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NASA Sustainable Flight National Partnership

Dr. Richard A. Wahls (Rich)
Sustainable Flight National Partnership Mission Integration Manager, Aeronautics Research Mission Directorate

Aeronautics Research & Technology Roundtable (ARTR) | Washington, DC

July 19, 2024

Bottom Line Up Front

Commercial air transportation of people & goods is vital to our quality of life

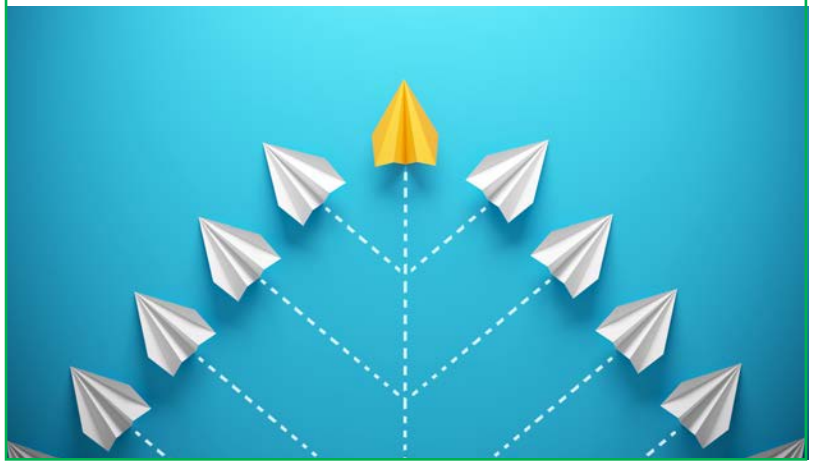
- 24/7 global mobility now and the foreseeable future

Sustainable aviation is a complex challenge without a silver bullet solution

- Time is of the essence

NASA's Sustainable Flight National Partnership (SFNP) is leading major demonstrations to accelerate revolutionary change

- Team USA must lead the way on this global challenge



Context

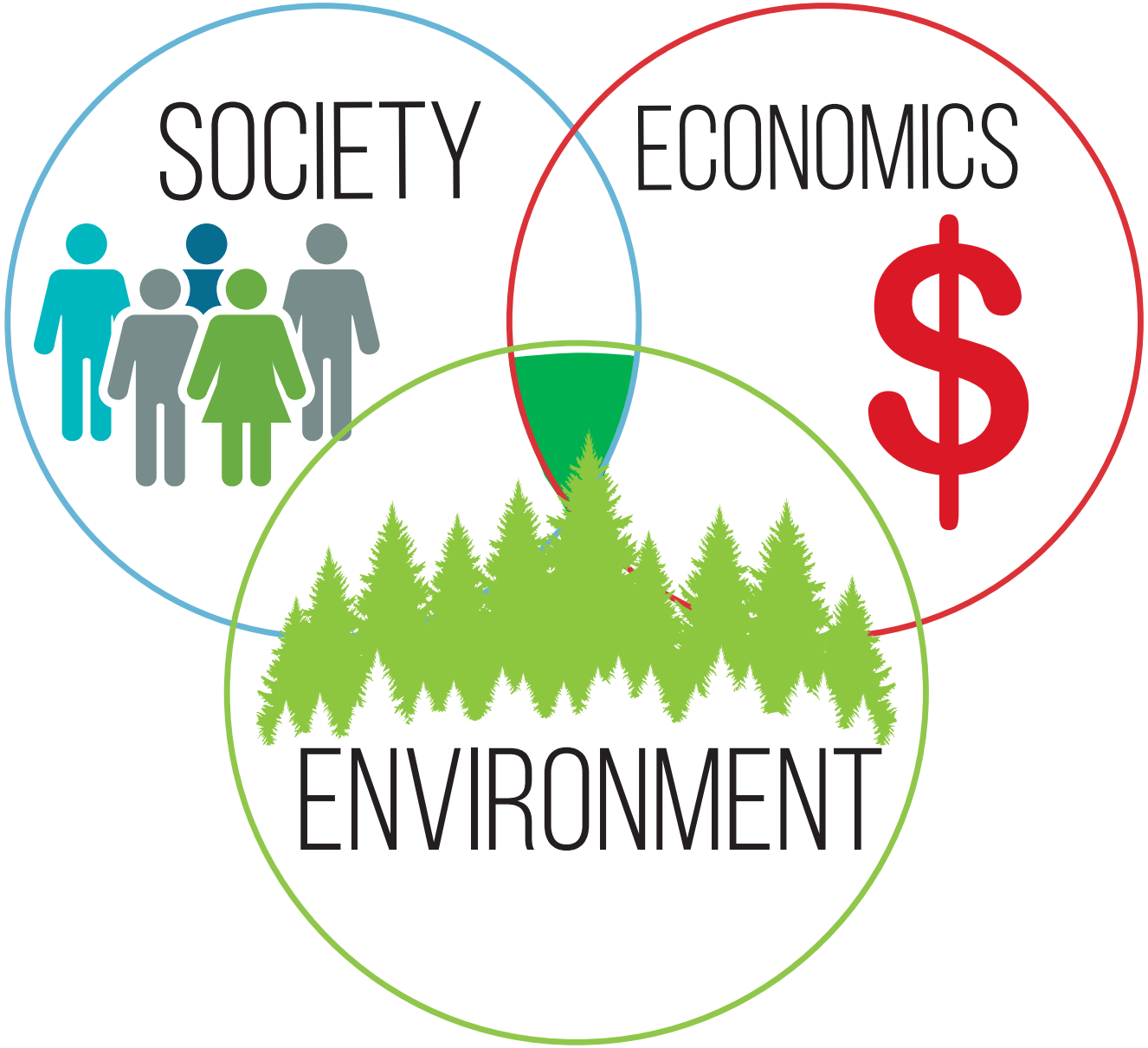
Four Transformations for Sustainability, Greater Mobility, and Economic Growth

