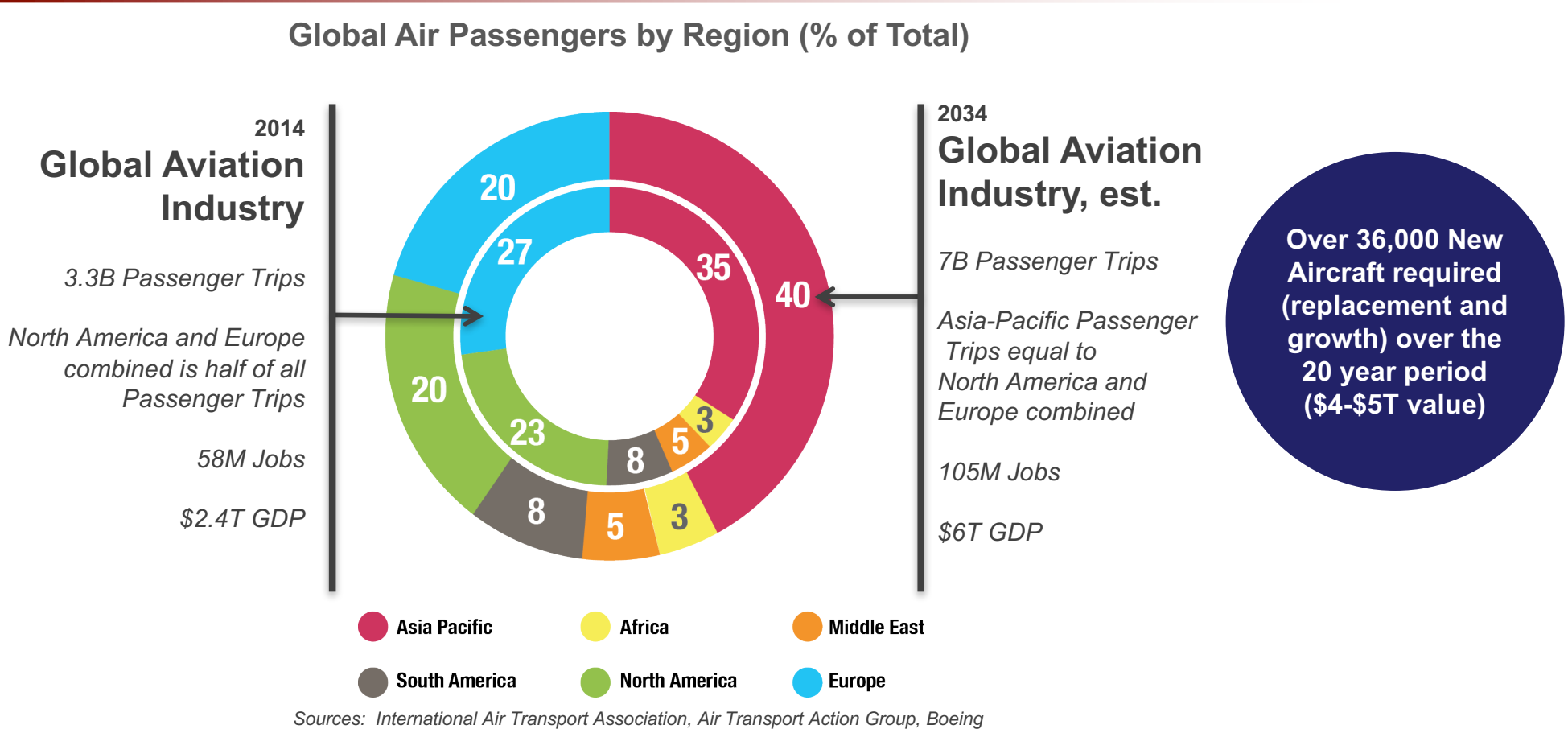
NASA Overview/Update
E&E REDAC Meeting

August 1, 2017

Brief Outline

- Summary/Refresher – NASA Strategic Planning
- FY2018 Budget Guidance
- New Aviation Horizons

