National Aeronautics and Space Administration

NASA Aeronautics – Vision for Aviation in the 21st Century
FAA CLEEN

Jennifer Cole
Sustainable Flight National Partnership (SFNP), Deputy Mission Manager
November 20 2024

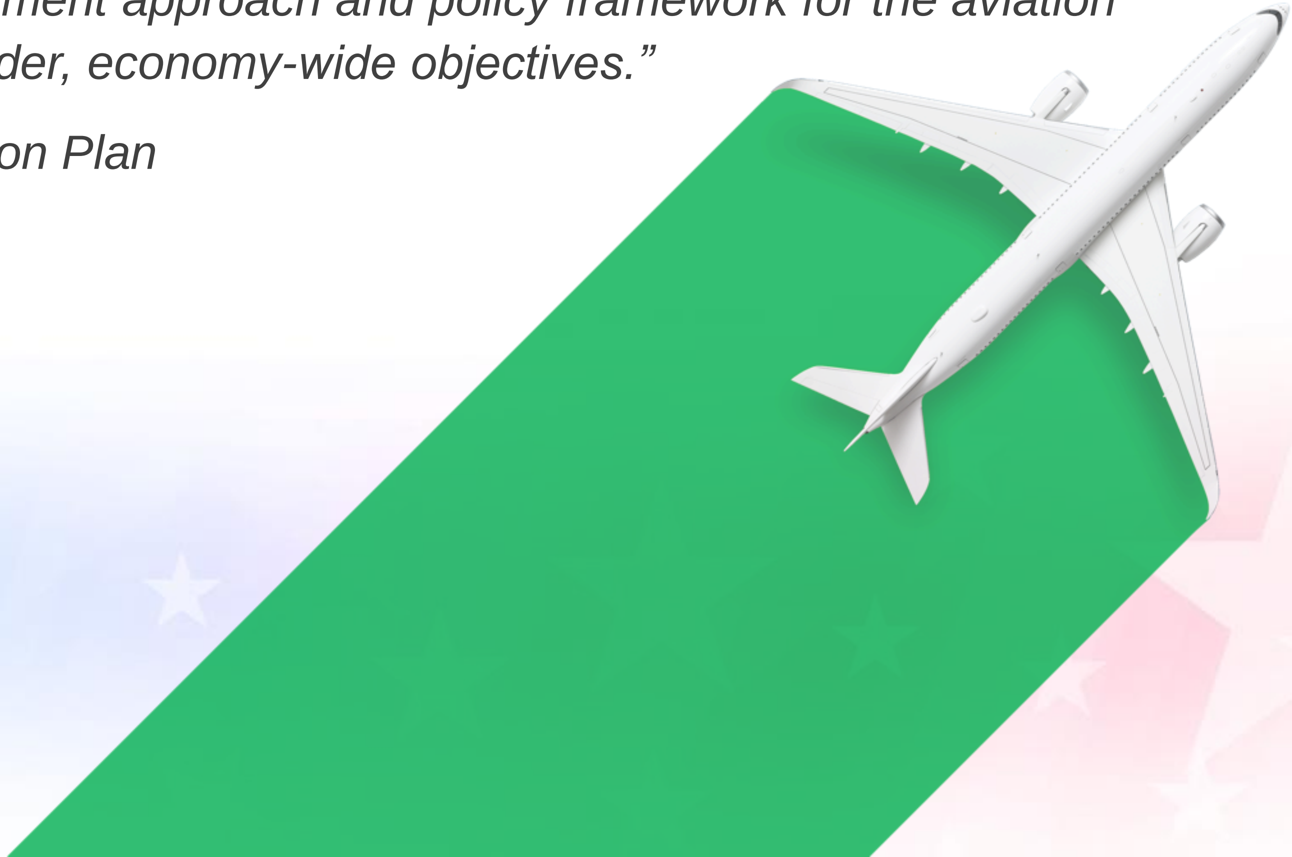
U.S. Aviation Climate Action Plan

U.S. Aviation Climate Goal:

Net-Zero Greenhouse Gas Emissions from the U.S. Aviation Sector by 2050

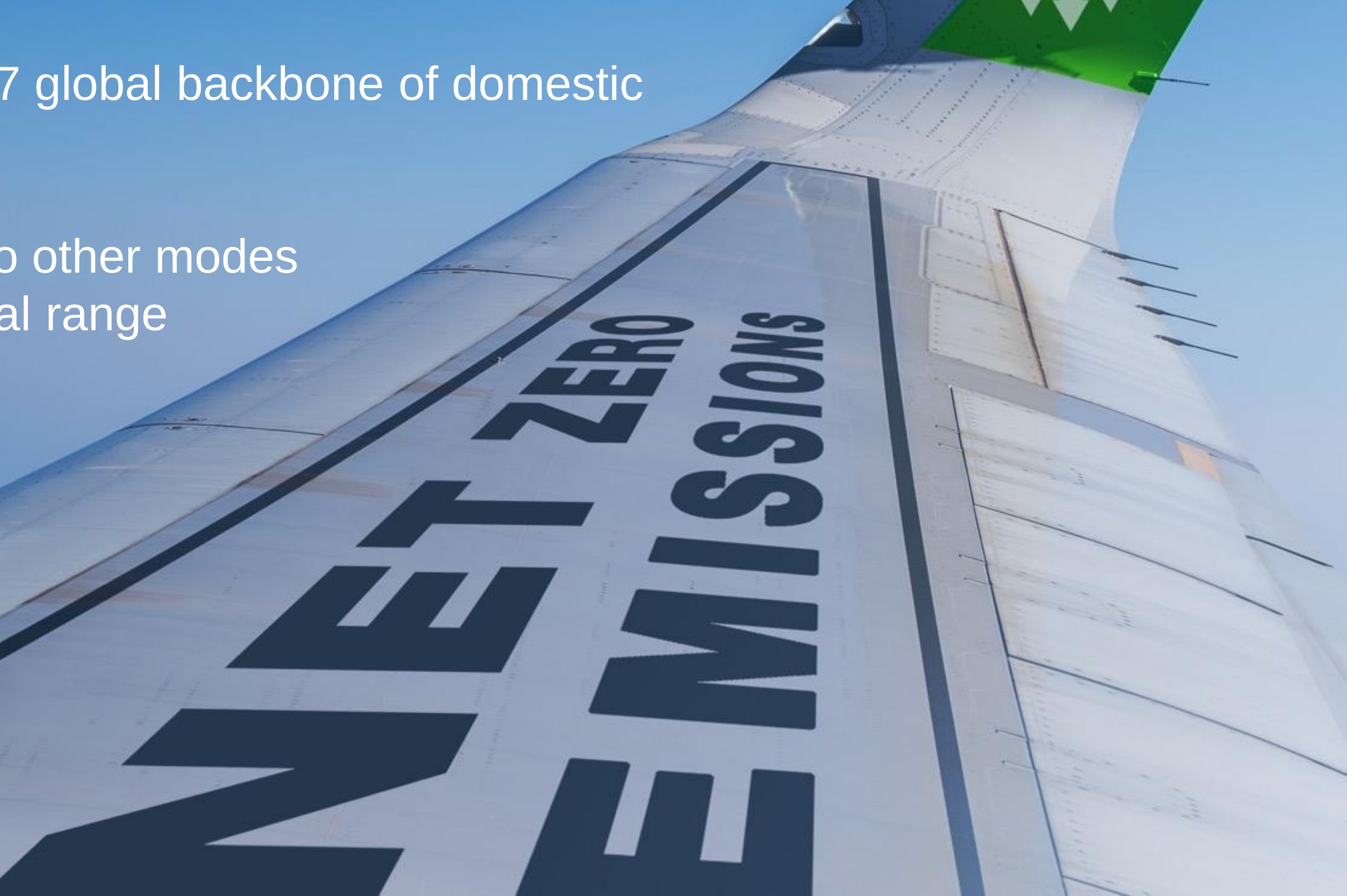
“The United States believes that addressing the climate crisis through enhanced ambition is a defining priority of our time. This Aviation Climate Action Plan provides a whole-of-government approach and policy framework for the aviation sector to contribute to broader, economy-wide objectives.”