Established value – global connectivity 24/7
Sustainable growth is the challenge

Emerging new/enhanced value from aviation
Sustainability required from day one

Commercial Airliners & Cargo are Integral to Our Quality of Life

Sustainability



Aviation is safe, clean, quiet, efficient, economical, operable, marketable

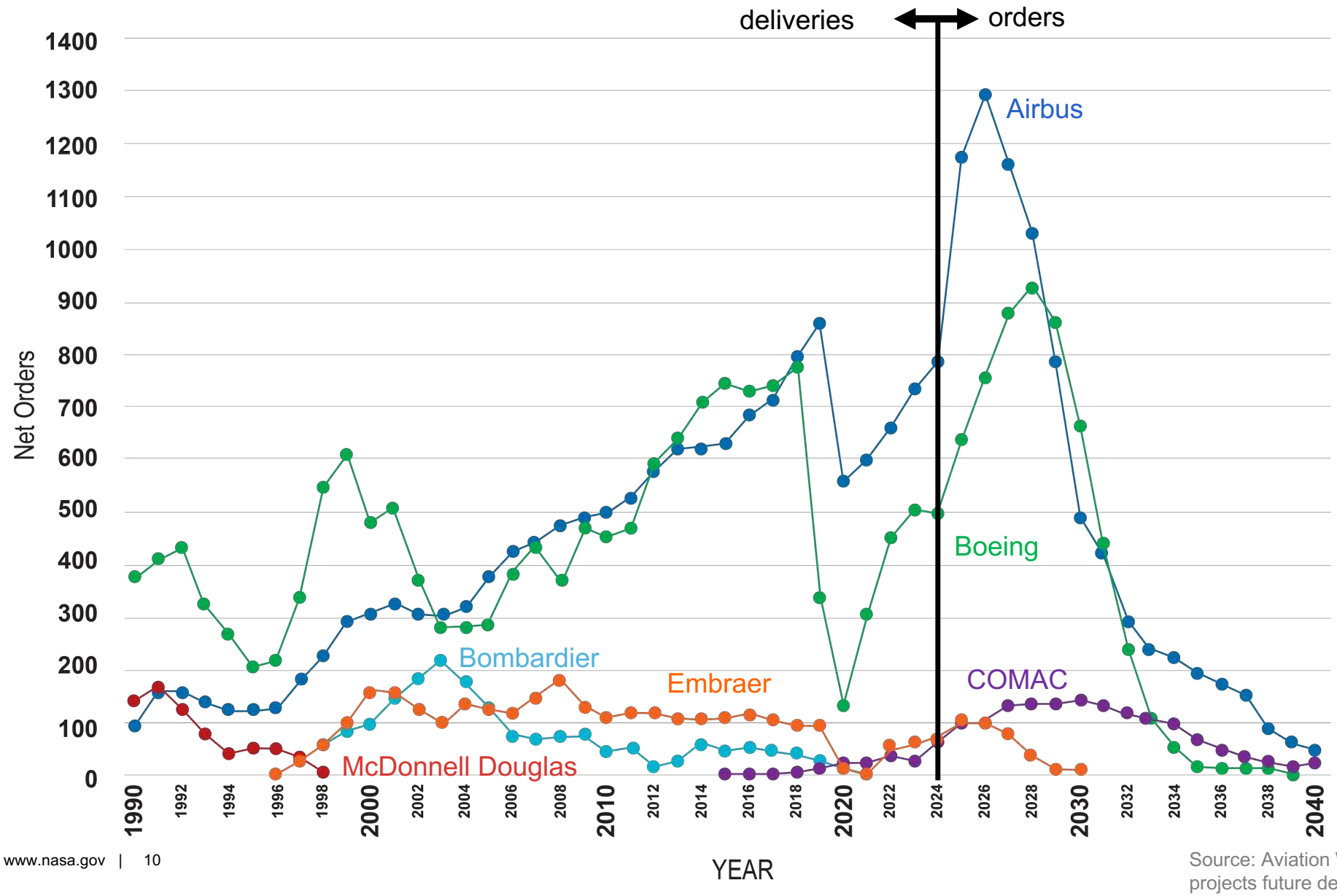
Aviation is Vital to our Nation's Economy & Quality of Life

- $1.25 trillion economic impact from commercial aviation in 2022*
- $77.3 billion positive manufacturing trade balance in 2022**
- 8.97 million flights by U.S. carriers worldwide in 2022***
- 24 million tons of freight transported by U.S. airlines in 2022***
- 2.2 million aerospace/defense jobs; 603,000 in aeronautics/aircraft in 2022**

* From Airlines for America
** From Aerospace Industries Association
*** From Bureau of Transportation Statistics

U.S. Leadership – Global Competition

Net Orders* as of 6/13/24 through 2040 (Commercial Jets)



Market Size Today
~25K aircraft

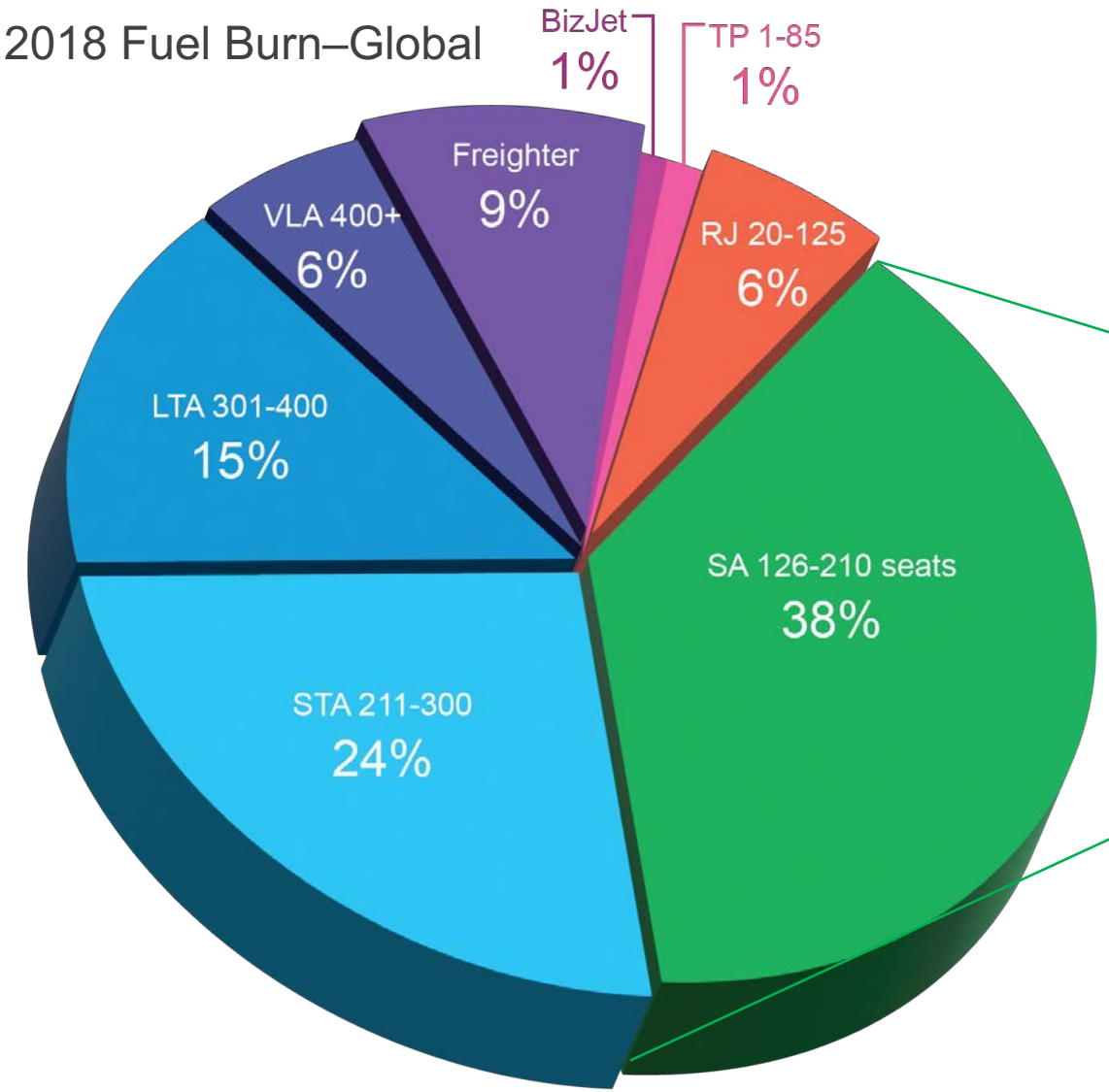
Growth & Replacement
~40K over next 20 years
~$7-8T

High Stakes Competition
US leadership at risk
Chinese market projected at ~20%

Source: Aviation Week Network – Fleet Discovery Civil Database 6/13/24 projects future deliveries from net order database

Fuel burn…directly proportional to cost and emissions

2018 Fuel Burn–Global



Volume (~75% of future deliveries)
Emissions (38%)
2030s Clean-Sheet Design Opportunity