Global Growth in Aviation: Opportunities and Challenges



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

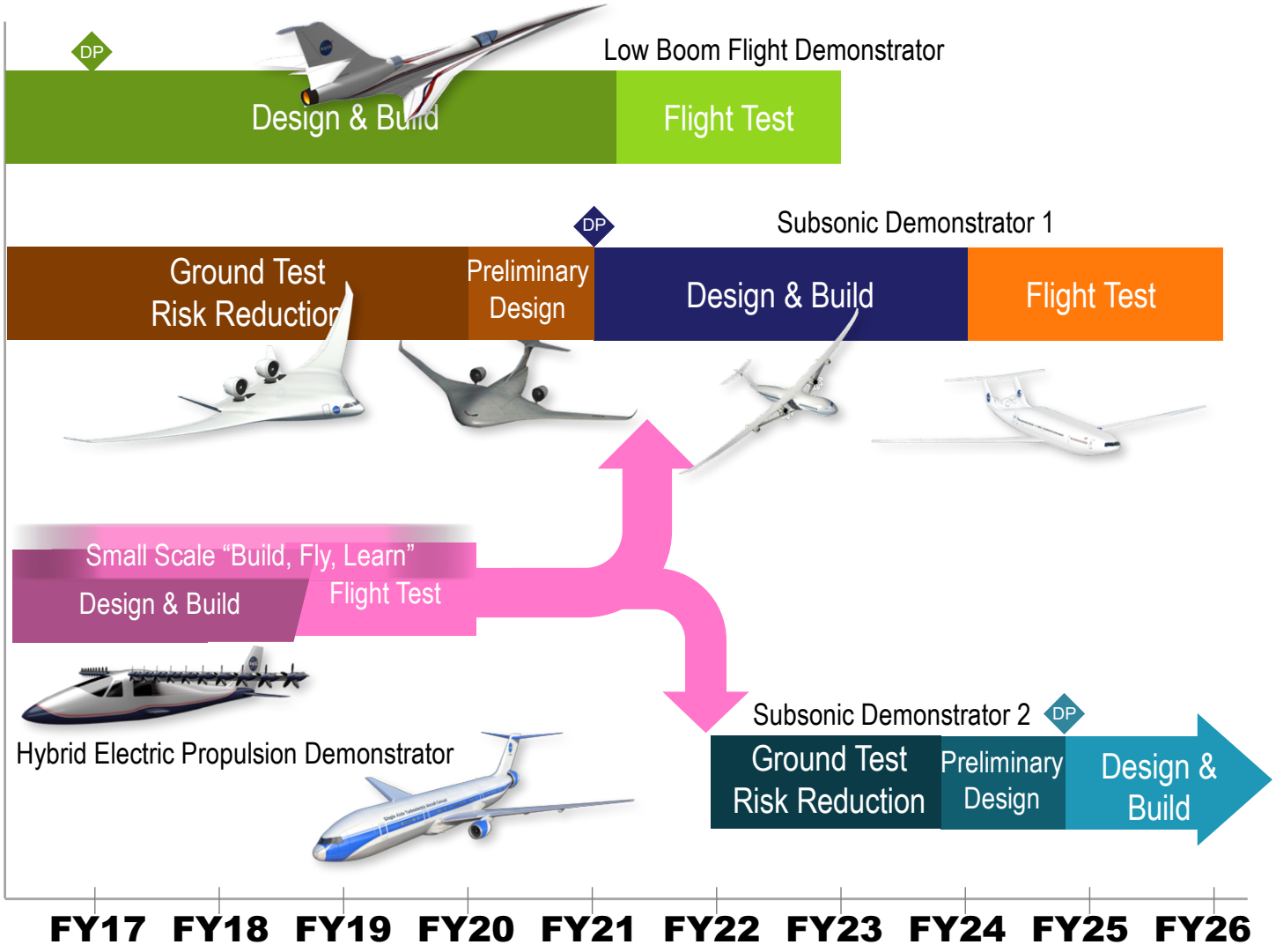
FY 2018 President's Budget Request

$ 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



Enables Low Boom Regulatory Standard and validated ability for industry to produce and operate commercial low noise supersonic aircraft

Validated ability for U.S. Industry to build transformative aircraft that use 50% less energy & contain noise within the airport boundary

