NASA Aeronautics Sustainable Flight National Partnership (SFNP)

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NASA

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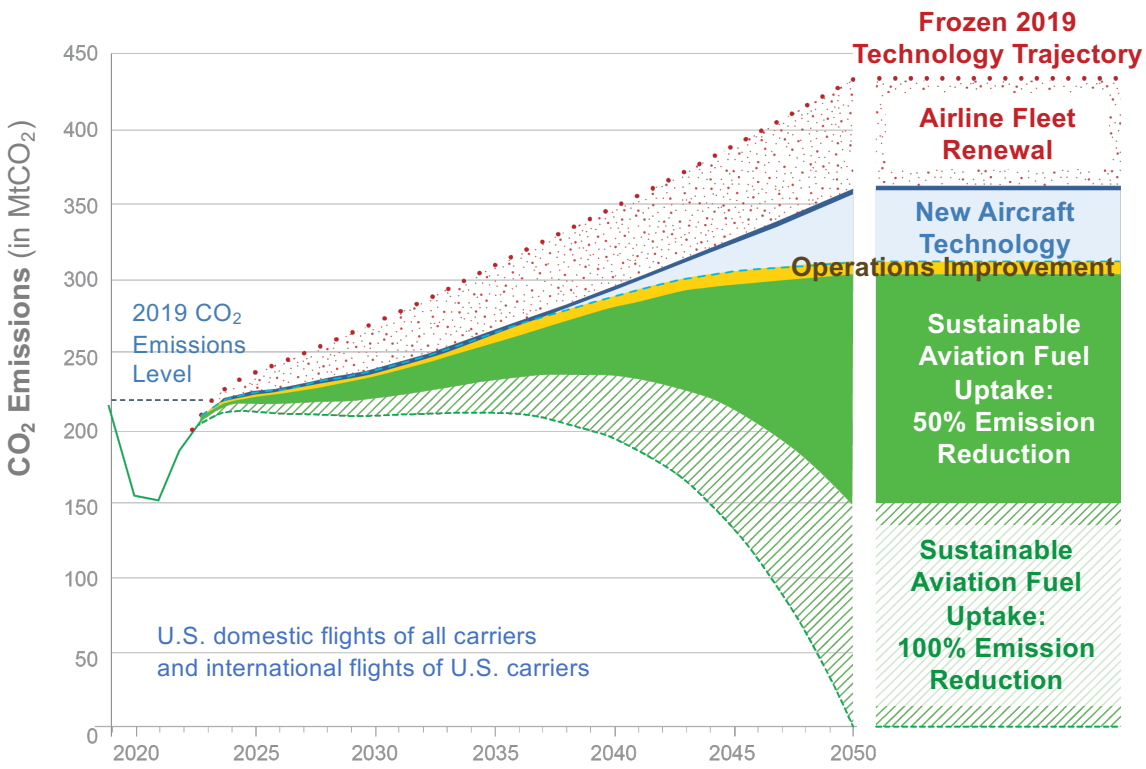
www.nasa.gov

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.