- U.S. Aviation Climate Action Plan



Vision for Sustainable Aviation

- Aviation system growth meets demand and improves quality of life for more people worldwide
- Aviation is broadly recognized for its value to society and as environmentally friendly
- Subsonic commercial airliners remain the 24/7 global backbone of domestic and international long-haul air transportation
- Small aircraft provide growing value relative to other modes of transportation at local and domestic regional range while incubating technology for airliners
- Aviation is safe, clean, quiet, efficient, economical, operable, marketable



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

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

Next-generation transports using up to 30% less fuel, current and future fleets flying optimal trajectories, engines burning sustainable aviation fuels for net-zero lifecycle greenhouse gas emissions

Four Transformations for Sustainability, Greater Mobility, and Economic Growth

ULTRA-EFFICIENT AIRLINERS

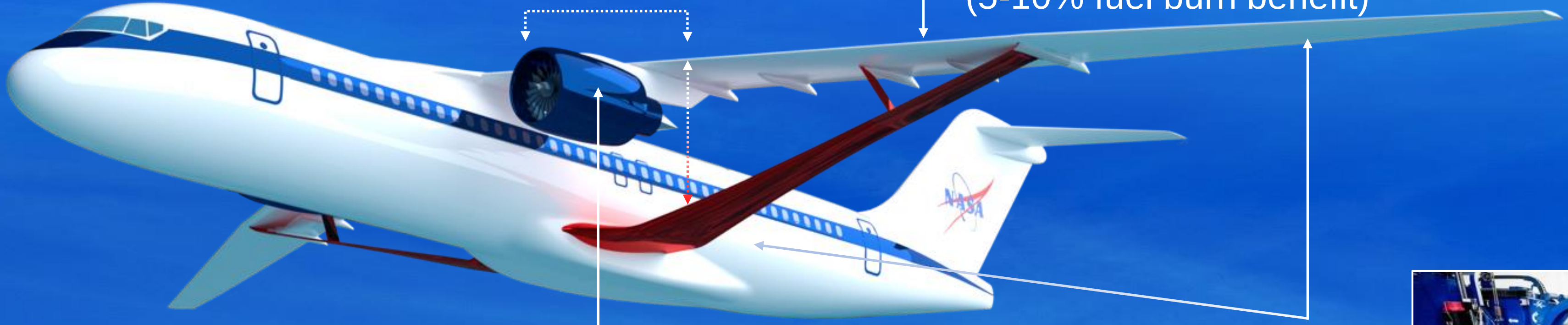
Real Progress. Real Value.

Subsonic Airliner Technologies

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

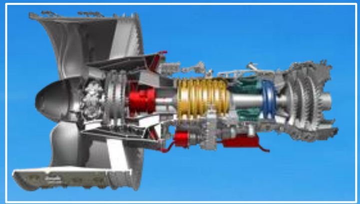
Integrated Aircraft System Efficiency
Propulsion Airframe Integration Opportunity

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



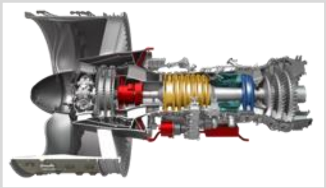
Weight
High-Rate Composites
(4-6x manufacturing increase)