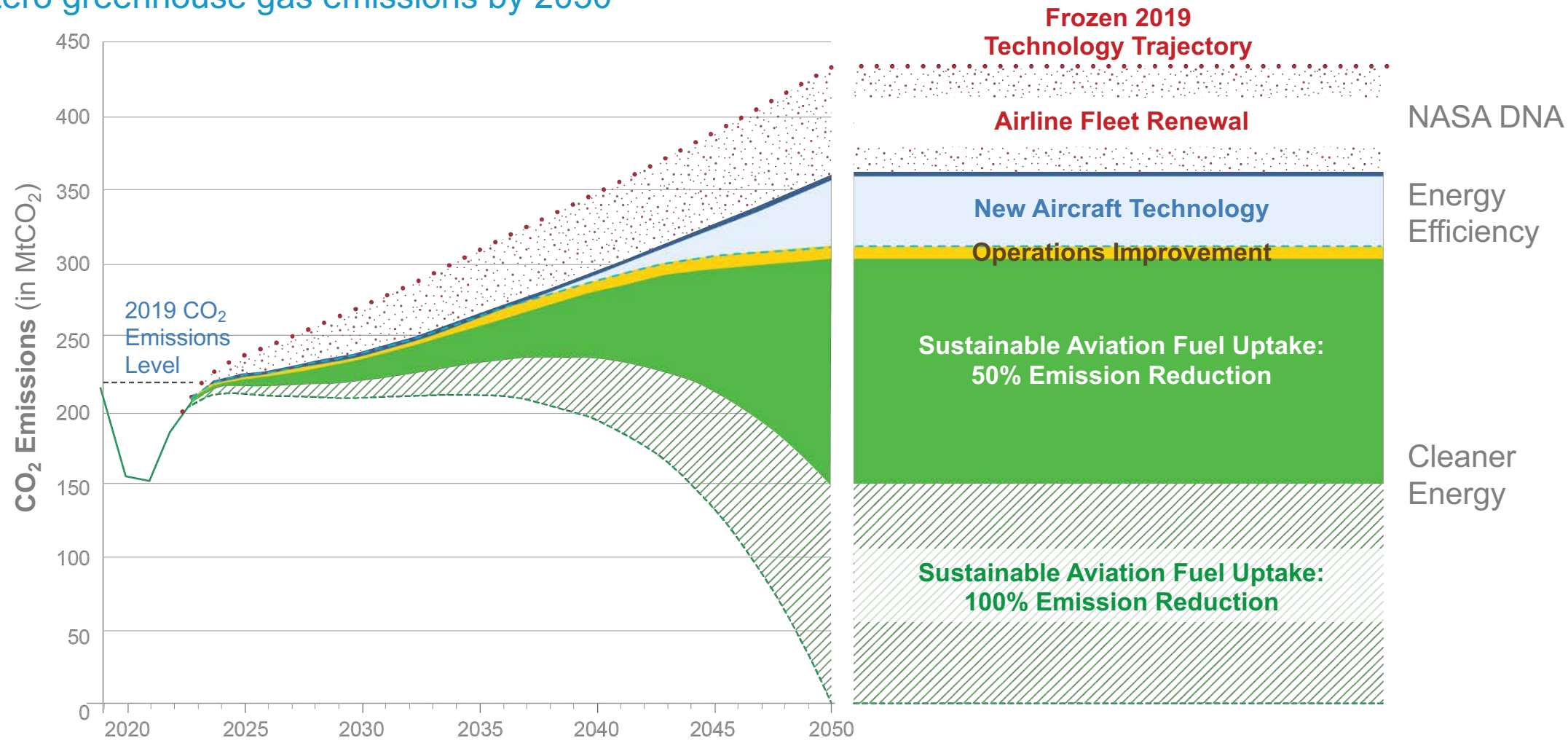
BizJet: Business Jet (all)
TP: Turboprop (seats)
RJ: Regional Jet (seats)
SA: Single Aisle (seats)
STA: Small Twin Aisle (seats)
LTA: Large Twin Aisle (seats)
VLA: Very Large Twin Aisle (seats)
Freighter: all (mostly twin aisle class)

Source data: DoT/Volpe Center, Flemming et al,: basis of 2022 ICAO Environmental Report, Chapter 1, p24
https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2022/ICAO%20ENV%20Report%202022%20F4.pdf

92% of commercial aviation fuel burn from aircraft larger than 125 seat-class

U.S. Aviation Climate Action Plan – 2021

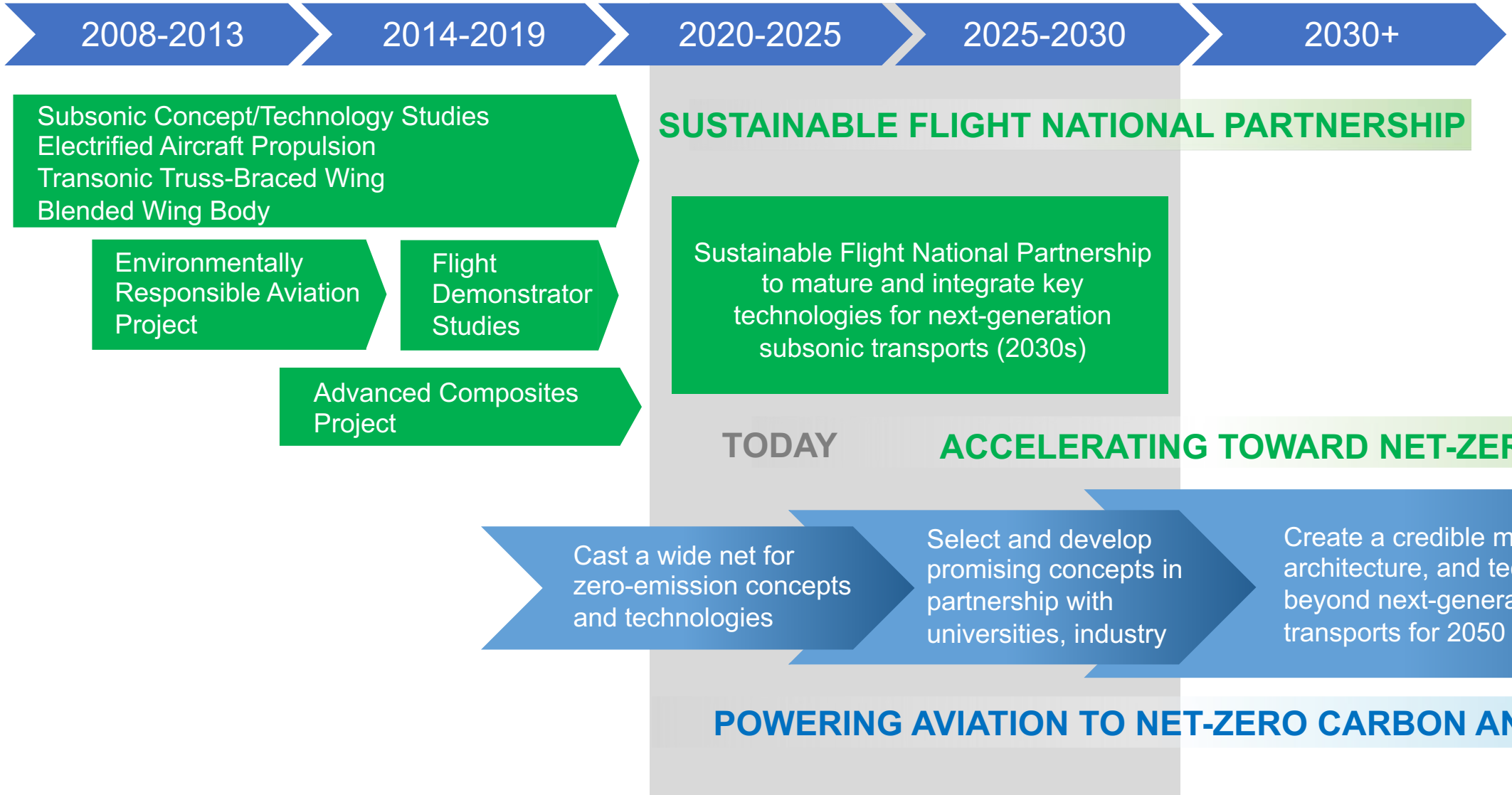
Net-zero greenhouse gas emissions by 2050



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 with reduced non-CO_2 (e.g. contrails), noise, and local air quality impacts

NASA Sustainable Aviation Strategy



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

Sustainable Flight National Partnership (SFNP)

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

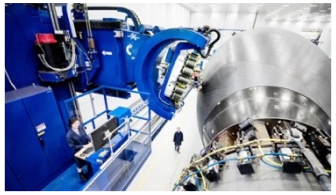
Enable use of 100% sustainable aviation fuels

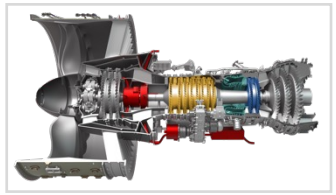
Next-generation transports using up to 30% less fuel, current & future fleet flying optimal trajectories, and engines burning SAF with greater than 50% reduction in lifecycle GHG emissions

ULTRA-EFFICIENT AIRLINERS

Real Progress. Real Value.