Validated HEP concepts, technologies & integration for U.S. industry to lead the clean propulsion revolution

Notional

Vision for Commercial Supersonic Flight

- The emerging potential commercial supersonic transport market has generated renewed interest in civil supersonic aircraft
  - Evidence of this growing interest is shown through start-ups' willingness to enter the market given restrictions in overland flight and other challenges
- Current restrictions dramatically limit market potential for supersonic commercial aircraft
- The vision of the Supersonics Community is a future where fast air travel is available for a broad spectrum of the traveling public.
  - Future supersonic aircraft will not only be able to fly overland without creating an "unacceptable situation" but compared to Concorde and SST will be more efficient and affordable

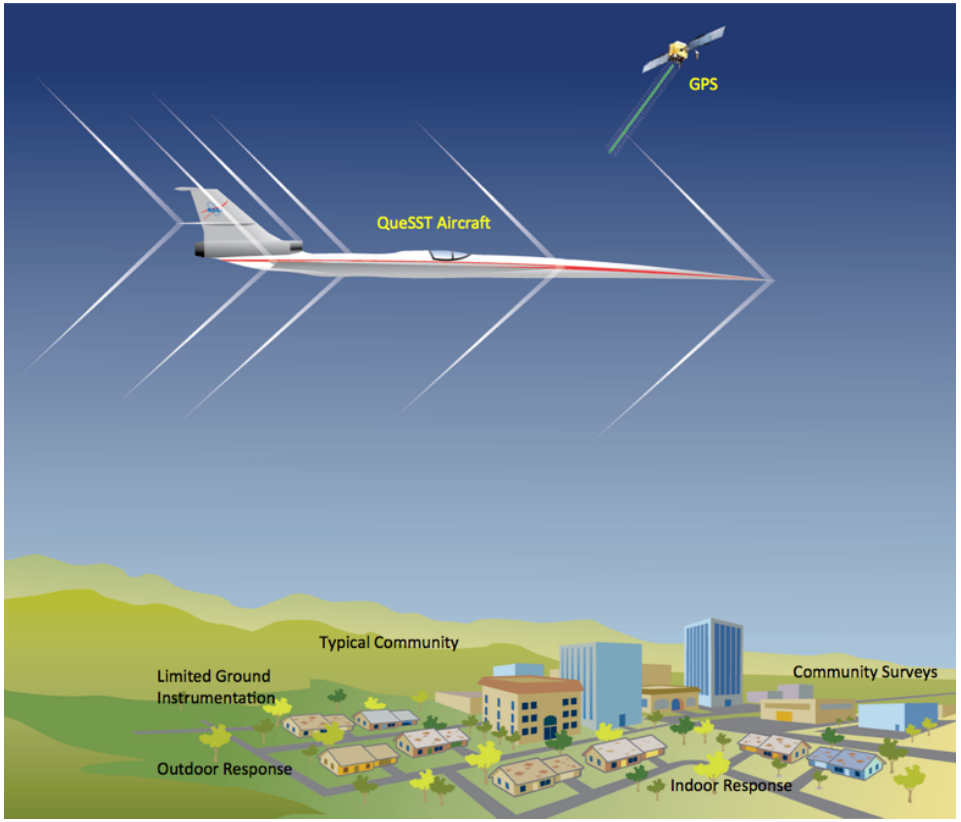
Overland flight restrictions based on noise are viewed as the main barrier to this vision

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



NASA's Low-Boom Supersonic Technology Ready For Flight

FIELD & LAB STUDIES

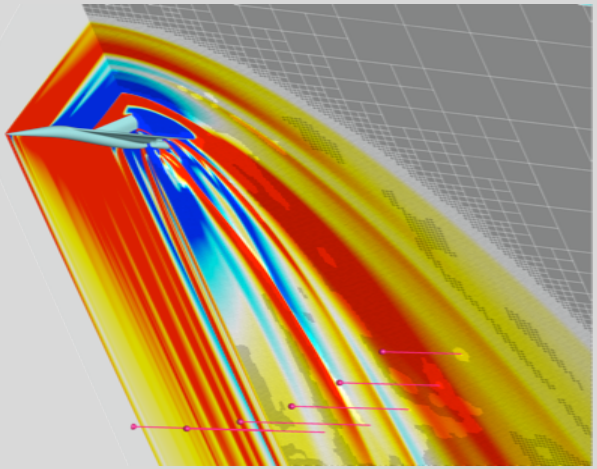
Studies show the potential for acceptable low boom noise.

