NASA Overview/Update
FAA ASCENT COE Meeting

September 26, 2017

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Brief Outline

- Summary/Refresher – NASA Strategic Planning
- FY2018 Budget Guidance
- New Aviation Horizons
- Strategic Thrust 4: Transition to Alternative Propulsion & Energy

Global Growth in Aviation: Opportunities and Challenges

Global Air Passengers by Region (% of Total)

2014

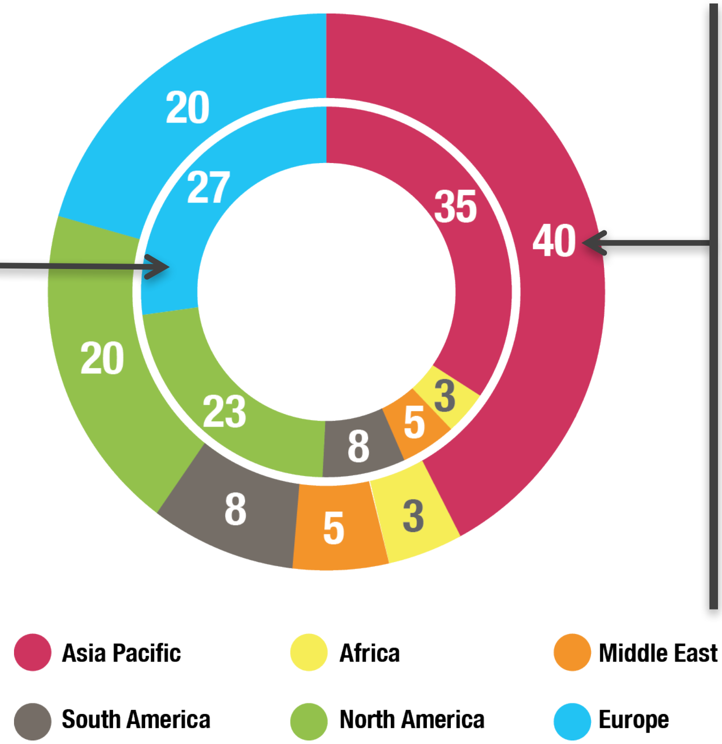
Global Aviation Industry

3.3B Passenger Trips

North America and Europe combined is half of all Passenger Trips

58M Jobs

$2.4T GDP



2034

Global Aviation Industry, est.

7B Passenger Trips

Asia-Pacific Passenger Trips equal to North America and Europe combined

105M Jobs

$6T GDP

Over 36,000 New Aircraft required (replacement and growth) over the 20 year period ($4-$5T value)

Sources: International Air Transport Association, Air Transport Action Group, Boeing

Major Opportunities / Growing Challenges

Competitiveness—New state backed entrants, e.g., COMAC (China); Growing global R&D

Environment—Very ambitious industry sustainability goals; Large technology advances needed

Mobility—More speed to connect the worlds' major cities; Opportunity for commercial supersonic flight

U.S. Technological Leadership Required!

NASA Aeronautics

Strategic Implementation Plan (SIP)

Three Mega-Drivers

Six Strategic Research & Technology Thrusts

Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles
- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Alternative Propulsion and Energy*
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

* Changed in official March 2017 release.

Research Programs align with Strategic Thrusts

MISSION PROGRAMS

Airspace Operations & Safety

AOSP

Safe, Efficient Growth in Global Operations

Real-Time System-Wide Safety Assurance

Advanced Air Vehicles

AAVP

Ultra-Efficient Commercial Vehicles

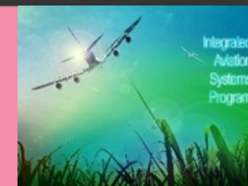
Innovation in Commercial Supersonic Aircraft

Transition to Alternative Propulsion & Energy

Integrated Aviation Systems

IASP

Flight research-oriented, integrated, system-level R&T that supports all six thrusts