Ultra-Efficient Airliner Integrated Technology Development





FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29

Technology Readiness Target

"Digital Flight Test"

Model Based Systems Analysis & Engineering

X-66 Sustainable Flight Demonstrator (SFD)

Flight Test

Transonic Truss Braced Wing (AATT)

TC Completion

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg & Structural Demonstrations

Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration

Electrified Powertrain Flight Demonstration (EPFD)

Flight Tests

Electrified Aircraft Propulsion Technologies (AATT)

TC Completion

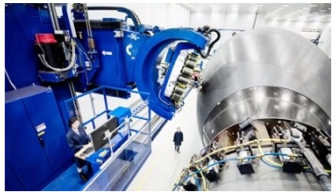
Achieve TRL 6 in time for industry product decision-making

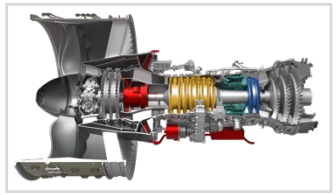
Test Duration

Planned

Notional

Ultra-Efficient Airliner Integrated Technology Development





FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29

Technology Readiness Target

Model Based Systems Analysis & Engineering

Framework developed

"Digital Flight Test"

X-66 Sustainable Flight Demonstrator (SFD)

Partner Selection

CDR

Flight Test

Transonic Truss Braced Wing (AATT)

Mid-Term Eval

TC Completion

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Demo(s) Down-select

Mfg & Structural Demonstrations

Hybrid Thermally Efficient Core (HyTEC)

Partner Selection

CDR

Core Demonstration

Electrified Powertrain Flight Demonstration (EPFD)

Flight Tests

Partner Selection

Electrified Aircraft Propulsion Technologies (AATT)

TC Completion

MW Altitude Capability (NEAT)

Achieve TRL 6 in time for industry product decision-making

Test Duration

Planned

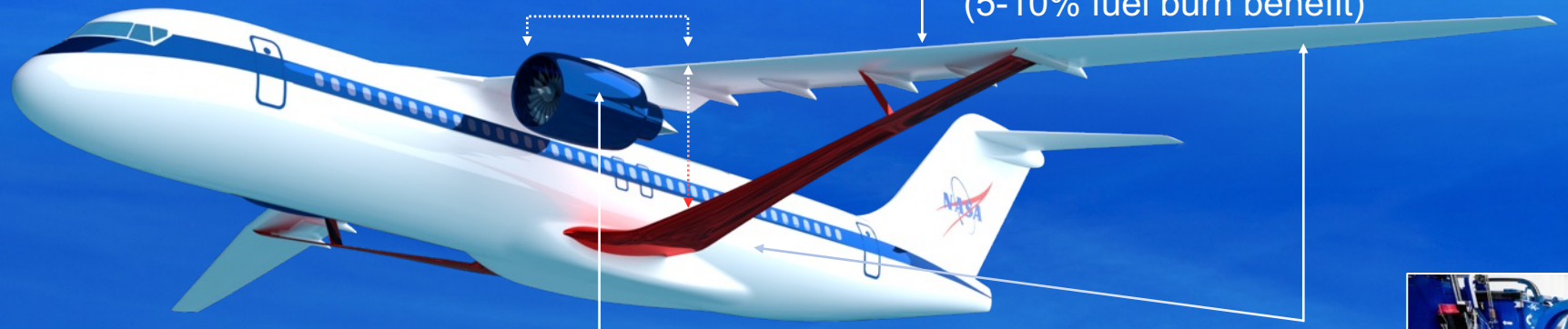
Notional

Ultra-Efficient 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

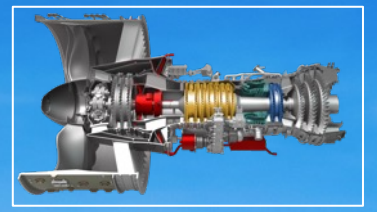
Aerodynamic Efficiency
Transonic Truss-Braced Wing
(5-10% fuel burn benefit)



Lightweight Composites
4-6x manufacturing rate
(5-8% fuel burn benefit)

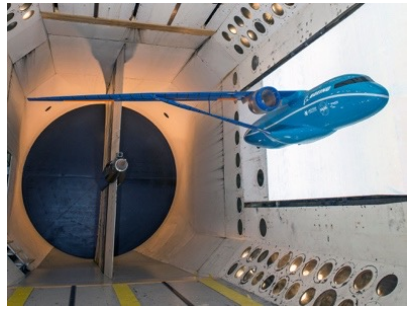
Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit

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

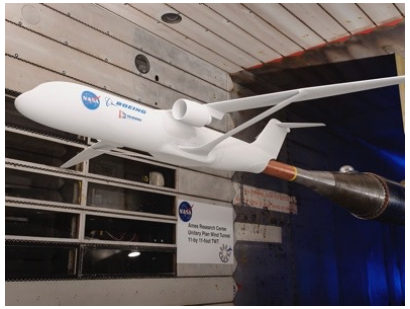


Transonic Truss-Braced Wing Technology Maturation

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

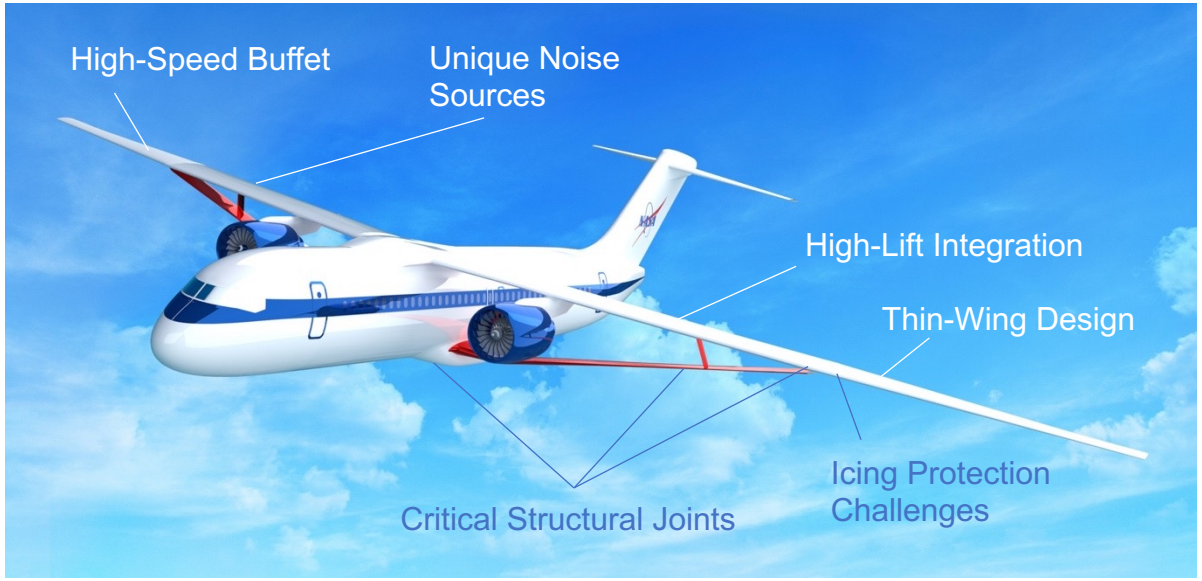


2013



2016

2022



Now: Reduce risks of TTBW technology not addressed by the X-66 demonstrator

Maturation of the concept through progressive design/analysis studies and wind-tunnel tests since 2009
2024 testing focused on icing, high-lift system integration, and deep stall