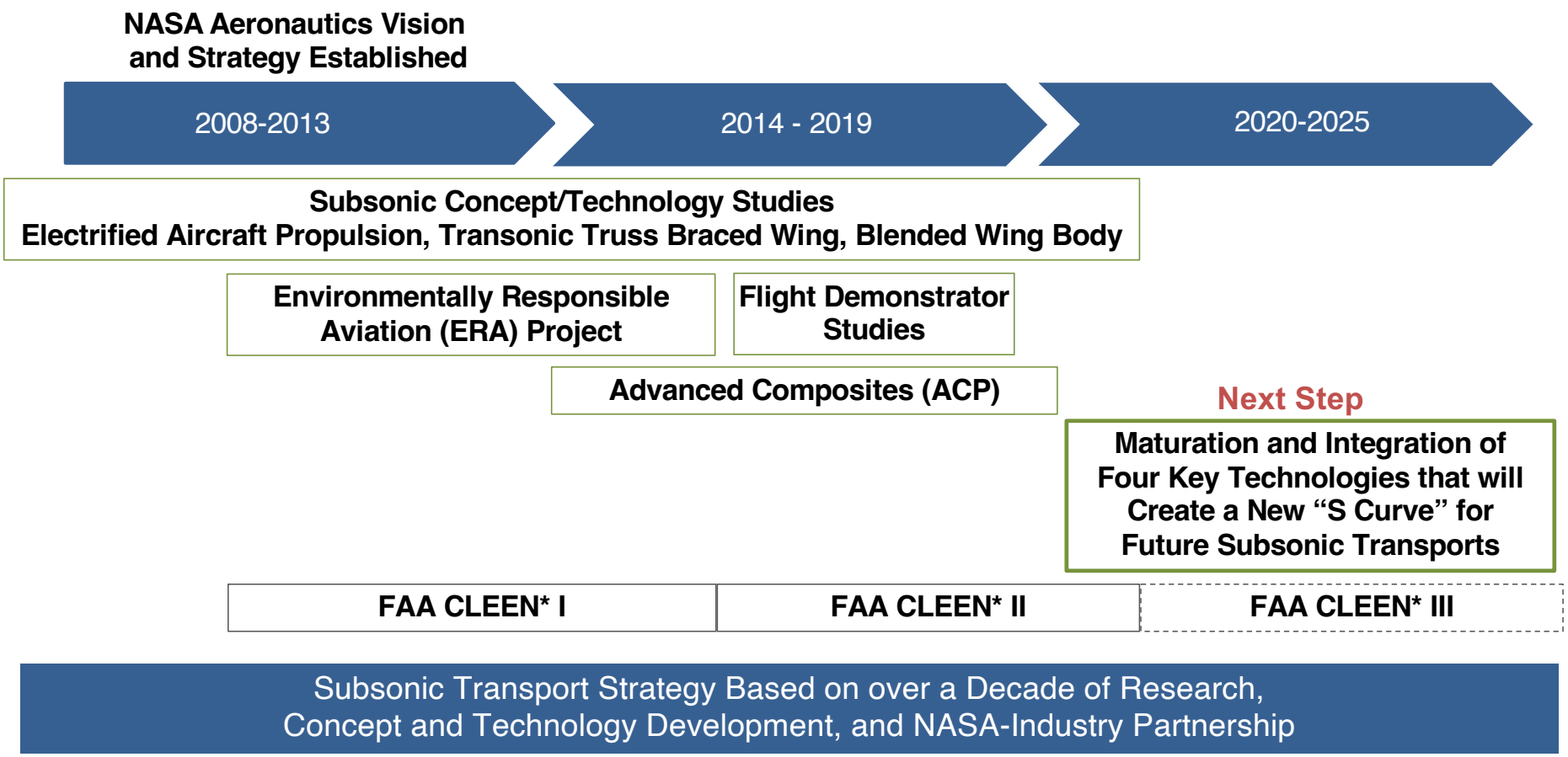
U.S. Aviation Climate Action Plan is aligned with
- U.S. economy-wide goal
- International Civil Aviation Organization
- Air Transport Action Group



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

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

Subsonic Transport Technology Prioritization



Subsonic Transport Strategy Based on over a Decade of Research, Concept and Technology Development, and NASA-Industry Partnership

* Sponsored by FAA Office of Environment & Energy (AEE)

Sustainable Flight National Partnership

Accelerating Toward Net-Zero Greenhouse Gas Emissions and Reduced Non-CO_2 Climate Impact in the 2030s

