NASA's Low-Boom Flight Demonstration Mission

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Low Boom Flight Demonstrator Project

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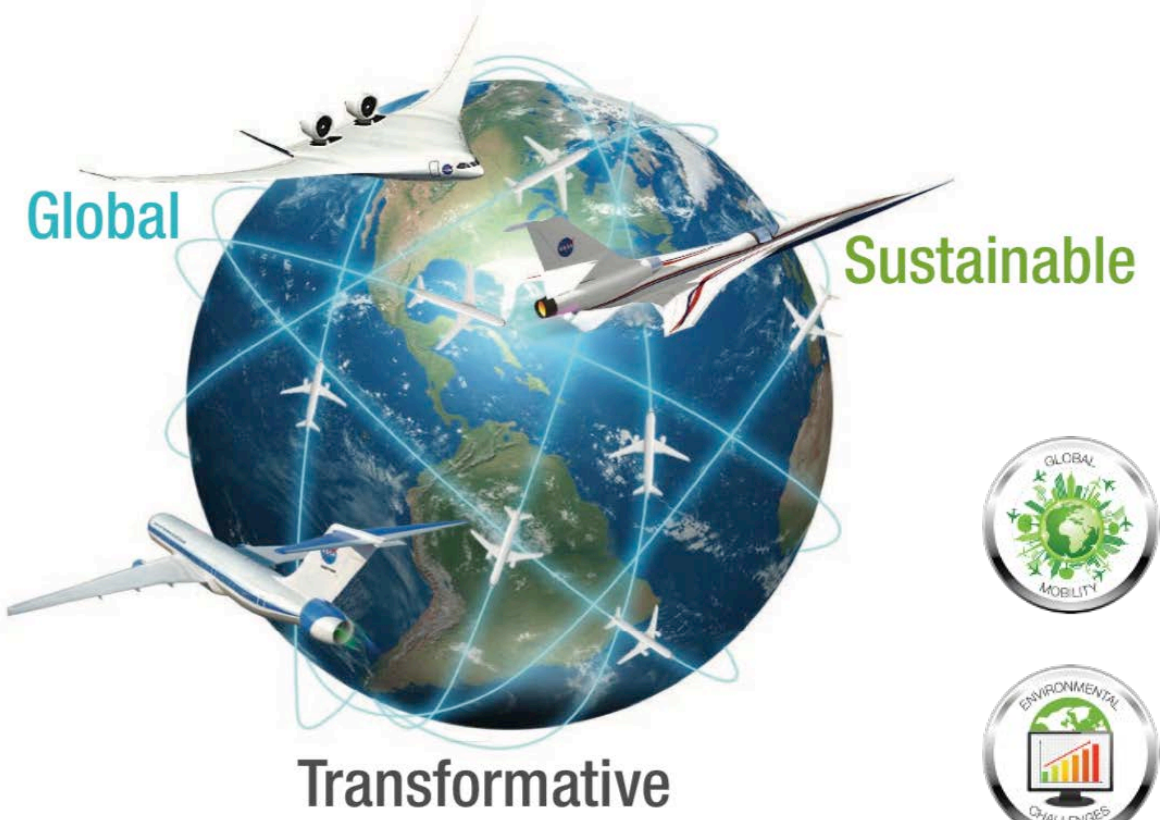
Presentation Topics

- Overview: NASA's Aeronautics Strategy
- Barriers to Successful Supersonic Commercial Aircraft
- Sonic Boom 101
- Overview of X-59 QueSST Aircraft Features
- Low-Boom Flight Demonstration Mission
  - Phase 1 – Aircraft Development
  - Phase 2 – Acoustic Validation
  - Phase 3 - Community Response

NASA Aeronautics

NASA Aeronautics Vision for Aviation in the 21st Century



U.S. leadership for a new era of flight

NASA's Aeronautics Research Mission Directorate (ARMD) continues to evolve and execute the Aeronautics Strategy *https://www.nasa.gov/aeroresearch/strategy*

Safe, Efficient Growth in Global Operations
- Achieve safe, scalable, routine, high-tempo airspace access for all users

Innovation in Commercial Supersonic Aircraft
- Achieve practical, affordable commercial supersonic air transport