Video credit: NASA (wind tunnel testing)
Video credit: Boeing (MD90/X66)
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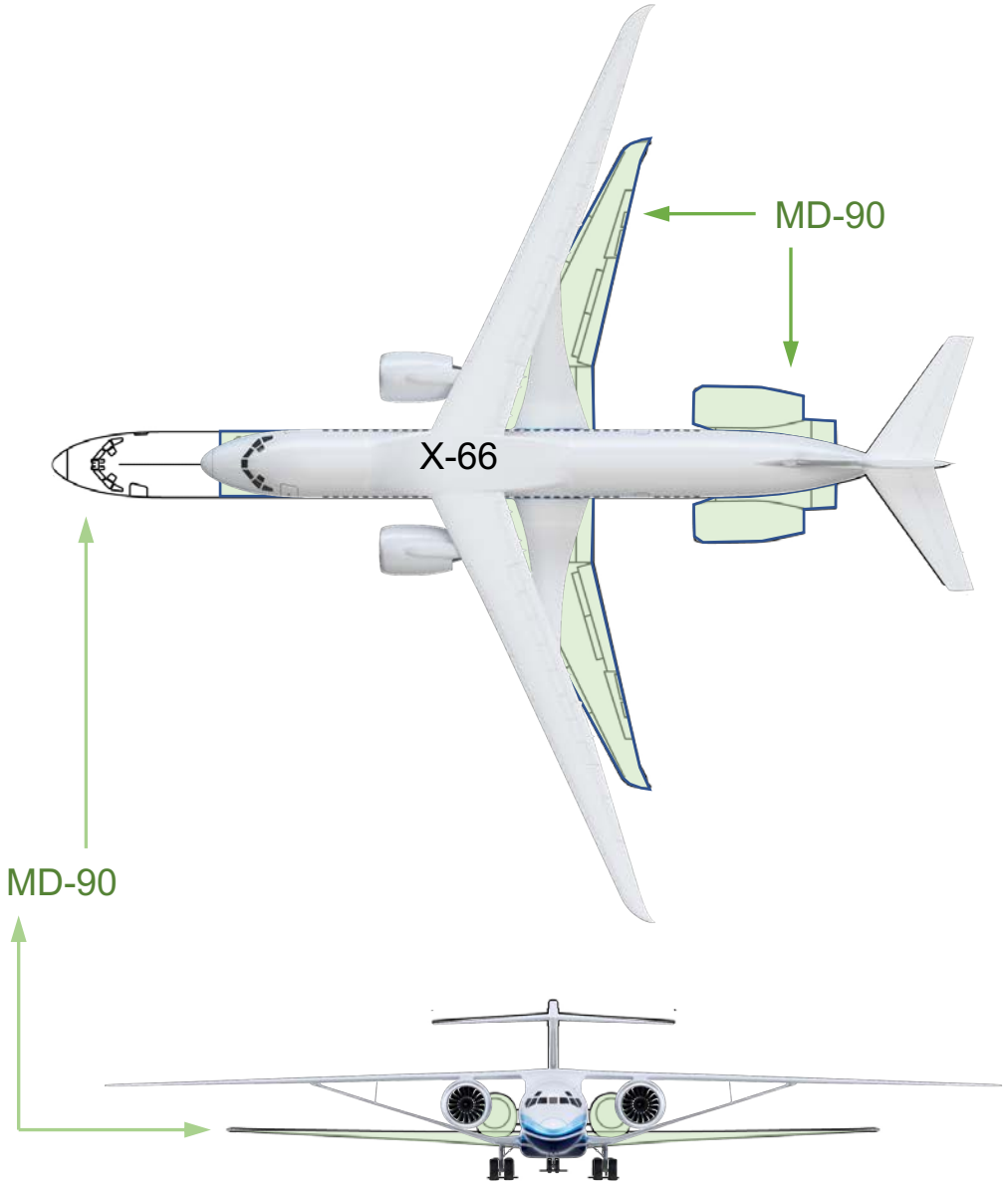
Sustainable Flight Demonstrator Project

Demonstrate integrated airframe-focused technologies in flight



First flight planned in 2028.
TTBW concept can reduce fuel consumption/emissions up to 5-10%.

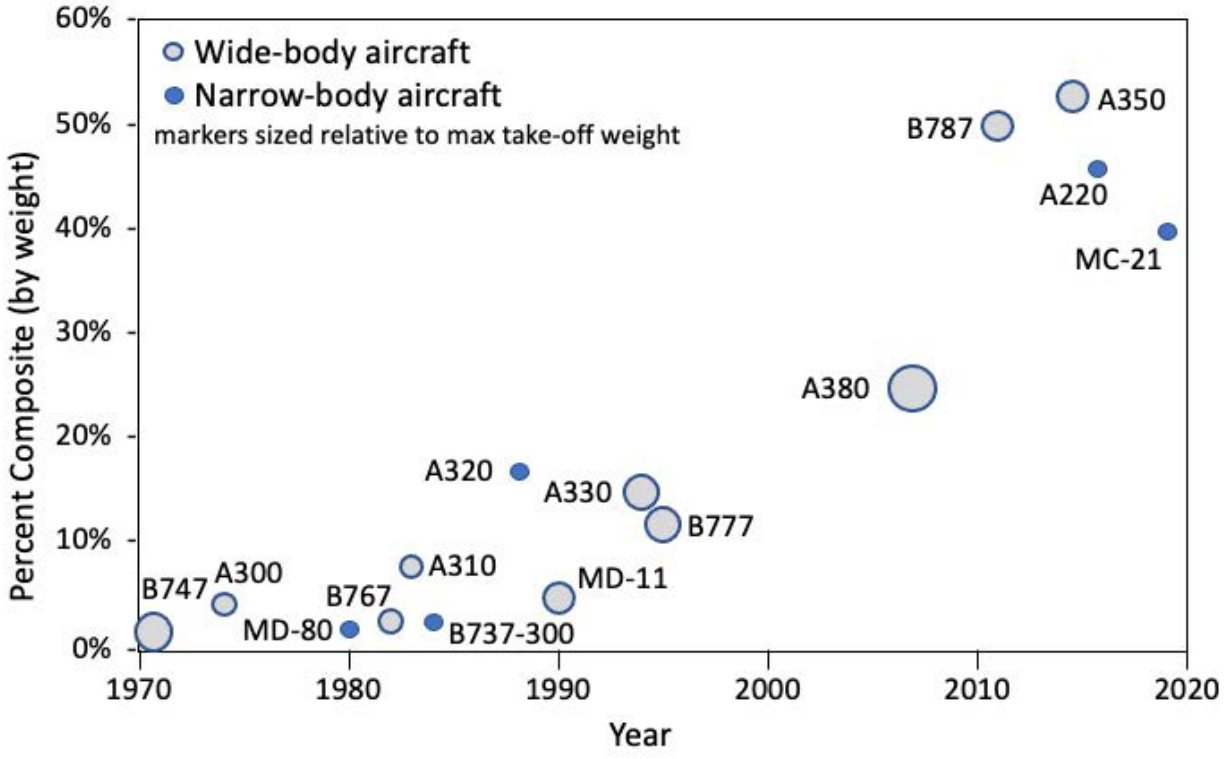
Hi-Rate Composite Aircraft Manufacturing (HiCAM)