X-planes/test environment

SEEDLING PROGRAM

Transformative Aeronautical Concepts

TACP

High-risk, leap-frog ideas that support all six thrusts

Critical cross-cutting tool development

Assured Autonomy for Aviation Transformation

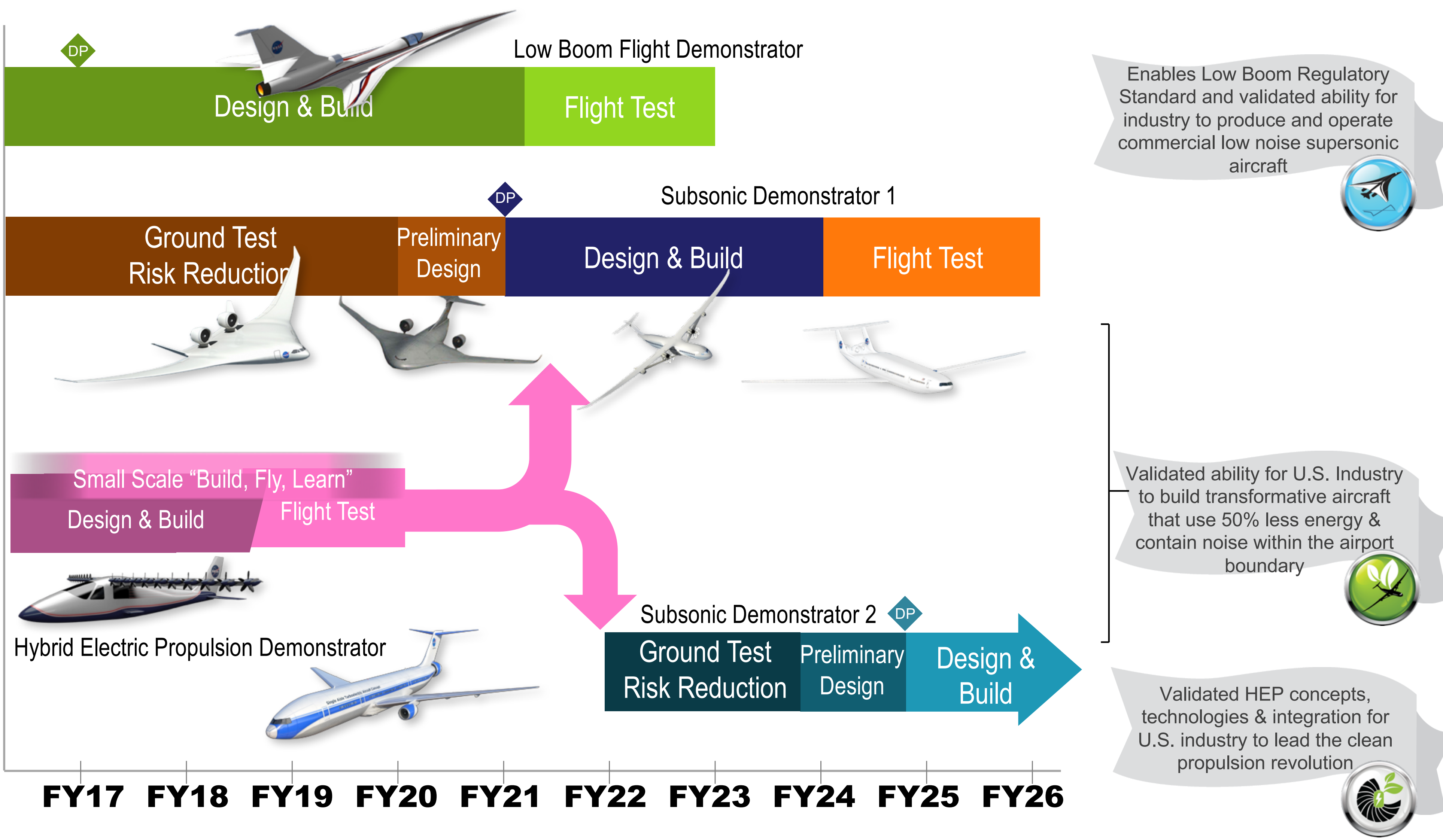
FY 2018 President's Budget Request

$ Millions	Enacted FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Aeronautics	**$633.8**	**$660.0**	**$624.0**	**$624.4**	**$624.4**	**$624.4**	**$624.4**
Airspace Operations and Safety	147.1		108.7	107.7	107.1	107.8	109.7
Advanced Air Vehicles	254.9		232.7	223.8	233.2	236.7	241.8
Integrated Aviation Systems	128.3		173.5	178.5	167.8	139.2	132.9
Transformative Aeronautics Concepts	103.5		109.2	114.5	116.3	140.7	139.9