Advance engine efficiency and emission reduction

Enable integrated trajectory optimization

Advance airframe efficiency and manufacturing rate

Enable use of 100% sustainable aviation fuels

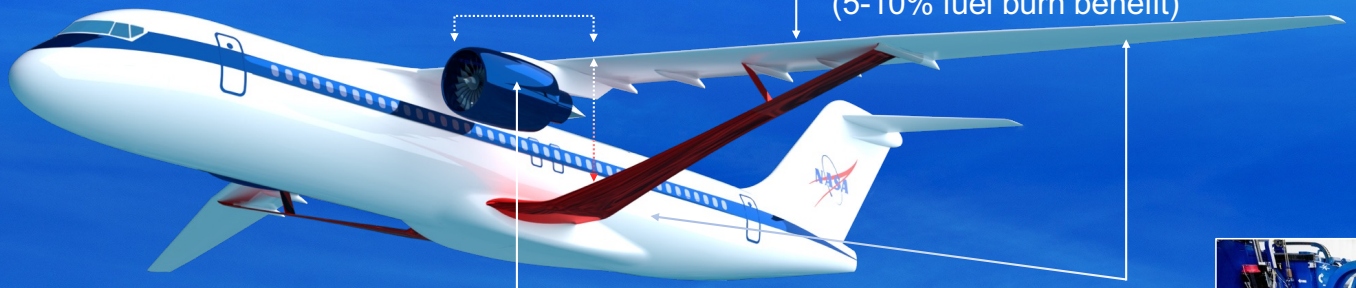
Next-generation transports using up to 30% less fuel, current & future fleet flying optimal trajectories, and engines burning SAF with greater than 50% reduction in lifecycle GHG emissions

Subsonic Transport Technologies

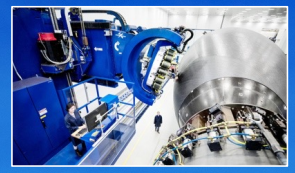
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports

Integrated Aircraft System Efficiency
Propulsion Airframe Integration Opportunity

Aerodynamic Efficiency
Transonic Truss-Braced Wing
(5-10% fuel burn benefit)

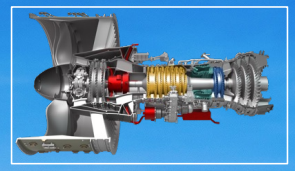


Weight
High-Rate Composites
(4-6x manufacturing increase)



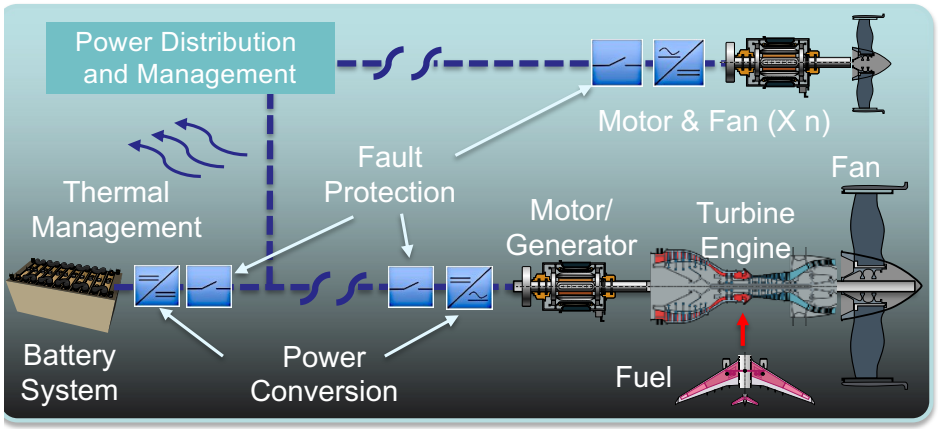
Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit

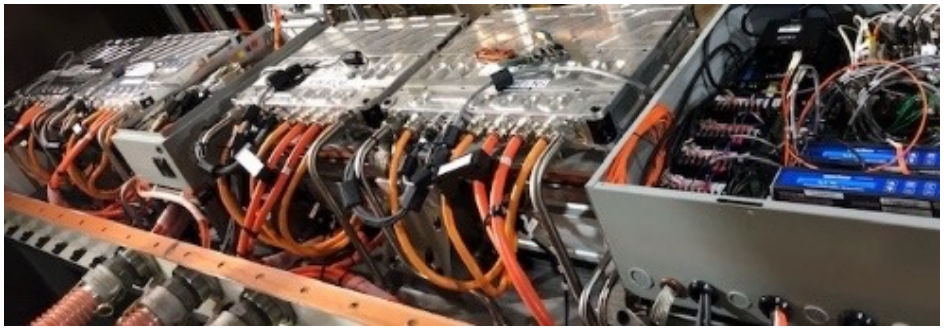
Engine Efficiency
Small Core Gas Turbine
(5-10% fuel burn benefit)



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.
Completed Altitude Integrated Test of high-power, high-voltage powertrain FY22

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.

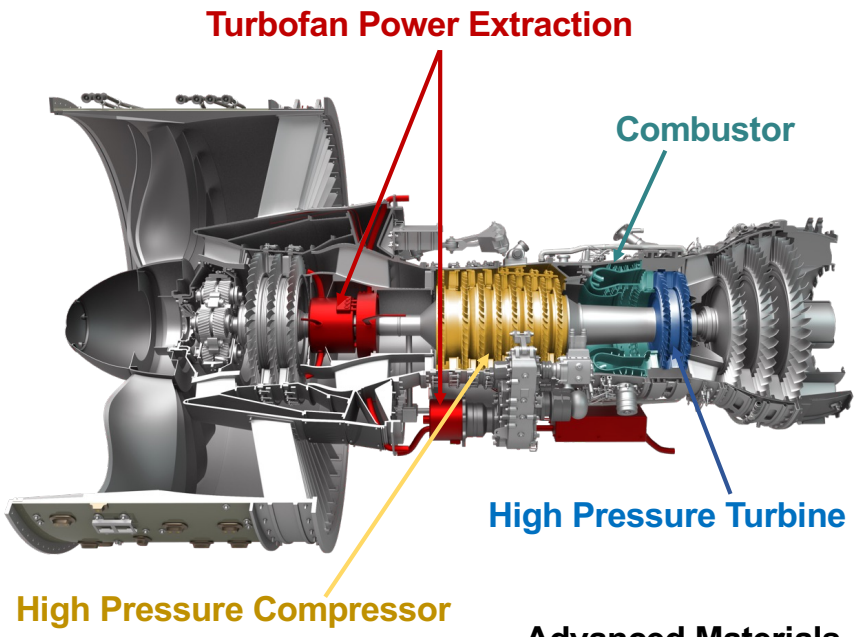
Approach

- 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.

Flight demonstration contracts awarded in September 2021.
Baseline unmodified flight testing of GE's Saab 340B conducted February-March 2023.

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
- Achieve small core combustors with efficient, effective operability using high blend (>80%) Sustainable Aviation Fuels (SAFs)