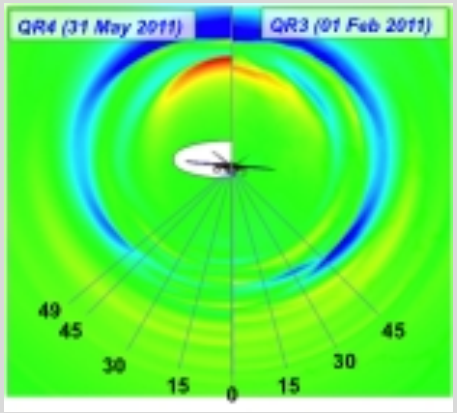
Low-Boom Flight Simulation using F-18 Dive Maneuver

Sonic Boom Acceptability Studies using Ground Simulators and in the Field

MODELING TOOLS

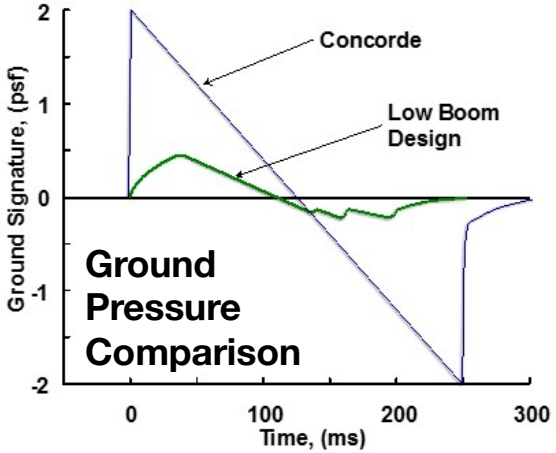
New advances in modeling tools allows design of new low-boom configurations.