- Integrated Aviation Systems Program funds the design and build of the Low Boom Flight Demonstrator as part of the New Aviation Horizons Initiative
- Continues to robustly fund UAS related investments

FY 2018 President's Budget Request

New Aviation Horizons Flight Demo Plan



Notional

NASA's Low-Boom Supersonic Technology Ready For Flight

FIELD & LAB STUDIES

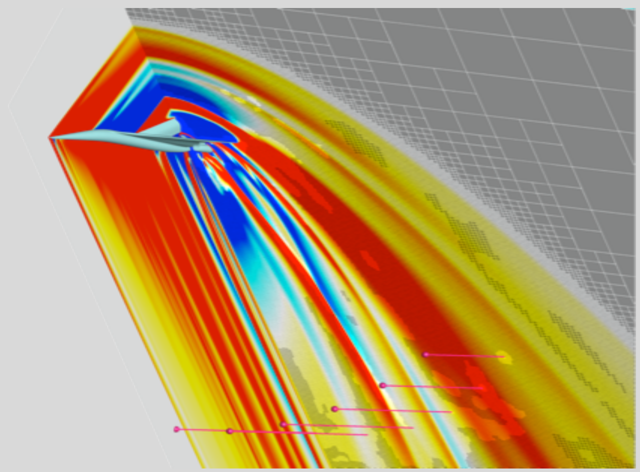
Studies show the potential for acceptable low boom noise.

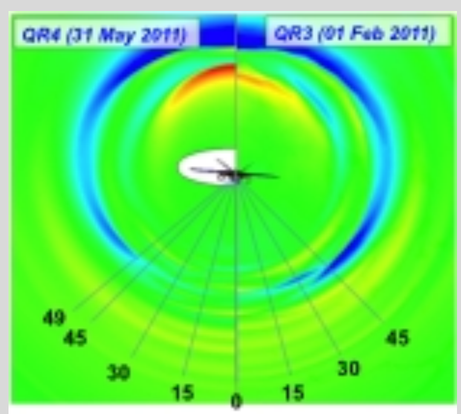
Low-Boom Flight Simulation using F-18 Dive Maneuver

Sonic Boom Acceptability Studies using Ground Simulators and in the Field

MODELING TOOLS

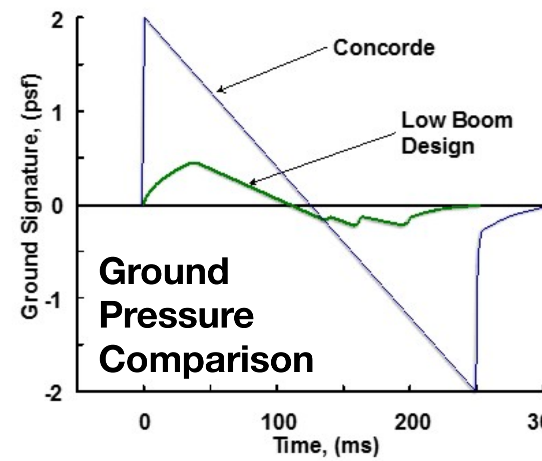
New advances in modeling tools allows design of new low-boom configurations.

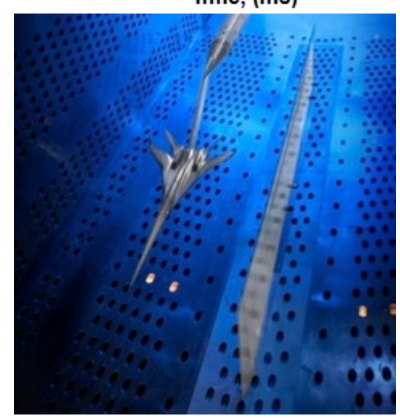




GROUND TESTING

Extensive wind tunnel tests indicate that these new designs show the low-boom characteristics as predicted.