Ultra-Efficient Subsonic Transports
- Realize revolutionary improvements in economics and environmental performance for subsonic transports with opportunities to transition to alternative propulsion and energy

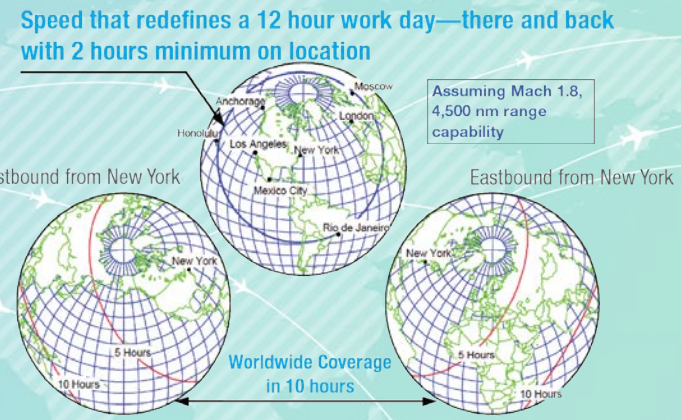
Safe, Quiet, and Affordable Vertical Lift Air Vehicles
- Realize extensive use of vertical lift vehicles for transportation and services including new missions and markets

In-Time System-Wide Safety Assurance
- Predict, detect and mitigate emerging safety risks throughout aviation systems and operations

Assured Autonomy for Aviation Transformation
- Safely implement autonomy in aviation applications

Innovation in Commercial Supersonic Flight

WHY? Commercial supersonic flight represents a potentially large new market for aircraft manufacturers and operators world-wide



- Global demand for air travel is growing, which places a demand on speed
- Supersonic aircraft will be excellent export products that can be capitalized on by the U.S. to support a positive balance of trade
- New supersonic products lead to more high-quality jobs in the U.S.
  - Large potential market predicted: business aircraft followed by larger commercial aircraft
  - Technology leadership established through initial products will lead to development of larger, more capable airliners

The government plays a central role in developing the data needed for the regulation change that is essential to enabling this new market

Overcoming the Barrier to Overland Flight

The Low-Boom Flight Demonstration mission is specifically planned to generate key data for success in NASA's Critical Commitment to support development of en route certification standards based on acceptable sound levels

- **New Environmental Standards are needed to open the market to supersonic flight**
- **An En route Noise Standard is the biggest challenge**
  - Requires proof of new design approaches
  - Must replace current prohibitions
  - No relevant data exists to define limits
    - Community data from large, diverse population is a requirement
  - Standard must be accepted internationally

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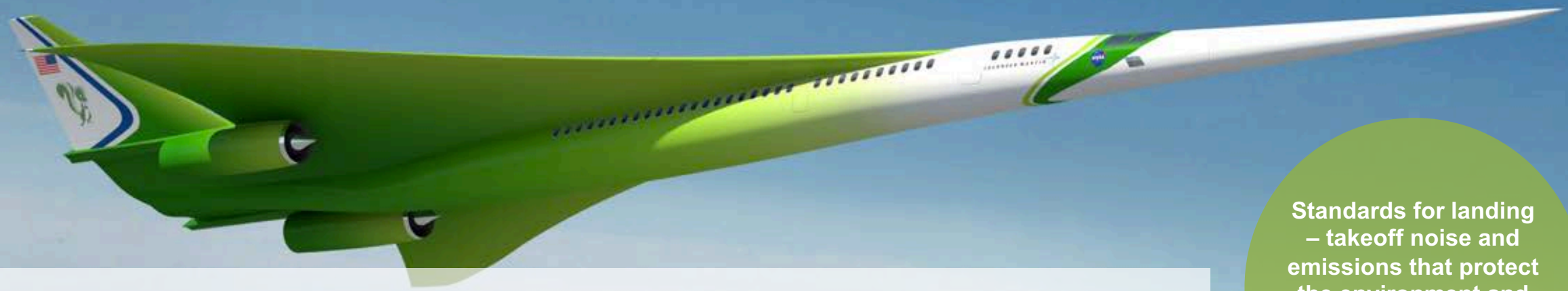
The Vision for Commercial Supersonic Flight

The emerging potential market has generated renewed interest in civil supersonic aircraft