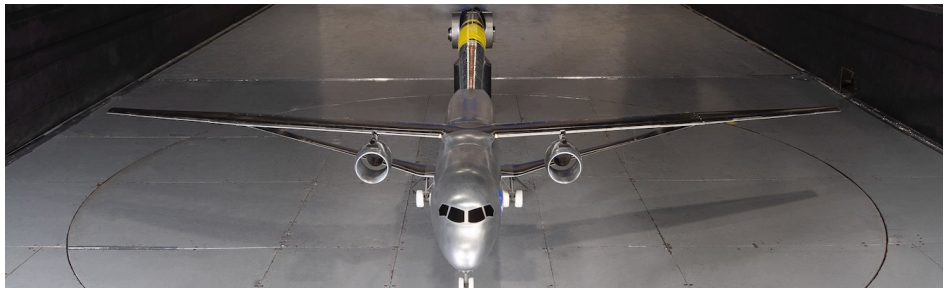
Approach

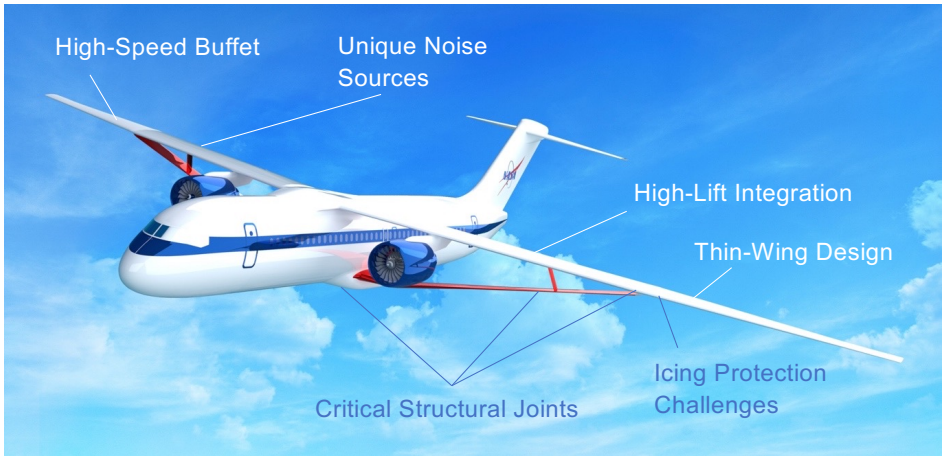
- Partner with industry to mature and demonstrate promising technologies

Phase 1 small-core turbofan technology contract awards were made in September 2021.
Phase 2 Request for Proposal released on March 16, 2023 and due May 3, 2023.

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 studies and wind-tunnel tests are underway.
Completed high-speed buffet wind-tunnel test in FY22.

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

- Competitive selection through Funded Space Act Agreement
- Partner with industry to demonstrate promising integrated airframe-focused technologies in flight including nontraditional configuration

Risk Reduction Contracts August 2021 – September 2022
Design/Build/Fly Funded Space Act Agreement Awarded January 18, 2023 - 1st Flight 2028

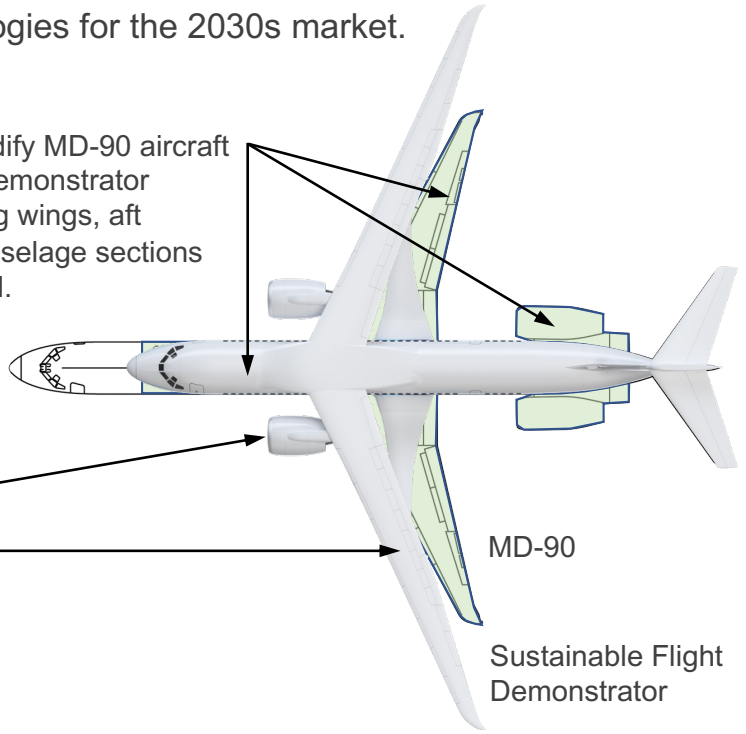
Sustainable Flight Demonstrator (SFD) Project

- Awarded a Funded Space Act Agreement (FSAA) to Boeing in January 2023 to design, build, test and fly an advanced airframe configuration demonstrator aircraft and related technologies to dramatically reduce fuel burn and CO_2 emissions.
  - $425M direct NASA investment + NASA facilities/labor of ~$125M over 7 years
  - $725M funding from Boeing and industry partners
- Boeing's Transonic Truss Braced Wing (TTBW) configuration utilizes a high aspect ratio, thin, truss-braced wing design to reduce drag and optimize fuel efficiency.