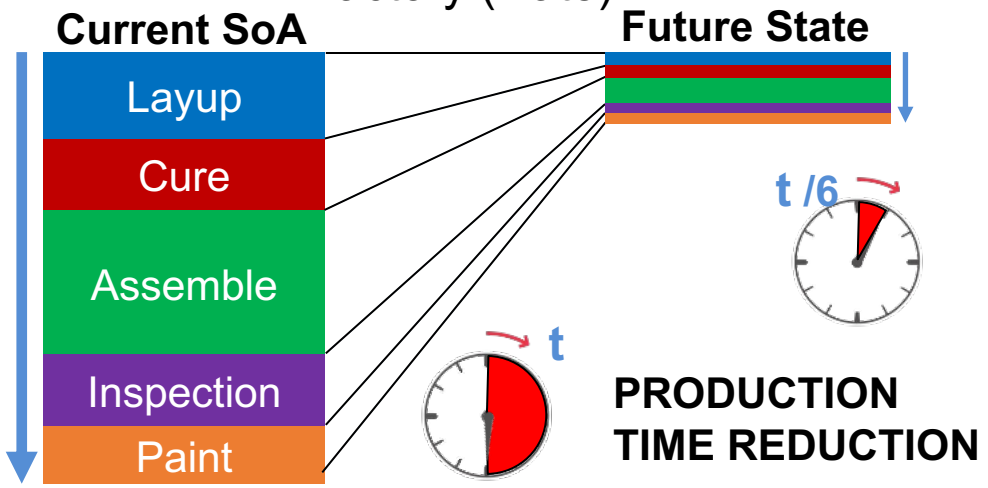
4–6x production rate increase without cost or weight penalty

Production Rate per Month		
• Metals	SOA:	60
• Composites	SOA:	10-15
	Target:	80-100

Two Relevant Environments

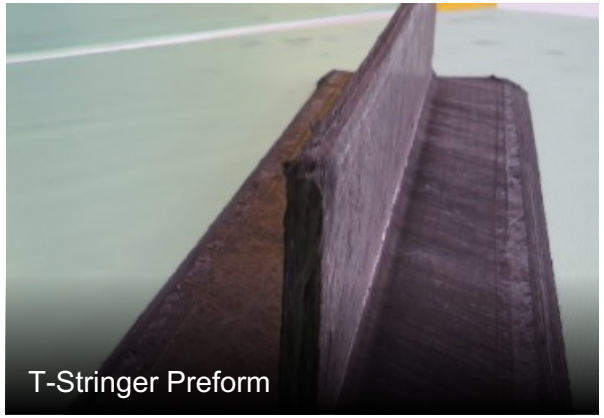
Flight (Weight) ← Cost → Factory (Rate)

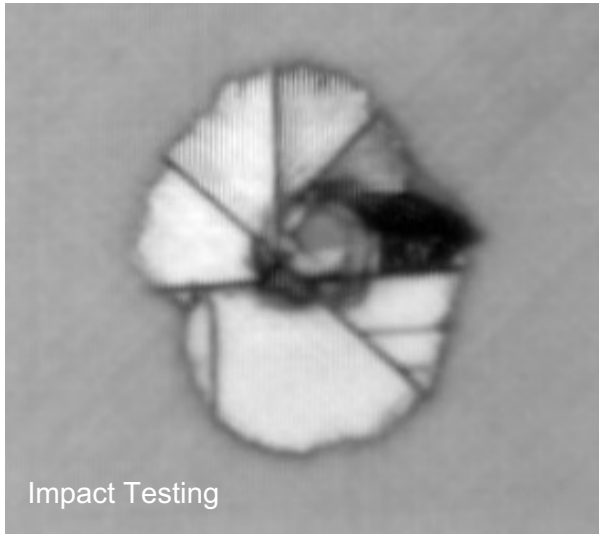




Hi-Rate Composite Aircraft Manufacturing

Phase 1 – Small Scale Tech Maturation

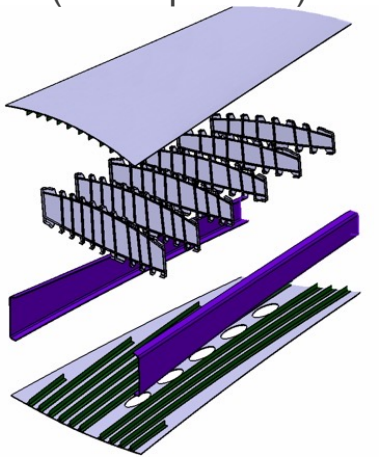




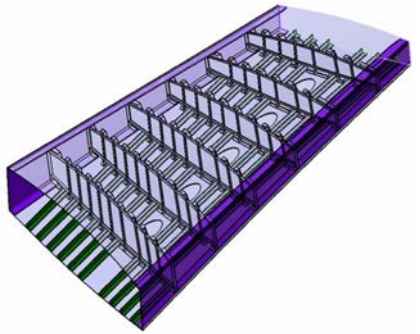
Phase 2 – Large Scale Demos (notional)

Wing box section near engine pylon

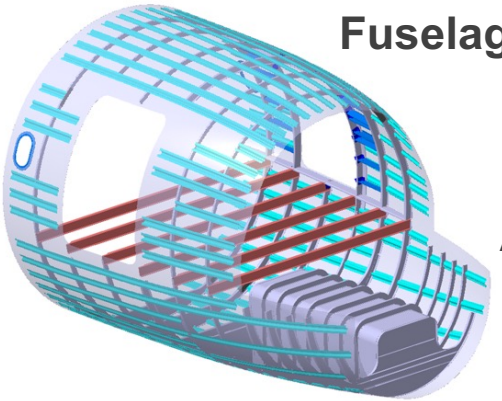
Subcomponents
(~10 replicates)



Assembled Component
(~3 replicates)



Fuselage forward section



Subcomponents
(~10 replicates)

Assembled Component
(~3 replicates)

Work by NASA Composites Consortium members leads to large-scale demonstrations in FY 2027.
Enabling high rate, more integrated lightweight structures for next-generation wing and fuselage needs.

Video Removed

Video credit: GE Aerospace
used with permission

Electrified Powertrain Flight Demonstrations

Demonstrate integrated electrified powertrains in flight using industry platforms