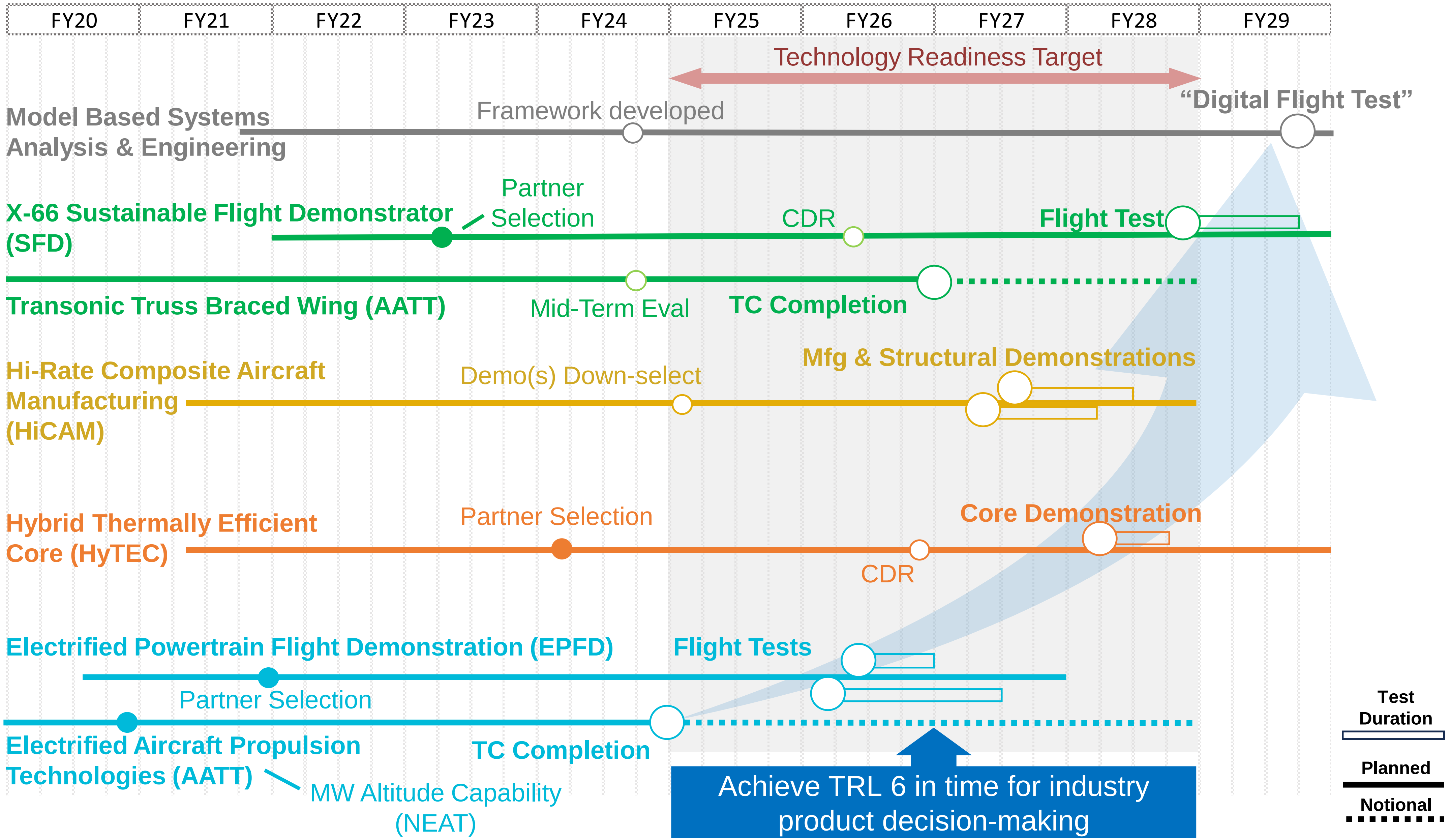
Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit



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

Ultra-Efficient Airliner Integrated Technology Development





Integrate and Demonstrate Technologies

Flight

Transonic Truss-Braced Wing

Photo credit: Boeing

Electric Propulsion Flight Demonstrators

magniX Dash 7 (top) and GE Saab 340B
Photo credit: NASA, GE, magniX

X-Planes to develop, integrate and flight test airframe and propulsion technologies for next generation transports

NASA and Boeing ecoDemonstrator Test SAF Impact on Contrails

BOEING
ecoDemonstrator PROGRAM
GE Aerospace
Transport Canada / Transports Canada
FEDERAL AVIATION ADMINISTRATION
AERODYNE RESEARCH, Inc.
UNITED
MIT
DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center
MISSOURI S&T

Progress

- Contrail-cirrus clouds are net climate warming and form on engine-emitted particles
- Ground tests in 2021-22 lay groundwork for joint flight test in FY24
- Initial data reveals substantial cruise altitude soot particle reductions from burning 100% SAF in advanced GE lean-burn aircraft engine combustors
- Novel water vapor sensors developed through the NASA Small Business Innovation Research program
- Industry, airlines, universities, and government agencies partnered to design and execute tests, gather data needed by national stakeholders
- Initiated National Academy of Sciences study to develop national research agenda on potential mitigations for impacts of persistent contrails (aviation-induced cloudiness)

A Look Ahead

- Test results guide and motivate industry investment in SAF and engine technology R&D and jobs
- Unique in-flight data to be publicly available in Nov 2024 for use in climate and aviation model assessments, university research, industry model validation
- Beginning to develop future contrails research plans

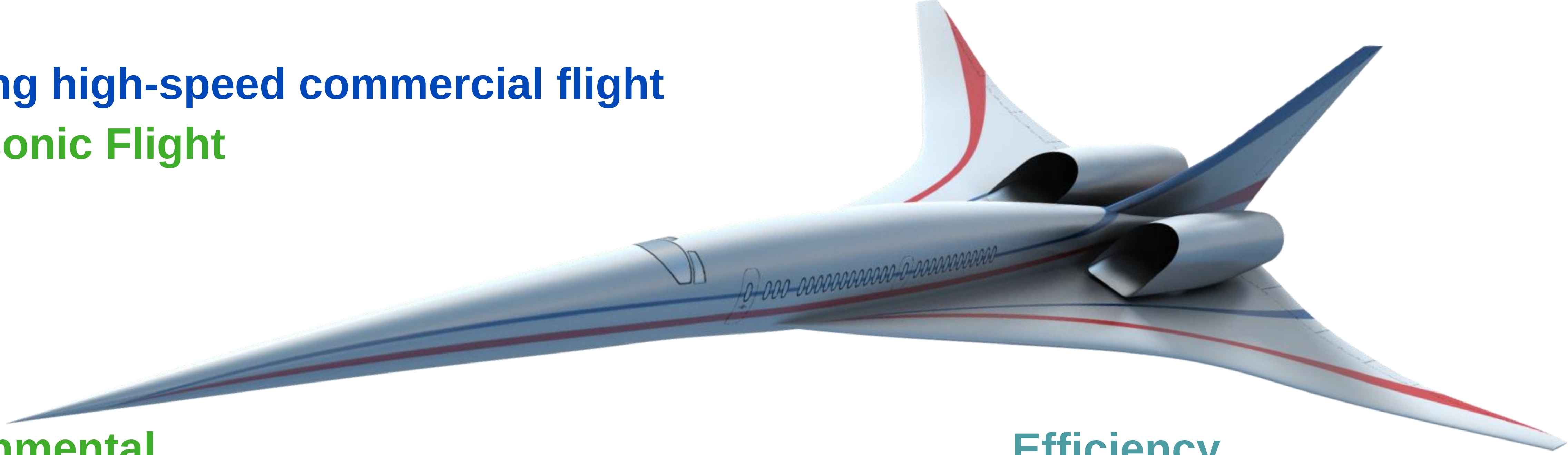
Funds are requested to continue research in aviation contrail formation modeling and mitigation.

HIGH-SPEED FLIGHT

Real Progress. Real Value.