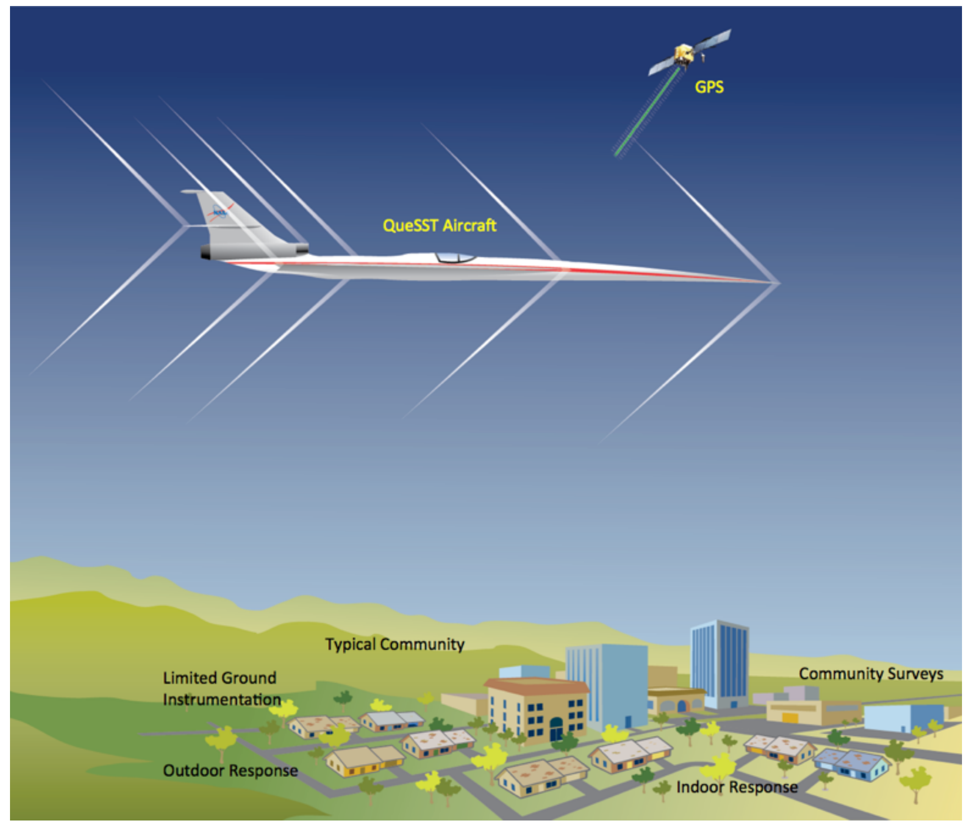


Low Boom Flight Demonstrator Tests
Three Required Elements

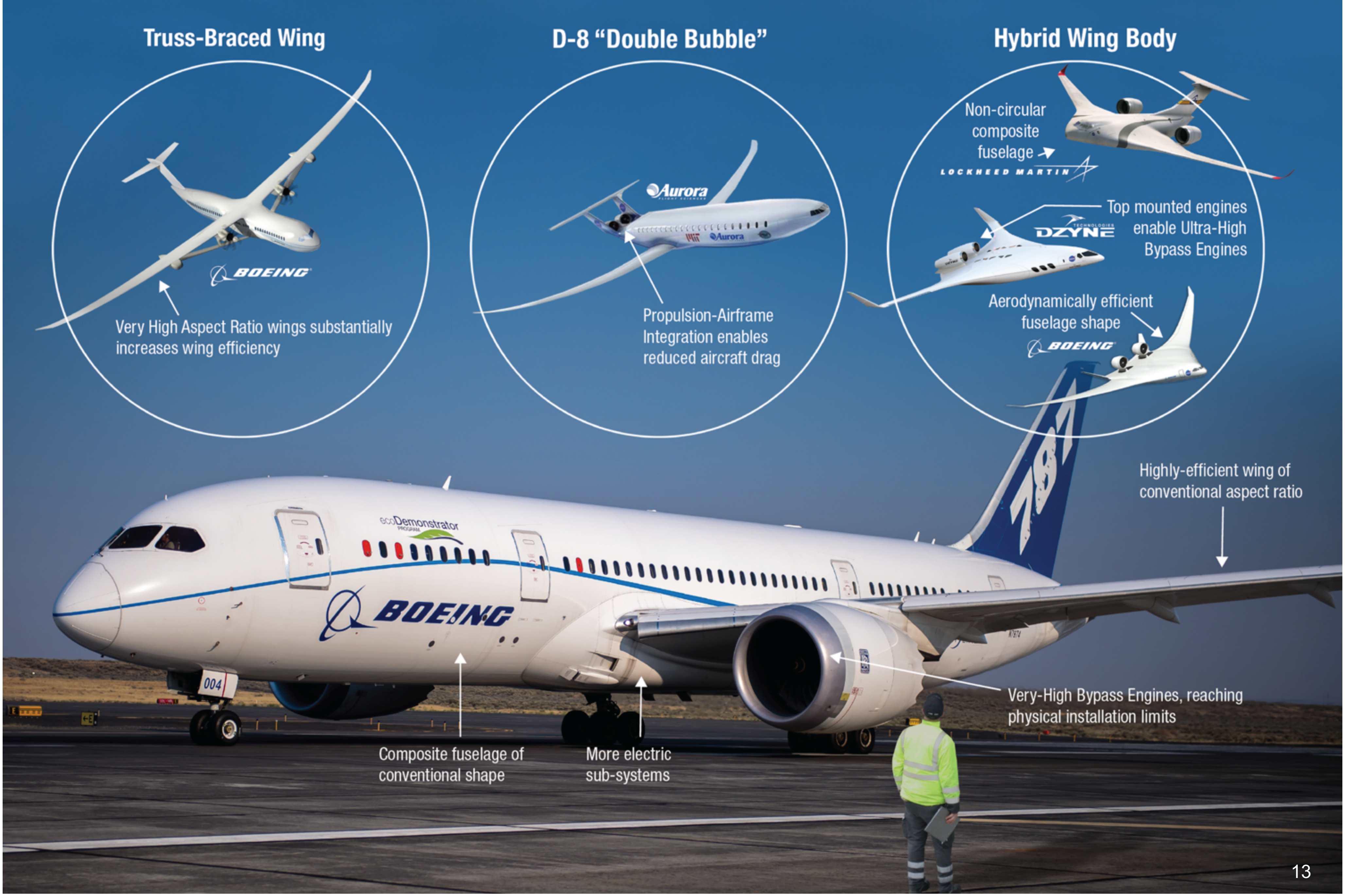
1. **Validated hardware for overflight testing (supersonic acoustic signature generator)**
   – Design & build a Low Boom Demonstrator of sufficient size that the acoustic data are representative of a commercial supersonic transport aircraft

2. **Development of test methodology** that allows data to be gathered that accurately represents the community response to supersonic overland flight

3. **Community response data** that is fully representative of a demographically diverse, non-biased population