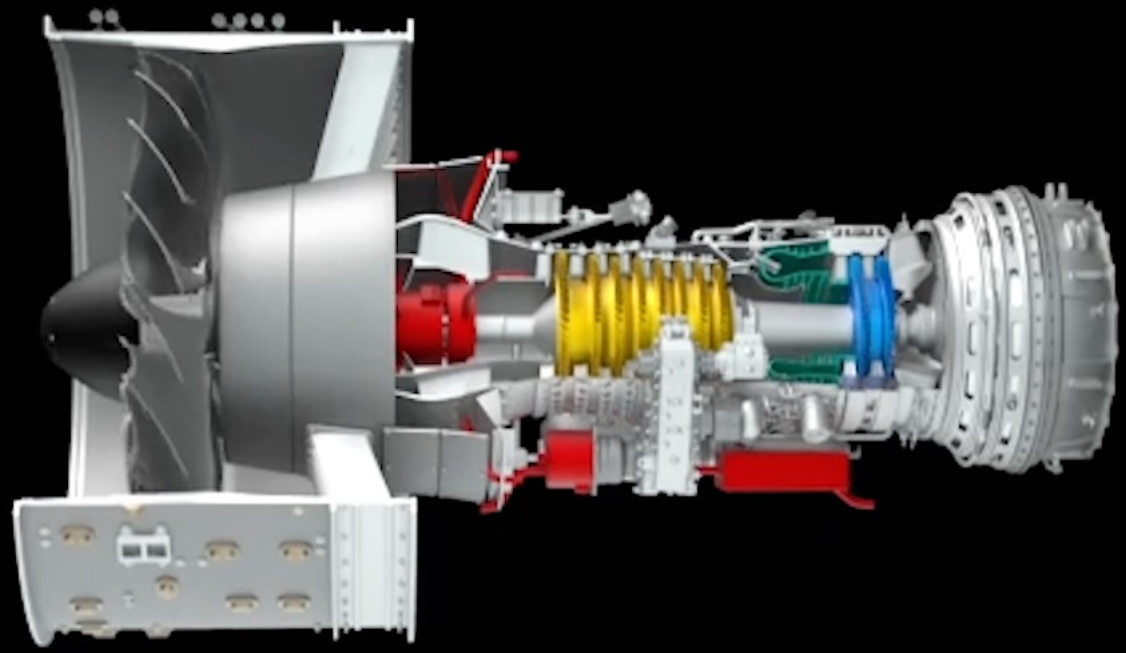
magniX motor
Photo credit: magniX


magniX Dash 7 aircraft
Photo credit: Air Tindi

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

Accelerating ability to consider megawatt-class powertrains for single-aisle commercial airliners and to meet Electrified Aircraft Propulsion certification requirements.

Flight tests begin in 2026.



Compact Design for Small-Core Engines

Video credit: NASA

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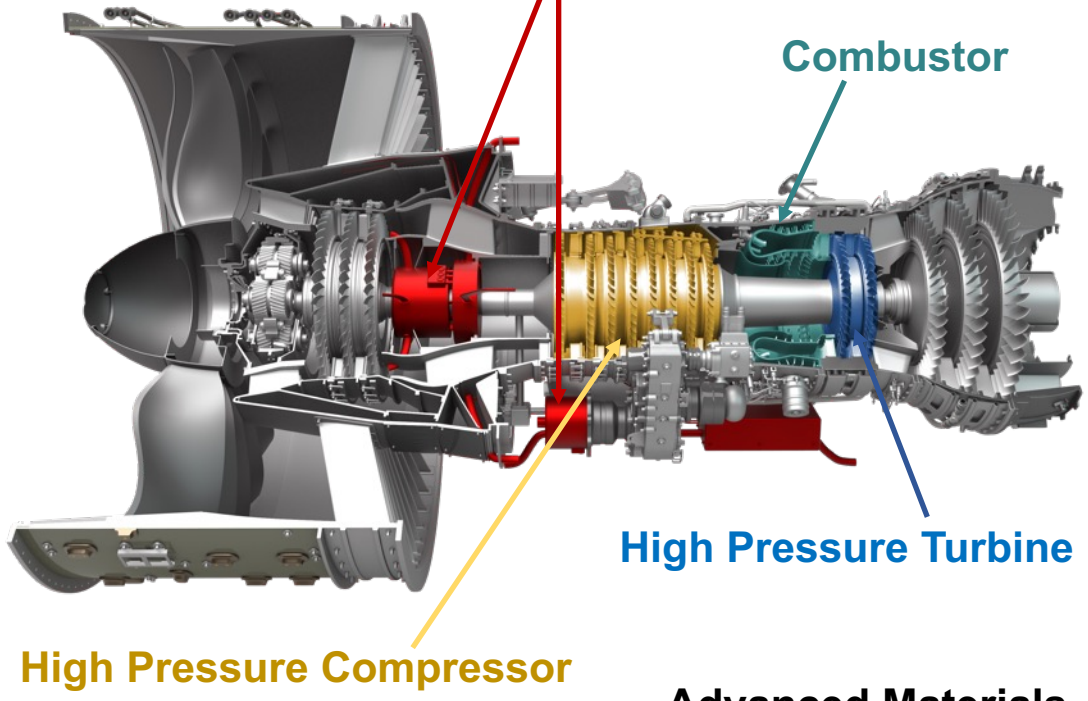
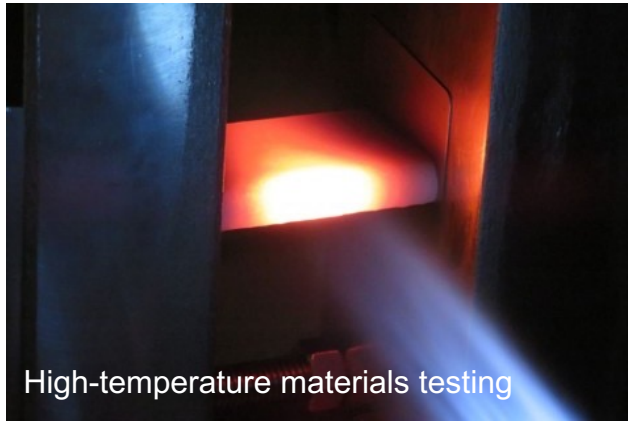
Hybrid Thermally Efficient Core Project (HyTEC)

Accelerate development and demonstration of advanced turbine engine technologies





Integrated core demonstration in 2028

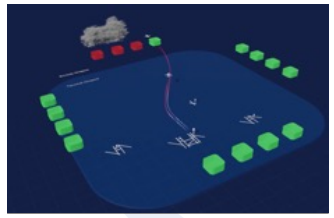
Contributing 5-10% fuel burn reduction and improved power extraction to SFNP goals

Sustainable Flight National Partnership (Technology) with ...

FUTURE AIRSPACE AND SAFETY

Real Progress. Real Value.

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

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

SFNP Ops 2: Integrated Airborne Rerouting

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

SFNP Ops 3: Fleet Wide Irregular Operations Recovery Management

Fleet-wide rerouting services for intelligent disruption management recovery strategies

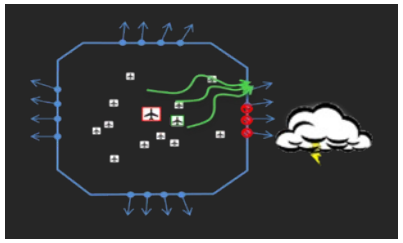
SFNP Ops 4: Capstone Demo

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

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


DIP CDDR Interface
int19:3001
DIP CDDR Interface
Updated: 16:32:23
search
TOS
ZFW
DFW
Settings
Help
AAL
1904
0893
948624276
726402054
504280832
837513165
615391943
160846498
4237
Video credit: NASA
Video Removed
DIP CDDR Interface
Flight Operator - AAL ...
Flight Operator - AAL ...
May 24 16:32:26

Benefits from Sustainable Flight Ops-1 Demonstration



Collaborative Digital Departure Re-Route (SFNP Ops-1)
The first nine months of this ongoing demonstration yielded savings for the environment, passengers, and airlines. This is a joint partner flight demonstration with the FAA, American Airlines, Southwest Airlines, and Envoy Air that uses tech with Trajectory Option Set to re-route flights and departures at Dallas Fort Worth and Dallas Love Field International.

American Airlines envoy Southwest FEDERAL AVIATION ADMINISTRATION

Fuel Savings

Over **24,000** lbs.