Enabling high-speed commercial flight

Supersonic Flight



Environmental

Sonic Boom

- Technology that reduces sonic boom to a soft thump sound
- Understand community response

Airport Noise

- Noise levels not louder than subsonic aircraft at appropriate airports

High Altitude Emissions

- No or minimal long-term impact at supersonic cruise altitudes
- Adequate quantities of sustainable aviation fuel available to fleet

Efficiency

Efficient Operations

- Airspace-Vehicle interaction for full utilization of high speed

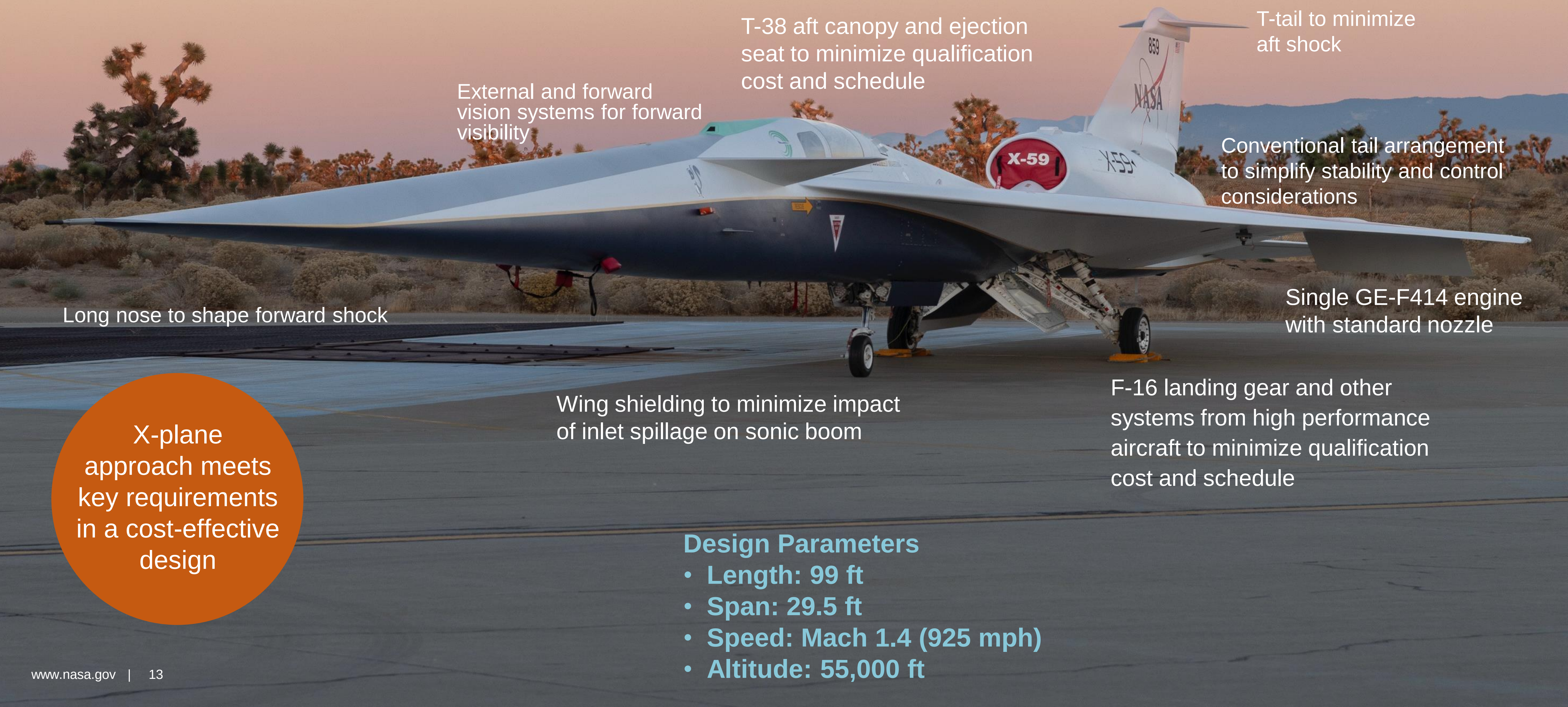
Efficient Vehicles

- Efficient airframe and propulsion throughout flight envelope

Community's Vision:

Development of efficient and environmentally sound commercial high-speed transportation solutions could be a game changer for transcontinental and intercontinental travel

NASA will use the X-59 to prove a sonic boom can be reduced to a sonic thump



External and forward vision systems for forward visibility

T-38 aft canopy and ejection seat to minimize qualification cost and schedule

T-tail to minimize aft shock

Conventional tail arrangement to simplify stability and control considerations

Long nose to shape forward shock

Single GE-F414 engine with standard nozzle

Wing shielding to minimize impact of inlet spillage on sonic boom

F-16 landing gear and other systems from high performance aircraft to minimize qualification cost and schedule