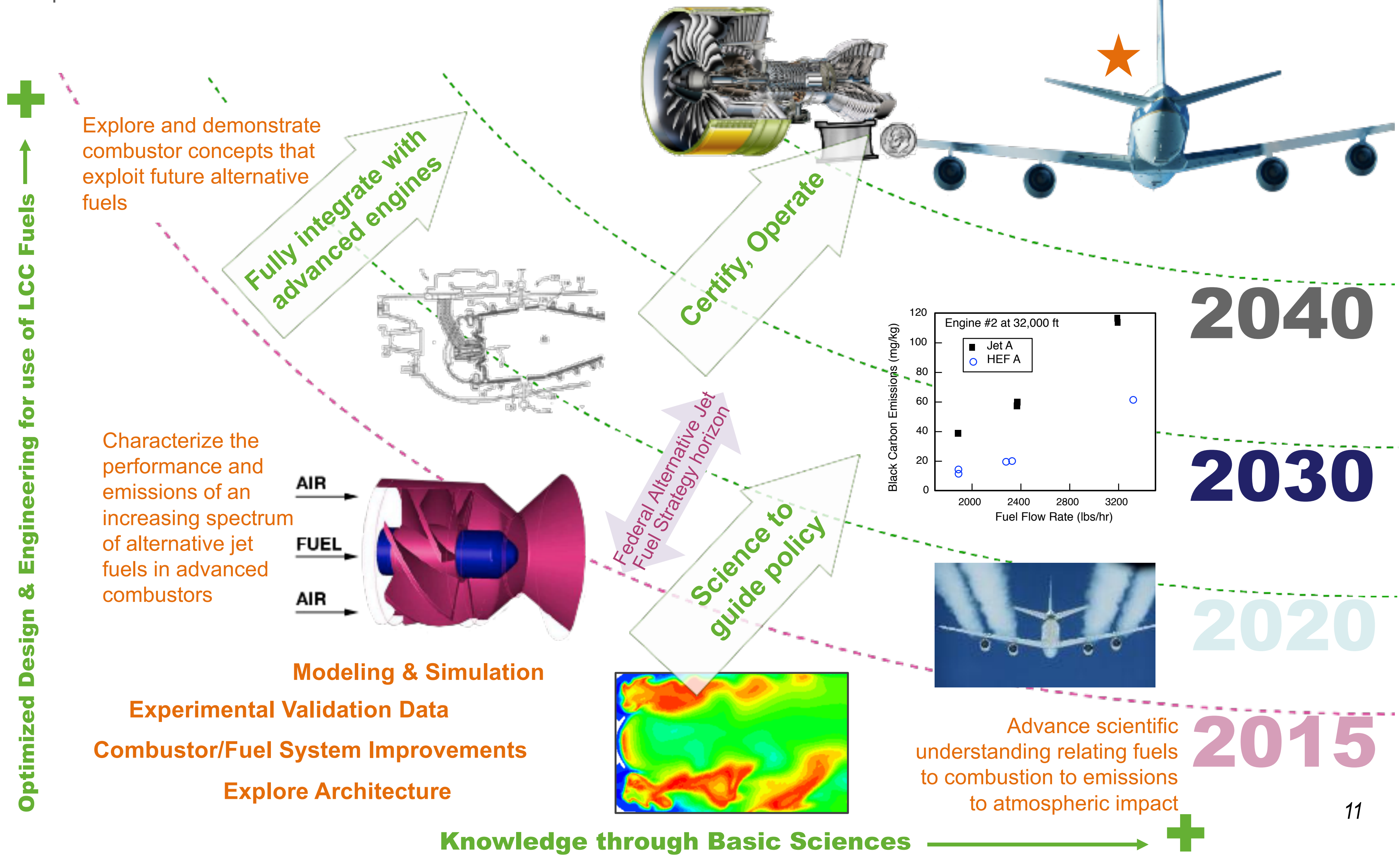
Ultra-efficient Subsonic Demonstrators Break Barriers



Transition to Alternative Propulsion & Energy

Alternative Jet Fuels

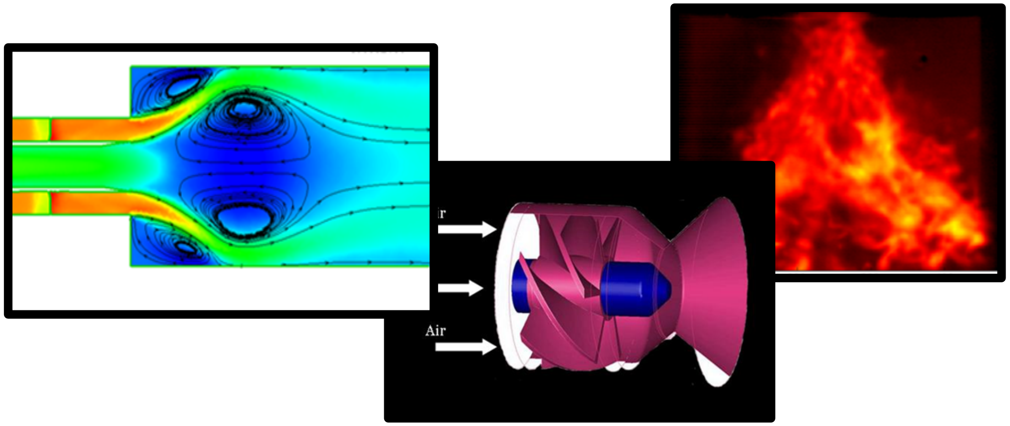
Optimize and accelerate the effective use