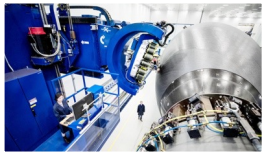
SFD modification includes addition of Transonic Truss-Braced Wing and subsystems, modern turbofan engines, and instrumentation.

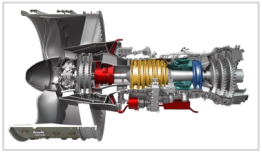
- Demonstrator aircraft will be a MD-90 aircraft modified with a truss-braced wing and shortened fuselage.
  - First flight planned for 2028.
- Completing the flight tests in the 2020s to enable the industry to evaluate the utilization of the related technologies for the 2030s market.

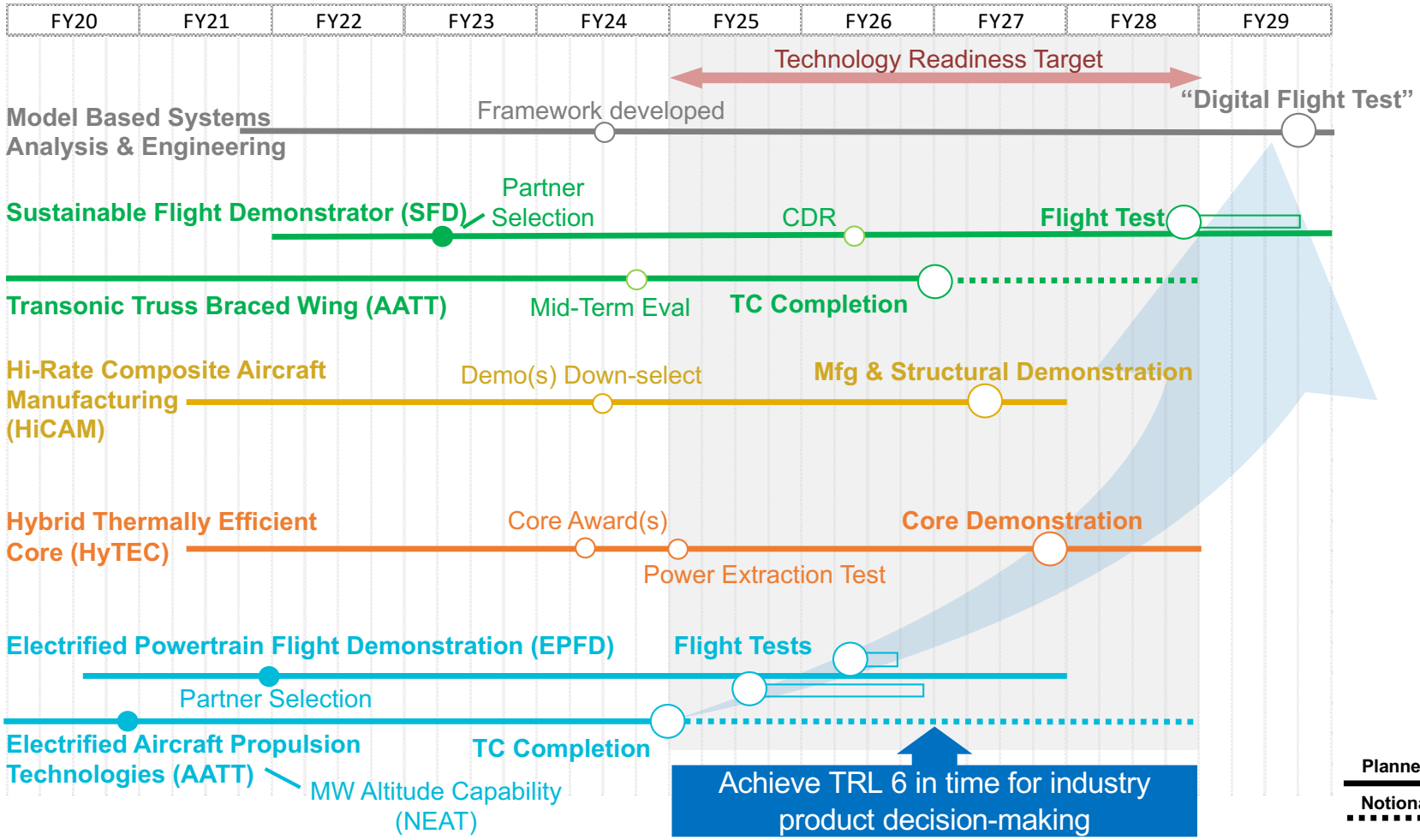
Boeing will modify MD-90 aircraft into the SFD Demonstrator aircraft. Existing wings, aft engines, and fuselage sections will be removed.