X-plane approach meets key requirements in a cost-effective design

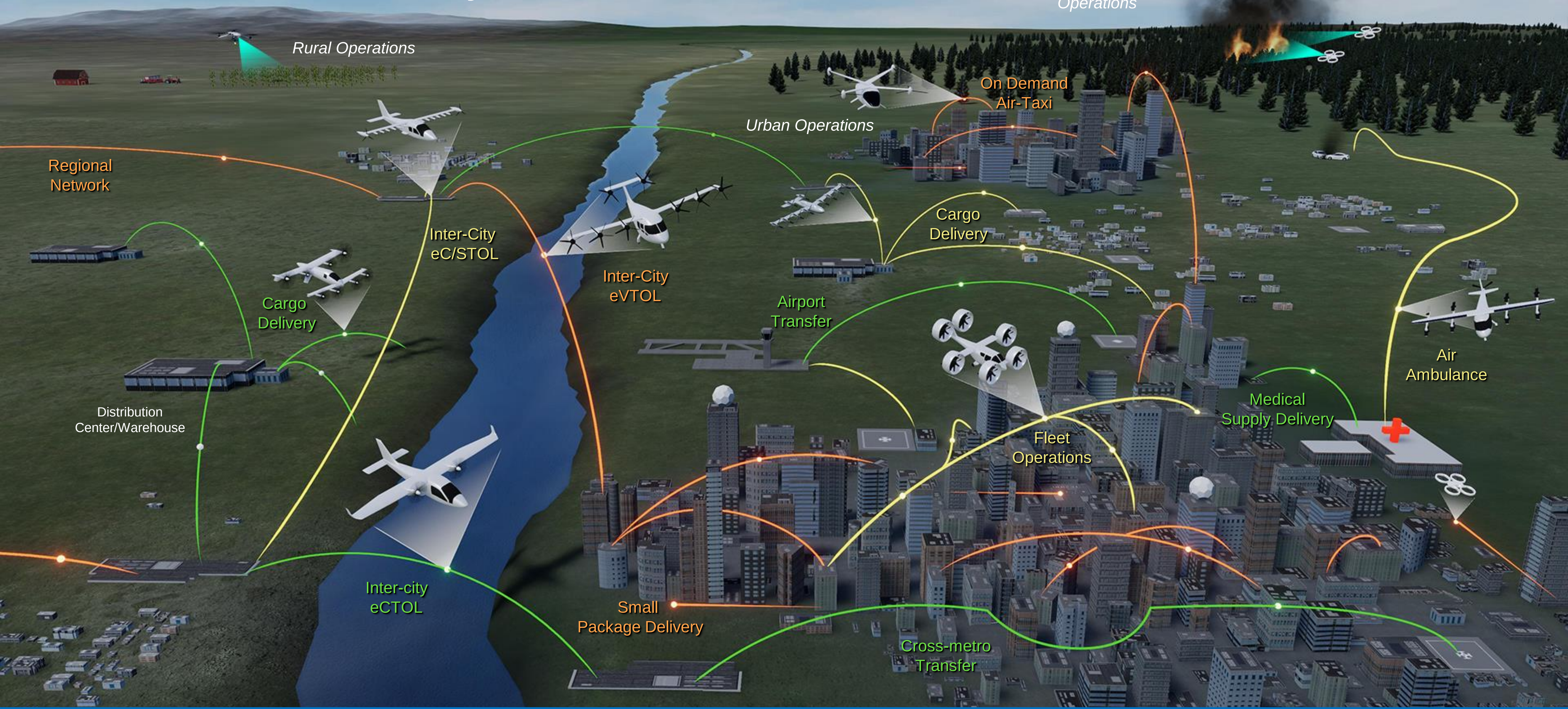
Design Parameters

- **Length: 99 ft**
- **Span: 29.5 ft**
- **Speed: Mach 1.4 (925 mph)**
- **Altitude: 55,000 ft**

ADVANCED AIR MOBILITY

Real Progress. Real Value.

Advanced Air Mobility Mission



Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

Integrated Advanced Air Mobility Portfolio

Concepts

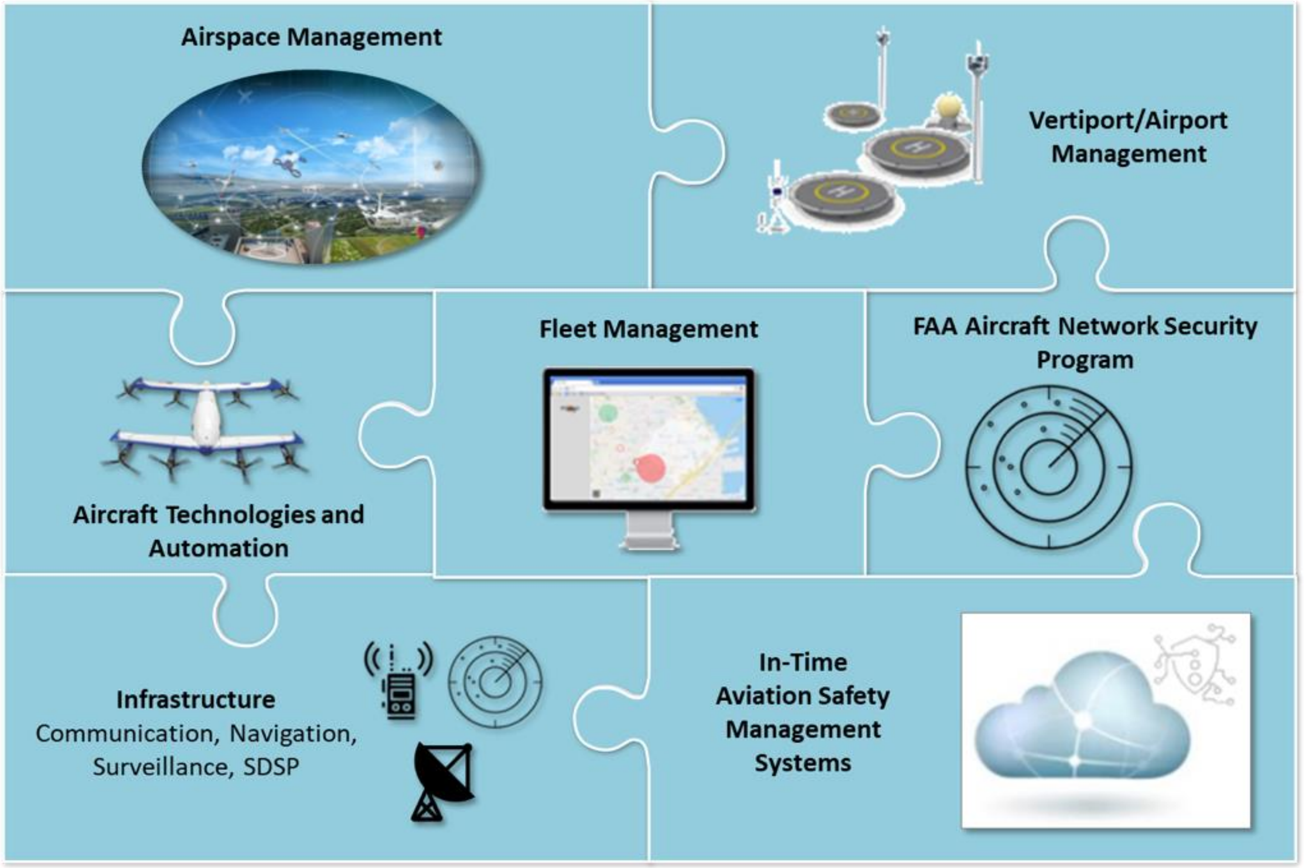
System Engineering & Integration

Deliver **reference architecture(s)**, and **integrated requirements**…

…validated by data from the research, development, and testing of automation prototypes.

Flight Operations

Airspace Operations



Resulting **architecture**(s) will support safe, secure, and scalable UAM operations.