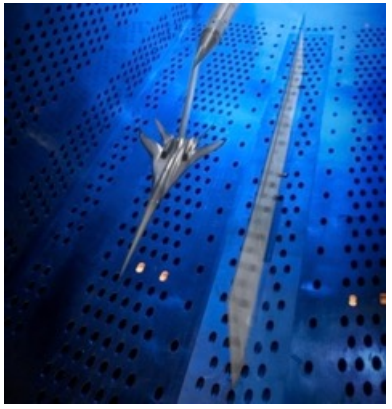




GROUND TESTING

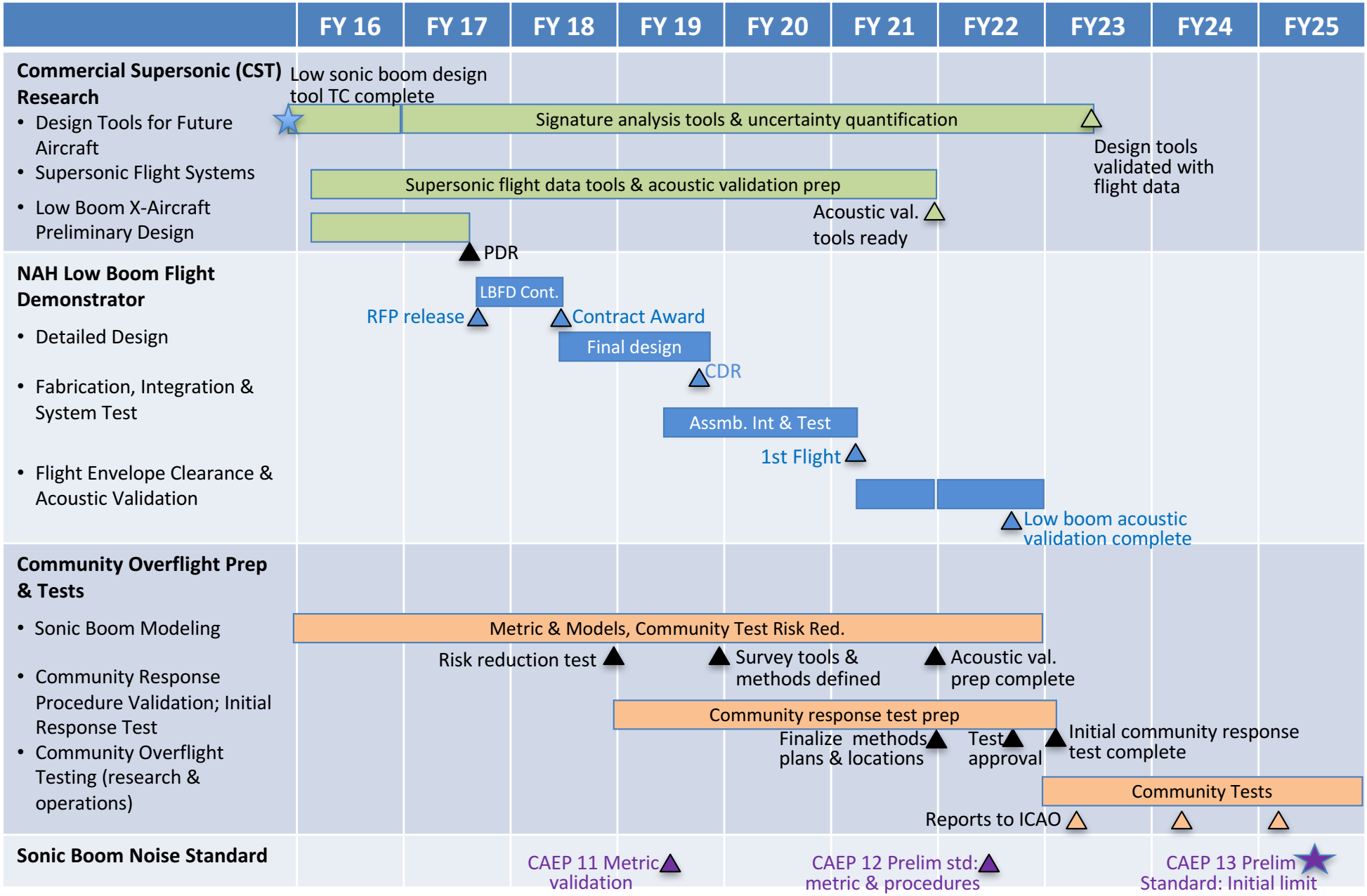
Extensive wind tunnel tests indicate that these new designs show the low-boom characteristics as predicted.





NAH Demonstration and NASA Research Plans

Alignment Supports Development of En Route Noise Standard



PDR, Preliminary Design Review
CDR, Critical Design Review

Low Noise Propulsion for Low Boom Aircraft

Design tools and innovative concepts for integrated supersonic propulsion systems with noise levels of 10 EPNdB less than FAR 36 Stage 4 demonstrated in ground test.

Deliverables: 1) Validated noise prediction and system modeling tools for design of N+2 supersonic airliner
2) Integrated aircraft solutions meeting airport noise requirements with viable range and low boom
3) Validation of acoustic performance and predicted design trades.

2013	2014	2015	2016	2017
Tool and model development Initial nozzle designs assessed computationally	Initial nozzle tests complete Test results for isolated nozzle met expectations First empirical models for three-stream and IVP nozzle systems	Aft-deck noise database acquired New models used in optimization studies Final candidate nozzles identified	Isolated nozzles, system models validated. Integrated acoustic test articles created and tested. **System predictions, acoustic goal validated.**	Inlet and fan effects assessment Alternative propulsion installation benefits assessed New candidate technologies for additional noise reduction

Integration of noise prediction, innovative nozzles, and system modeling to achieve aggressive goals.

Ultra-efficient Subsonic Demonstrators Break Barriers

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.