Subsonic Transports: Integrated Technology Development





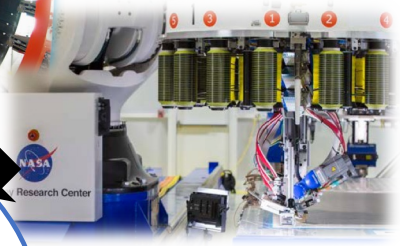


Model-Based Systems Analysis & Engineering

SFNP Vision

Advanced Aero-Configuration Ground & Flight Tests (AATT & SFD)

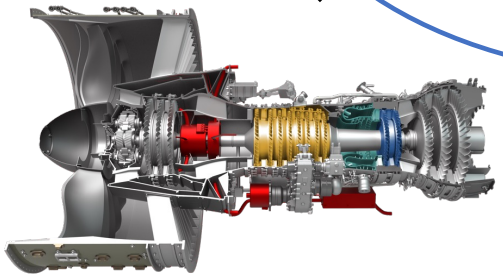
High-Rate Composite Manufacturing Processes (HiCAM)

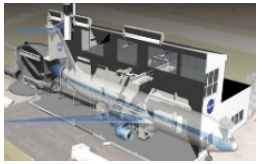


MBSA&E
Digital Integration
Knowledge Capture

Vision Vehicles
System of Systems

Small Core Engine Ground Tests (HyTEC)





Electrified Propulsion Ground & Flight Tests (AATT & EPFD)

Systems-level, digital integration across SFNP projects capped by a Digital Flight Test

NASA Higher TRL Tech Maturation Activities + recent starts

Smart Vortex Generators

https://www.nasa.gov/aeroresearch/nasa-looks-for-a-new-twist-on-sustainable-aviation

Low Drag Facesheet/MDOF Liner

https://ntrs.nasa.gov/citations/20200002460

Integrated Aircraft System Efficiency
Propulsion Airframe Integration Opportunity

Efficient Quiet integrated Propulsor (EQuiP) Technical Challenge
- Advanced propulsor tech maturation, TRL 5 by 2028

