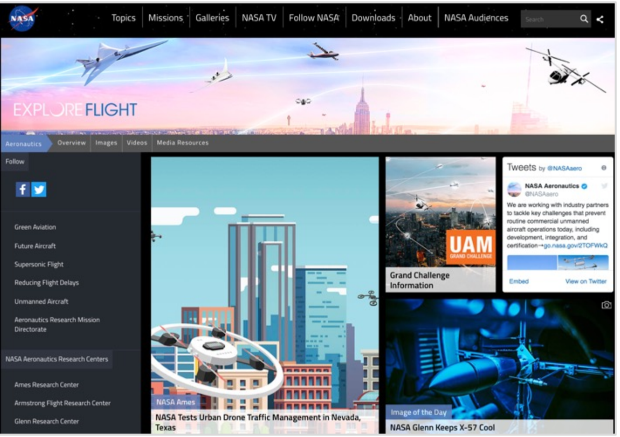

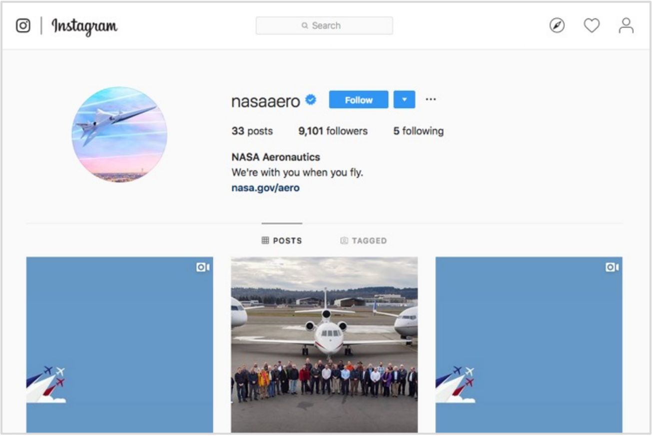

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