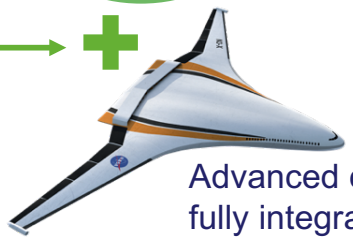
Energy usage reduced by more than **60%**

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

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

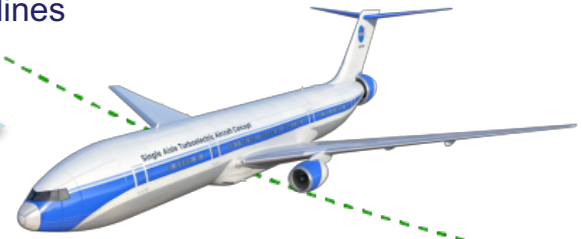
Knowledge through Integration & Demonstration

Environmental Benefit



Advanced configuration with fully integrated hybrid electric propulsion and airframe

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



Gain experience through integration and demonstration on progressively larger platforms

2040

2030

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

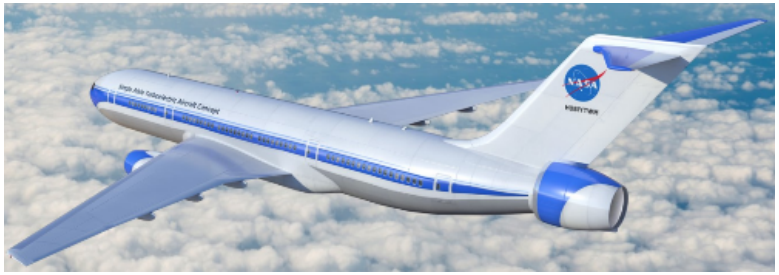
– Insulators and conductors for high power and altitude components

– Nanocomposite magnetic materials for targeted machines and drives

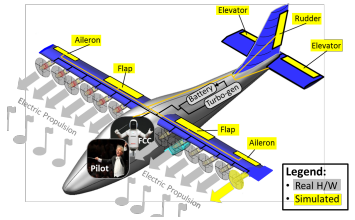
Benefit/Payoff

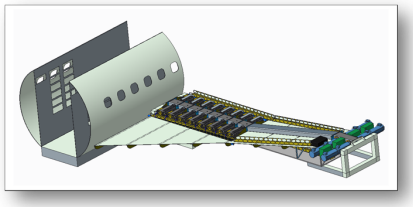
– Enable paradigm shift from gas-turbine to electrified propulsion

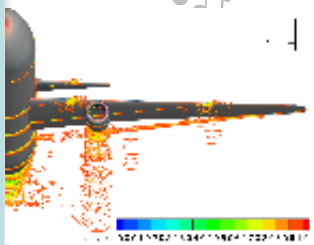
– Reduce fuel & energy consumption, emissions, and noise



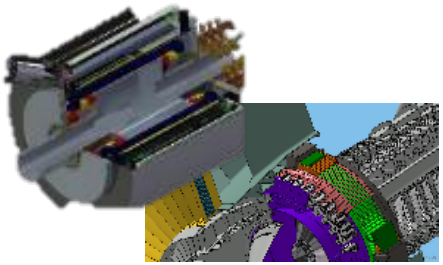
Exploring Tube-and-Wing Architectures





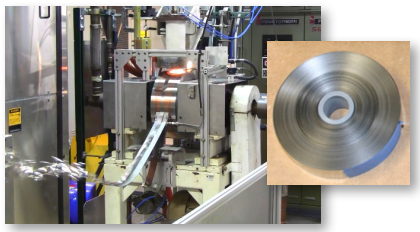


Powertrain, Controls & Flight Simulation Testbeds and Advanced CFD



Superconducting and Ambient Motor Designs

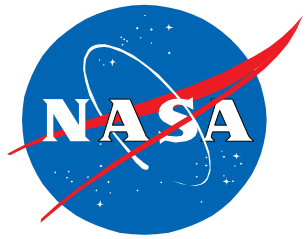
Advanced Materials & Novel Designs for Flightweight Power



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 is entering the Administration transition with a strong portfolio with good stakeholder support.
- No decisions have been made regarding the New Aviation Horizons (X-Plane) Initiative – support expressed for low boom demonstrator.
- The X-57 distributed propulsion electric aircraft making progress.


NASA