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

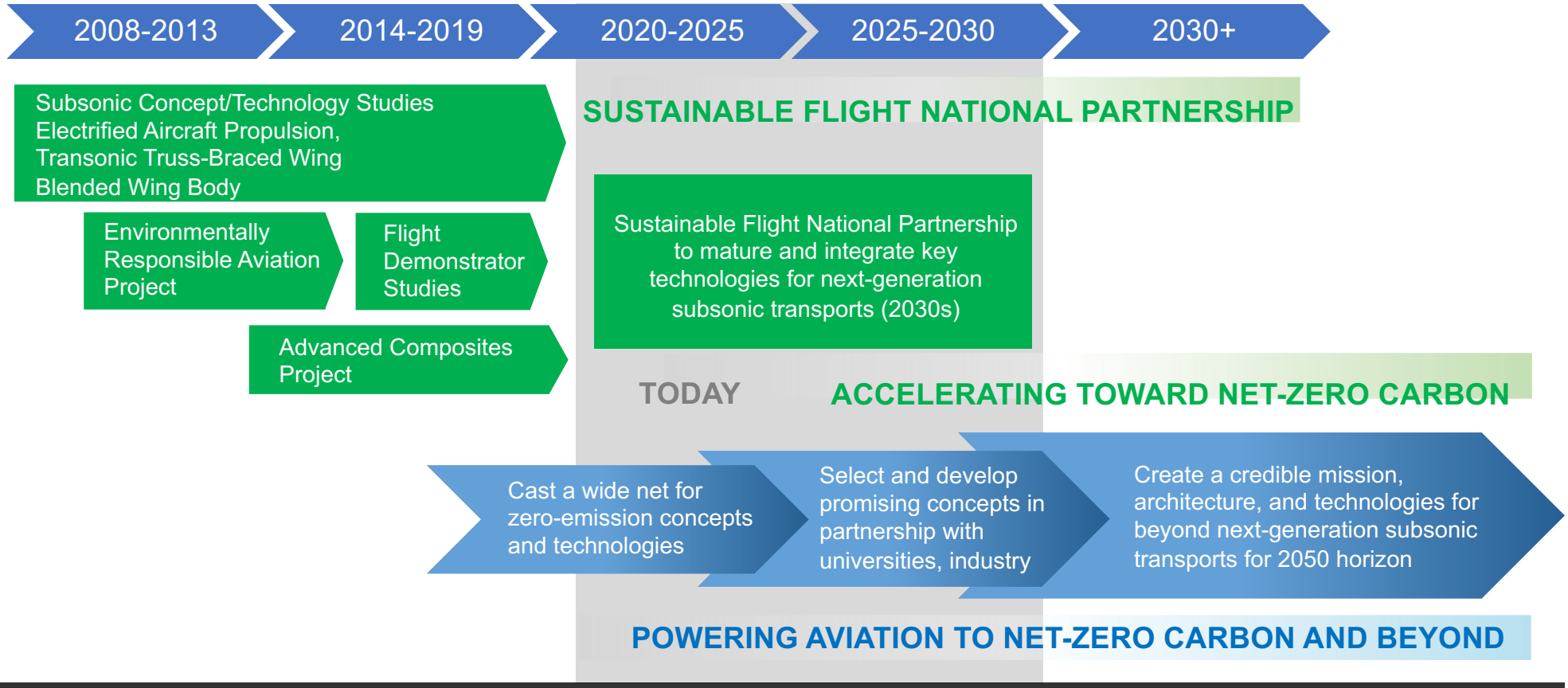
- Reduced aviation environmental impact
- Reduced uncertainty for climate impact of aviation-induced cloudiness
- Improved efficiency/emissions with drop-in synthetic and biofuels

Approach

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

Future SAF Research Plans in Development

NASA Sustainable Aviation Strategy



Investment in innovation today paves the way
to a net-zero carbon and beyond aviation future.

- Global aviation faces significant challenges to sustainable growth
  - Halt aviation's contribution to global warming without suppressing flight demand and without out-of-sector offsets, while remaining a viable and valued cornerstone of transportation (safe, clean, quiet, efficient, operable, economical, marketable)
  - Challenges require multiple, often interdependent, solutions across technology, operations, and energy domains
  - No silver bullets

- NASA Aeronautics is addressing the challenges of Sustainable Aviation
  - Maturing and demonstrating the most promising solutions for application in the 2030s
  - Exploring innovative solutions for application 2040+