Partnering Approach for AAM Technology Demonstrations

TCL-1: eVTOL pilot on board operations for multiple operators

- Live Virtual Construct with NASA and FAA, including crewed eVTOL aircraft
- Cooperative operating practices
- Airspace automation
- System actor roles & responsibilities

NASA

FEDERAL AVIATION ADMINISTRATION

TCL-2 [FY28]: Initial remotely piloted operations

TCL-3 [FY29]: Degraded weather operation

Industry partner engagement

AFWERX

Joby

Focus: Integration of eVTOL aircraft into UAM airspace infrastructure

SKYGRID

wisk

Focus: Uncrewed operations and UAM service provision

AURA

Focus Area: UAM communication digitization needs including command & control

TCL = Technical Capability Level

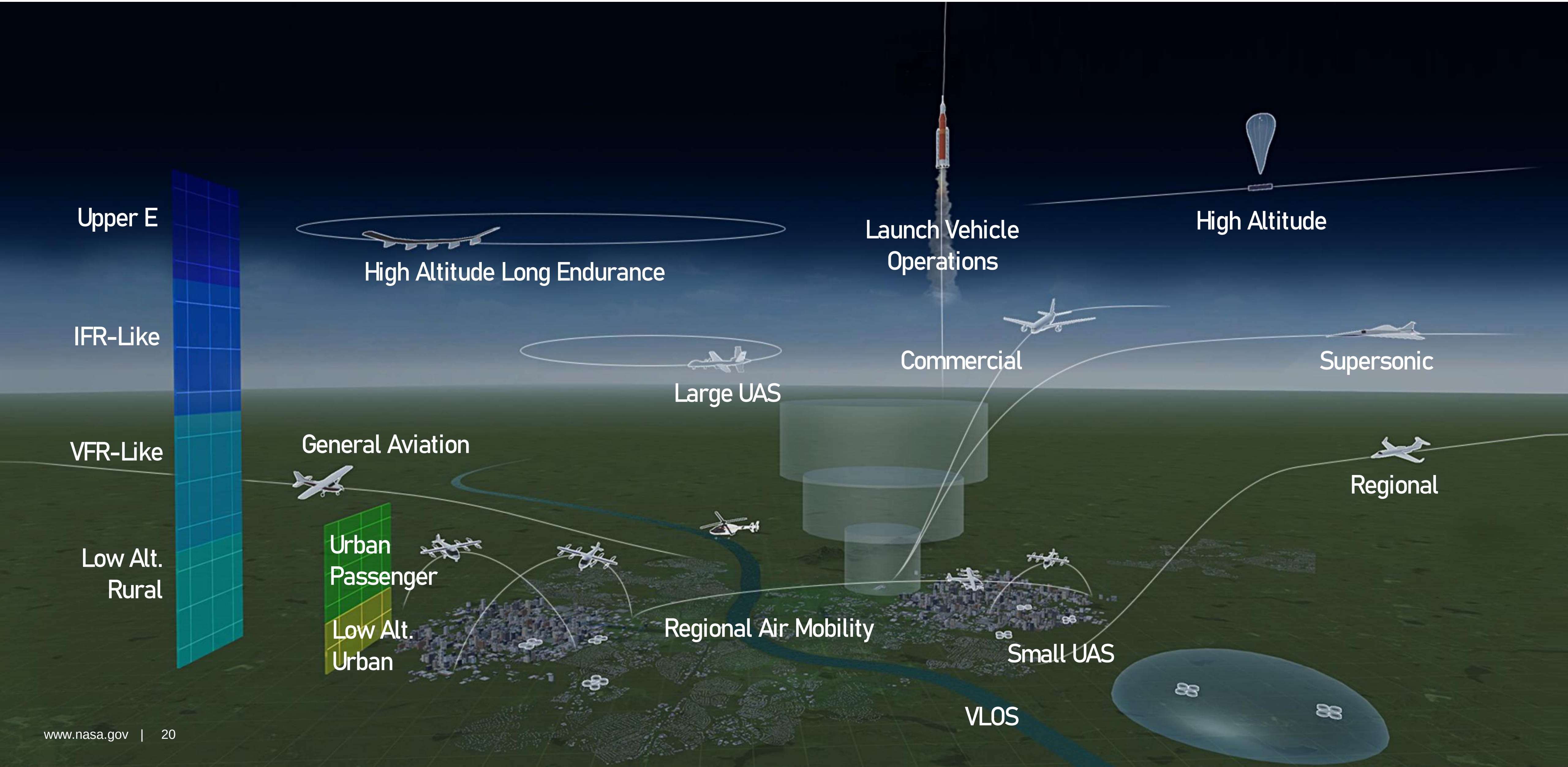
Advanced Air Mobility Vehicle Research at NASA

NASA sets the standard in tools and technology development to push Advanced Air Mobility forward.