Emissions Savings

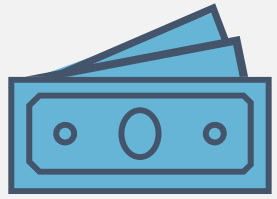
Over **76.6K** lbs. **CO^2**

Over **569** urban trees

Delay Savings

OFF delay	**IN** delay
	
3.9+ hrs	**4.7+** hrs

Cost Savings



Passenger	**$31.7K**
Flight Crew	**$6.9K**

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

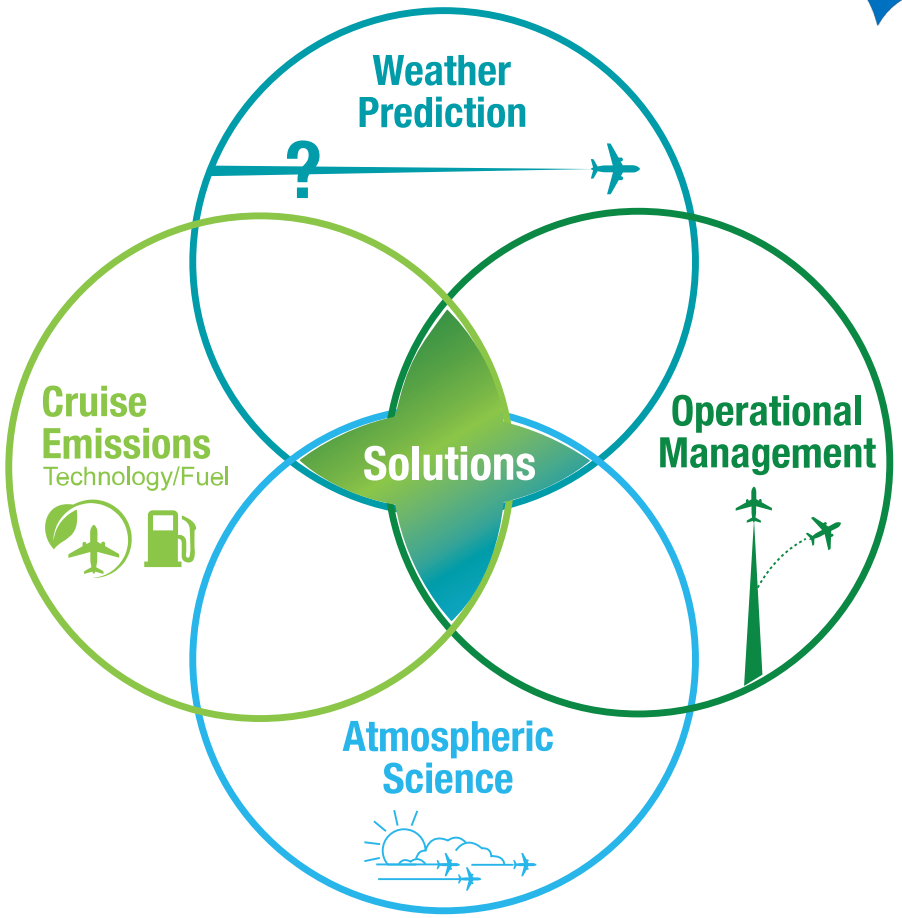

CONTRAILS
Real Progress. Real Value.

In-Flight Testing With 100% Sustainable Aviation Fuel Completed In October 2023 In Collaboration With Boeing, US, & International Partners

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

Video credit: NASA and Boeing
Used with permission

National Academies Study - Contrails



- 2024 Jan 23 – Task Order Awarded
  "*Research Agenda for Reducing the Climate Impact of Aviation-Induced Cloudiness and Persistent Contrails from Commercial Aviation*"
- 18 months
- Jointly funded by NASA ARMD and SMD

Link to the NASEM Study Site
https://www.nationalacademies.org/our-work/research-agenda-for-reducing-the-climate-impact-of-aviation-induced-cloudiness-and-persistent-contrails-from-commercial-aviation

Concluding Remarks

Key Takeaways

Commercial air transportation of people & goods is vital to our quality of life

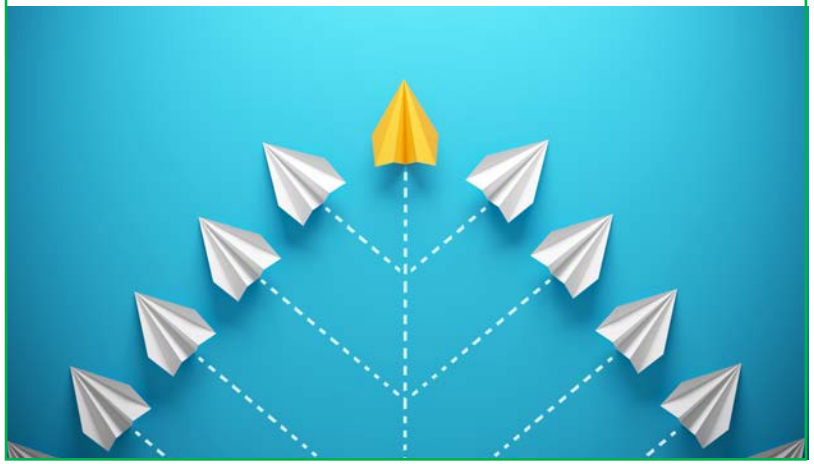
- 24/7 global mobility now and the foreseeable future

Sustainable aviation is a complex challenge without a silver bullet solution

- Time is of the essence

NASA's Sustainable Flight National Partnership (SFNP) is leading major demonstrations to accelerate revolutionary change

- Team USA must lead the way on this global challenge



Real Progress. Real Value.

Questions

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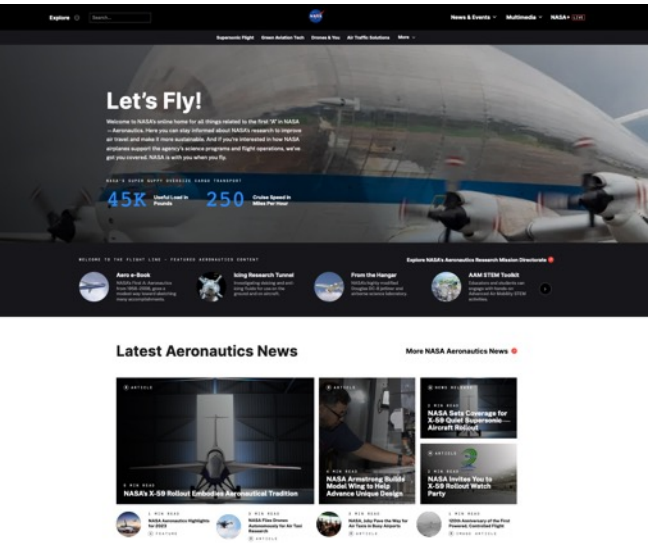

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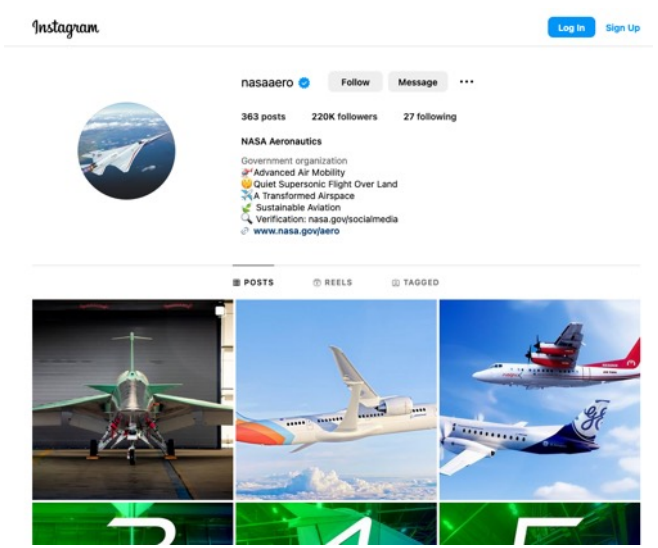

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