Advanced Small Core, Fuel-Flexible Combustor

Multiple Programs

Transformative Aeronautical Concepts (TAC) Program



Develop/Validate Critical Computational Tools

- Physics-based CFD combustion models
- Combustor-Turbine Interactions
- Validation experiments

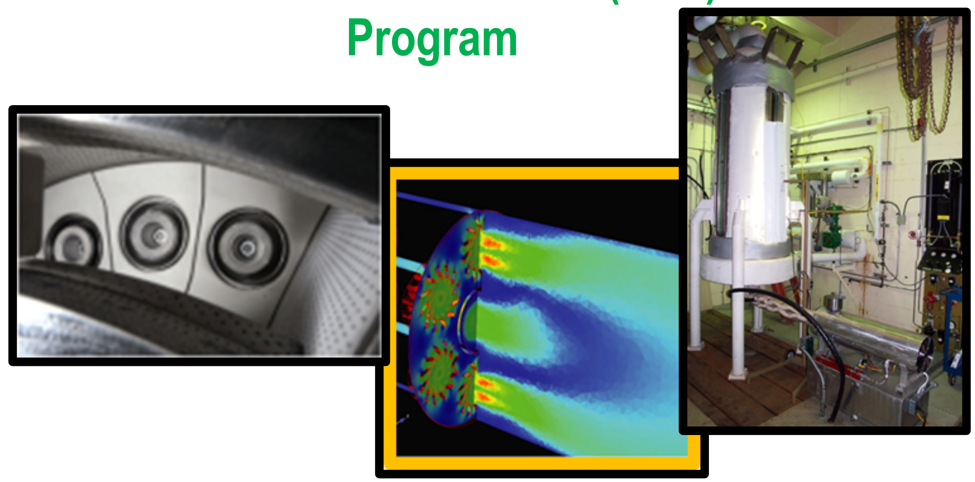
Develop/Test Critical Combustion Technologies

- Lean Direction Injection (LDI)
- Staging Technologies
- Combustion Dynamics Mitigation/Control

Explore/Evaluate Innovative Combustion Technologies/Concepts

- Pressure Gain Combustion Concepts

Advanced Air Vehicles (AAV) Program



Fuel-Flexible Combustion

- Small Core Injection
- Combustor Stability
- Durability
- Performance

Alternative fuel performance

- Thermal stability
- Emissions
- Lean blowout / ignition
- Auto-Ignition / Flashback
- Low aromatic effects

Particulate Matter Emissions

- PM emissions at ground and cruise altitudes extracted from combustor only

Transition to Alternative Propulsion & Energy

Electrically-Enhanced Propulsion

Turbo-Electric Propulsion technology (no battery storage) integrated with Boundary Layer Ingestion technology is a rapidly developing opportunity with significant industry interest.

Energy usage reduced by more than **60%**

Harmful emissions reduced by more than **90%**

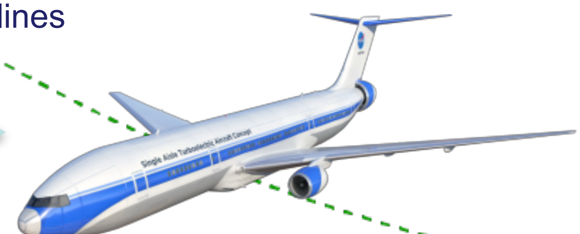
Objectionable noise reduced by more than **65%**

Knowledge through Integration & Demonstration

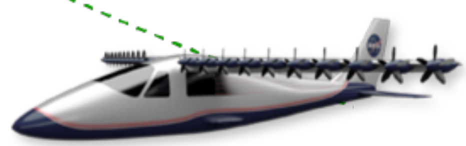
Environmental Benefit

Advanced configuration with fully integrated hybrid electric propulsion and airframe

Increasingly electric aircraft propulsion with minimal change to aircraft outer mold lines