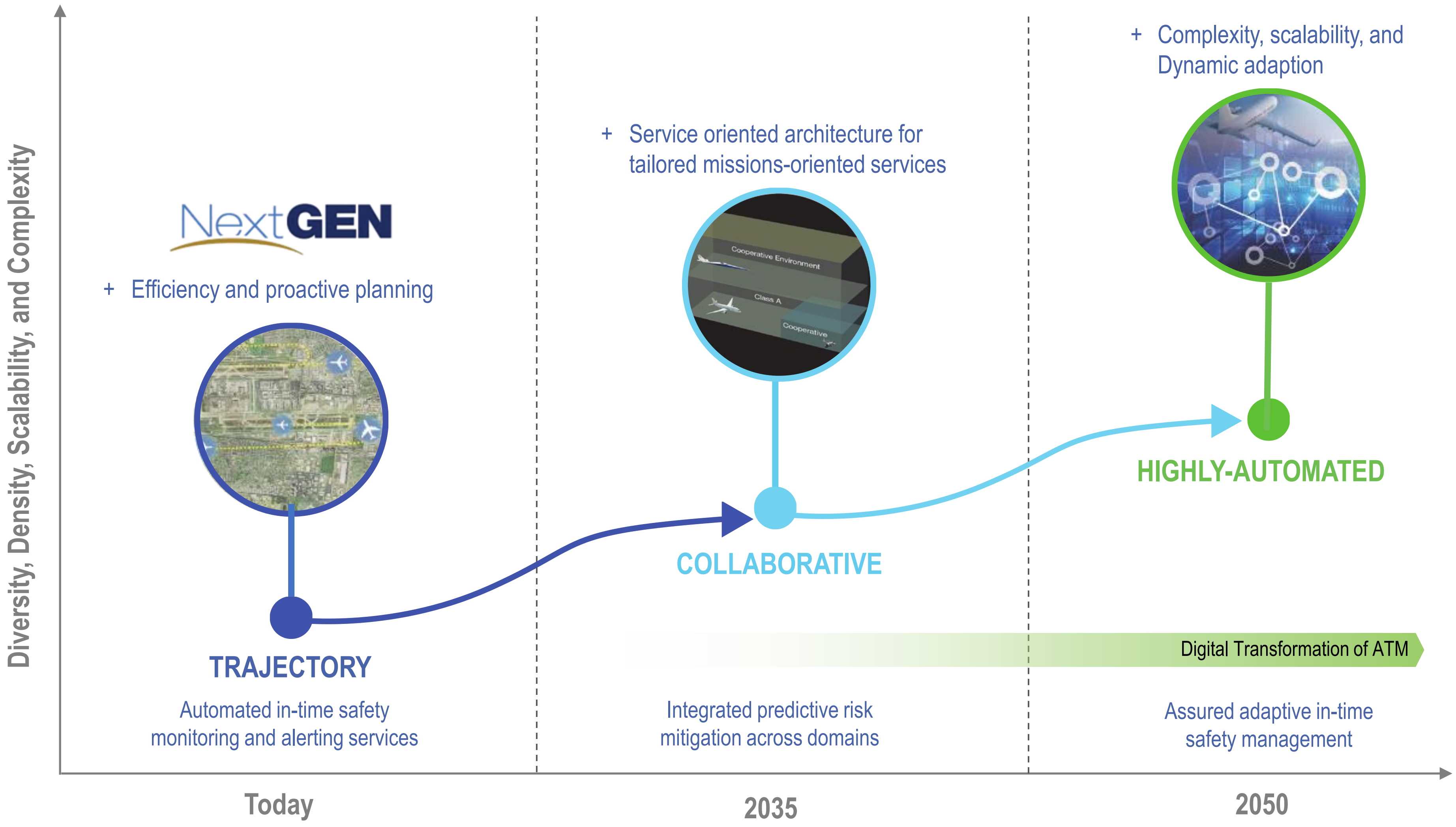
FUTURE AIRSPACE AND SAFETY

Real Progress. Real Value.

Operational Domains in the Future Airspace



Future Airspace and Safety



Data driven approaches with automation key to enable Airspace transformation.

Future Airspace and Safety Ecosystem Transformation Plan

NAS 2040 → SKY for ALL

FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31

Extensible Traffic Management (xTM)

Demonstrate future complimentary service environment for scalability of operations

Increasingly automated operations in cooperative XTM volumes

Digital Services Environment: Application to SFNP Ops Demonstrations

Demonstrate emission and fuel reductions through use of digital services

Integrated digital information environment for common operating picture and third-party services

In-Time Aviation Safety Management System

Integrate safety assurance capabilities to monitor, assess and mitigate risks in current and future operations

Integrated system-wide safety assurance leveraging digital data

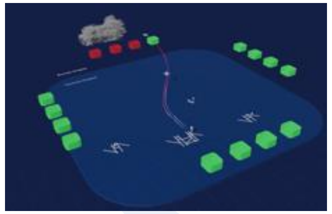
Planned

Notional

Future airspace and safety transformation will be enabled through novel airspace concepts, digitization of data, and system-wide safety assurance.

Sustainable Flight National Partnership Operational (SFNP Ops) Demo Plan

FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31



SFNP Ops 1: Pre-Departure Rerouting (FY22–FY25)

Operator and ATC digital services in a metroplex and a complex multi-center environment

SFNP Ops 2: Integrated Airborne Rerouting (FY23–FY27)

Integrated Pre & Post Departure Rerouting to inform FAA advanced flight data and trajectory management requirements

SFNP Ops 3: Fleet Wide Irregular Operations Recovery Management (FY24–FY28)

Fleet-wide rerouting services for intelligent disruption management recovery strategies

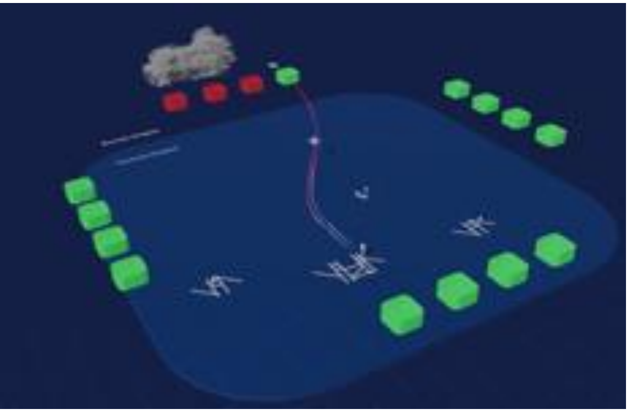
SFNP Ops 4: Capstone Demo (FY25–FY29)

4D trajectory optimization through an end-to-end digital workflow across NAS users

Planned

Using NASA, FAA, and partner assets to demonstrate reduction in emissions and fuel for aviation operations

SFNP Ops1: FY22–FY25, Pre-Departure Rerouting Tests in Texas

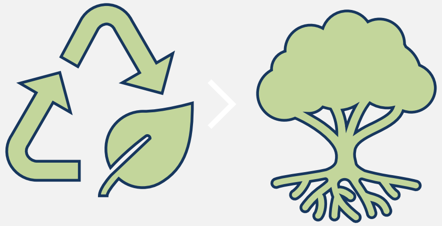


SAVINGS

Actual: 68 flights
Over **55,000 lbs**

Projected: 173 flights
Over **89,000 lbs**

1/23–9/23



Actual: 68 flights
Over **169K** lbs. **CO^2** or over 1200 urban trees

Projected: 173 flights
Over **276K** lbs. **CO^2** or over 2000 urban trees

Accomplishments

- Field engagement with flight operators and ATC facilities for Ops1b (Houston airspace)
- System-wide benefits assessment of Collaborative Digital Departure Rerouting (CDDR) service
- Tech transfer plan for CDDR and Fuser
- Participation in Artificial Intelligence/Machine Learning certification process with FAA

Ongoing

- Operational data collection in North Texas ongoing since January 2023
- Expansion into multi-center complex airspace (Houston) in FY24-FY25

A Look Ahead

- Complete an operational assessment of a cloud-based digital information aviation service to demonstrate improvements to the sustainability of aviation operations resulting in reduced fuel use and emissions (FY25)

Progress towards FAA's NAS 2040 by demonstrating digital services on the cloud and reducing the impact of aviation on the climate

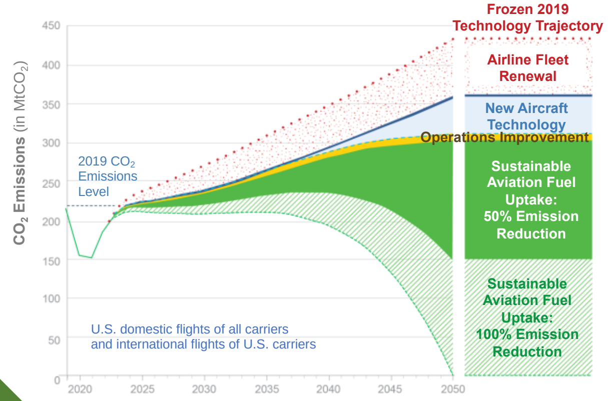
The Long Game: Aviation Eras on the Path Toward Sustainability

Accelerating Toward Net-Zero →

Net-Zero GHG, 2050

2020s | 2030s | 2040s | 2050s | 2060s

Reducing Non-CO_2 Impacts →



Era One: Evolution

Tube-and-Wing, Existing Infrastructure, Transition to Drop-In SAF, Increasing Electrification

Era Two: Revolution

Vehicle Architecture Change, Major SAF Adoption, Mild Hybrid Electrified Aircraft Propulsion (EAP), Minor Infrastructure Change

Era Three: Transformation

Major Vehicle Architecture Change, Non-Drop-In Fuel Adoption, Many-MW EAP, Major Infrastructure Change

Growing Risk

Growing Impact

Slide created in collaboration with FAA Office of Environment and Energy

Transformation doesn't happen overnight; the U.S. is making deliberate, long-term investment in broad-ranging technologies beyond industry's risk tolerance

NASA Sustainable Aviation Strategy

2008-2013 | 2014-2019 | 2020-2025 | 2025-2030 | 2030+

Subsonic Concept/Technology Studies
Electrified Aircraft Propulsion
Transonic Truss-Braced Wing
Blended Wing Body

Environmentally Responsible Aviation Project

Flight Demonstrator Studies

Advanced Composites Project

SUSTAINABLE FLIGHT NATIONAL PARTNERSHIP

Sustainable Flight National Partnership to mature and integrate key technologies for next-generation subsonic airliners (2030s)

TODAY

ACCELERATING TOWARD NET-ZERO CARBON

Cast a wide net for zero-emission concepts and technologies

Select and develop promising concepts in partnership with universities, industry

Create a credible mission, architecture, and technologies for beyond next-generation subsonic transports for 2050 horizon

POWERING AVIATION TO NET-ZERO CARBON AND BEYOND

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

Implications for Sustainable Aviation

Time is of the essence as the climate is not waiting

Energy-sector transformation is critical

Energy Efficiency is necessary but not sufficient

Fleet / Infrastructure Inertia is massive

Business Physics of Todays Network is slow to change

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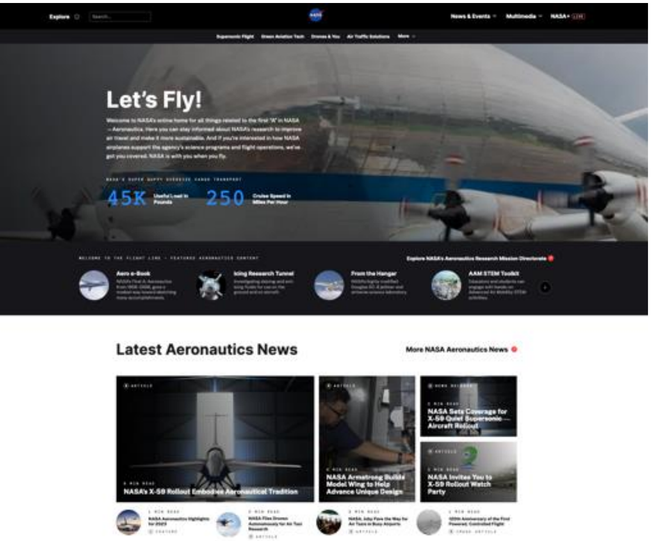

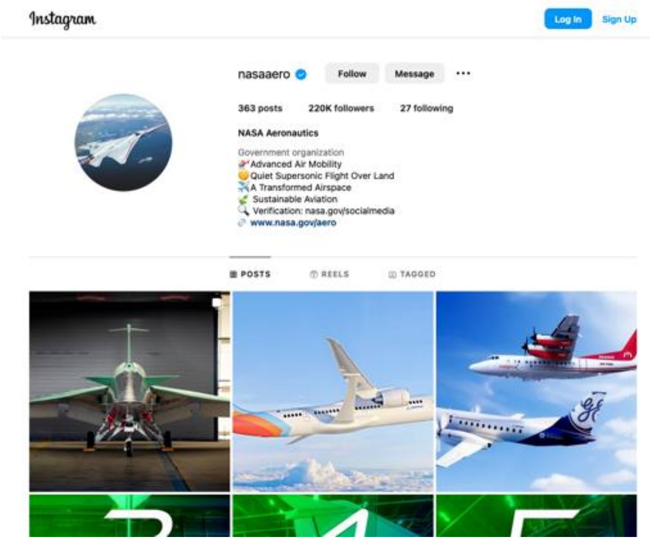

NASA

Sustainable Flight Demonstrator Project

Demonstrate integrated airframe-focused technologies in flight

Scope

- Develop and flight test an advanced airframe configuration and related technologies to dramatically reduce aircraft fuel burn and CO_2 emissions to help enable the next-generation single-aisle aircraft in the 2030s
- Inform industry decisions to maximize the potential to meet U.S. environmental goals articulated in the U.S. Aviation Climate Action Plan

Benefit

- Reduce fuel consumption and emissions 5-10% relative to today's most efficient single-aisle aircraft

Approach

- NASA and Boeing are committed to a collaborative approach, consistent with the awarded Funded Space Act Agreement
- Obtain wind tunnel, ground and flight data that will be used by the NASA/industry teams to validate the transonic truss braced-wing configuration and associated technologies

X-66 first flight planned in 2028.
Value: Integrated technologies reduce fuel consumption/emissions 5-10%.

Electrified Powertrain Flight Demonstration Project

Demonstrate integrated electrified powertrains in flight using industry modified aircraft

magniX Dash 7 Concept Art

GE Saab 340B Concept Art

Scope

- Conduct ground and flight tests of electrified aircraft propulsion technologies to enable a new generation of hybrid electric-powered aircraft
- Accelerate the transition of megawatt (MW)-class powertrains to single-aisle seat class commercial airliners
- Assess gaps in regulations/standards to support future Electrified Aircraft Propulsion (EAP) certification requirements

Benefits

- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft that offer ~5% reduction in fuel burn
- Meet U.S. environmental goals articulated in the U.S. Aviation Climate Action Plan

Approach

- Collaborate with GE Aerospace and magniX to conduct ground and flight tests of hybrid electric propulsion systems using existing testbed aircraft retrofitted with new EAP technologies
- Engage with the FAA and other organizations to contribute data that inform EAP standards and regulations

Flight tests begin FY 2026

Value: Accelerate ability to consider megawatt-class powertrains offering ~5% reduction in fuel burn and to meet Electrified Aircraft Propulsion certification requirements