2040



2030

Gain experience through integration and demonstration on progressively larger platforms

2020

Gas-Electric Propulsion Concept

Objective

Establish viable concept for 5-10 MW hybrid gas-electric propulsion system for a commercial transport aircraft (TRL 2)

Technical Areas and Approaches

Propulsion System Conceptual Design

- Early selection of system concepts that allow drill-down in issues of system interaction concept refinement

Integrated Subsystems

- Develop flight control and mission operations methodology for distributed propulsion
- Explore component interactions, power management, and fault management

High Efficiency/Power Density Electric Machines

- Explore conventional and non-conventional topologies
- Integrate novel thermal management
- Demonstrate component maturation

Flight-weight Power System and Electronics

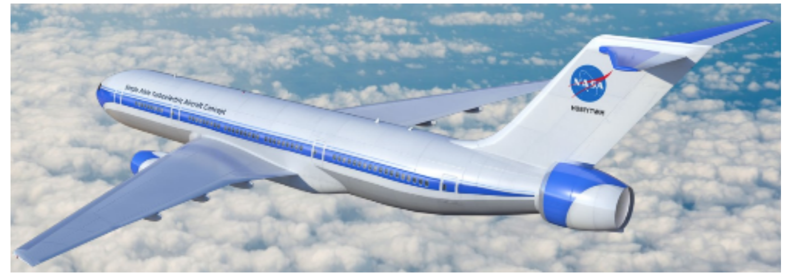
- Develop/demonstrate powertrain systems and components
- High voltage, MW power electronics, transmission, protection

Enabling Materials

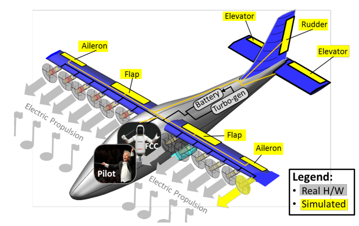
- Insulators and conductors for high power and altitude components
- Nanocomposite magnetic materials for targeted machines and drives

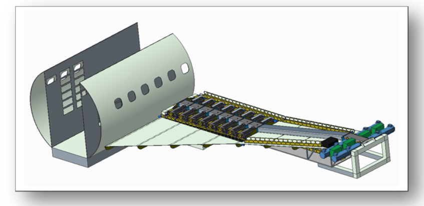
Benefit/Payoff

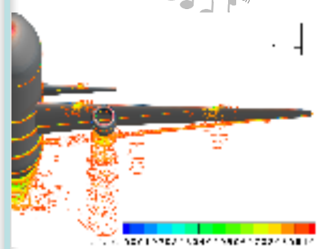
- Enable paradigm shift from gas-turbine to electrified propulsion
- Reduce fuel & energy consumption, emissions, and noise



Exploring Tube-and-Wing Architectures

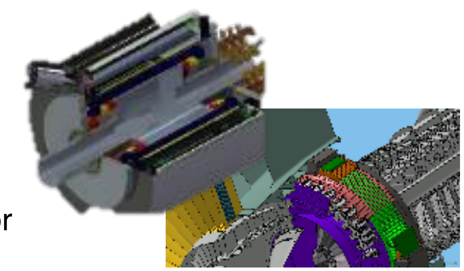




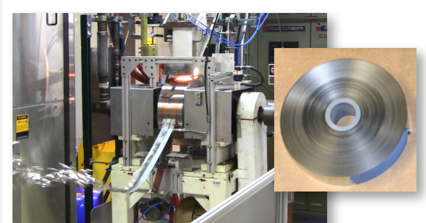


Powertrain, Controls & Flight Simulation Testbeds and Advanced CFD

Superconducting and Ambient Motor Designs



Advanced Materials & Novel Designs for Flightweight Power



Summary – A New Era for NASA Aeronautics

Investing In Our Future - Investments in NASA's cutting edge aeronautics research today are investments in a cleaner, safer, quieter and faster tomorrow for American aviation:

- NASA has entered the Administration transition with a strong portfolio with good stakeholder support.
- New Aviation Horizons (X-Plane) Initiative progressing – Administration support expressed for low boom demonstrator.
- The X-57 distributed propulsion electric aircraft making progress.

NASA