- Evidenced by the appearance of several commercial programs even with existing restrictions on overland flight and other challenges

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



Standards for landing – takeoff noise and emissions that protect the environment and support early entrants are key to market development

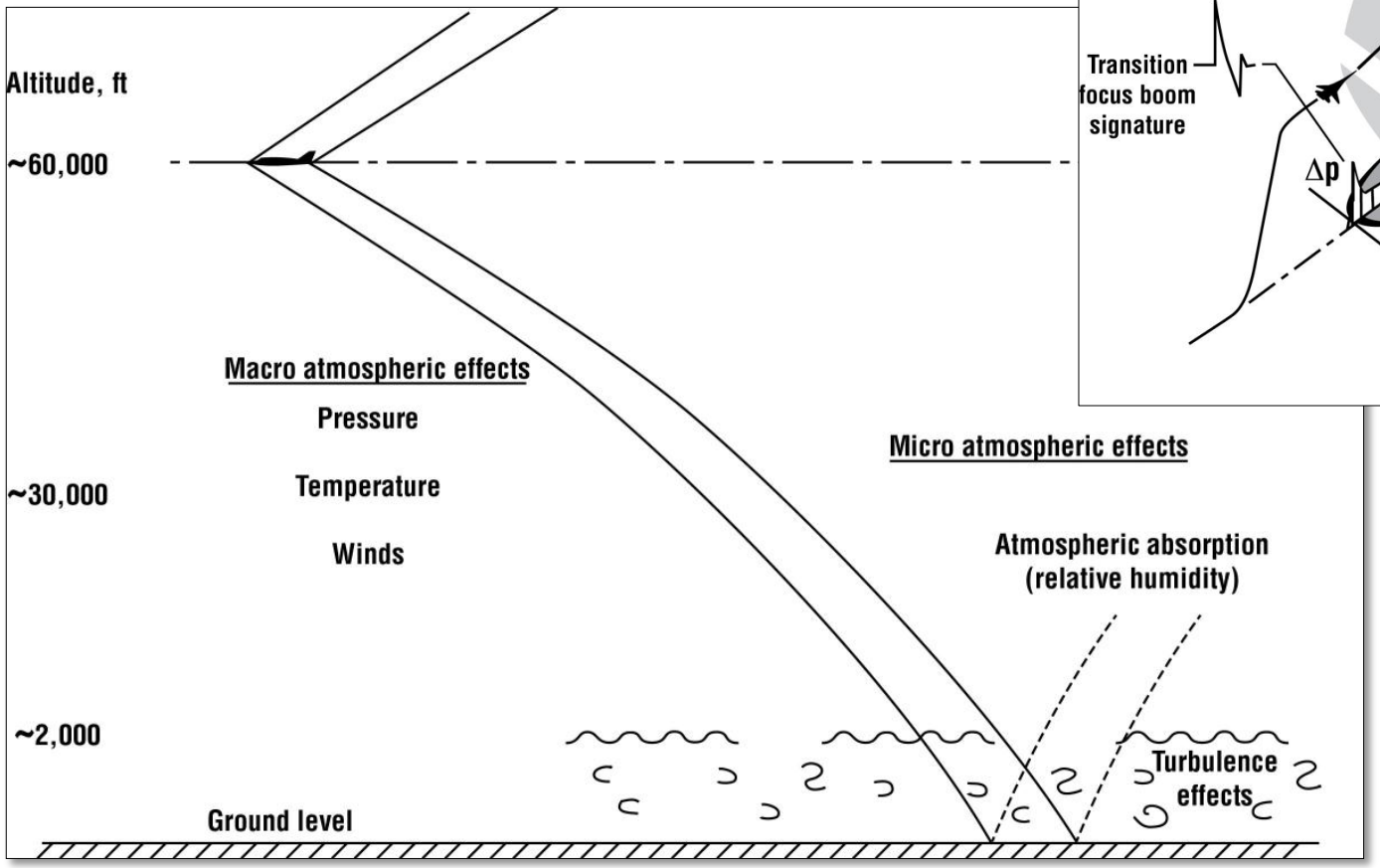
The vision of the Supersonics Community is a future where fast air travel is available for a broad spectrum of the traveling public.

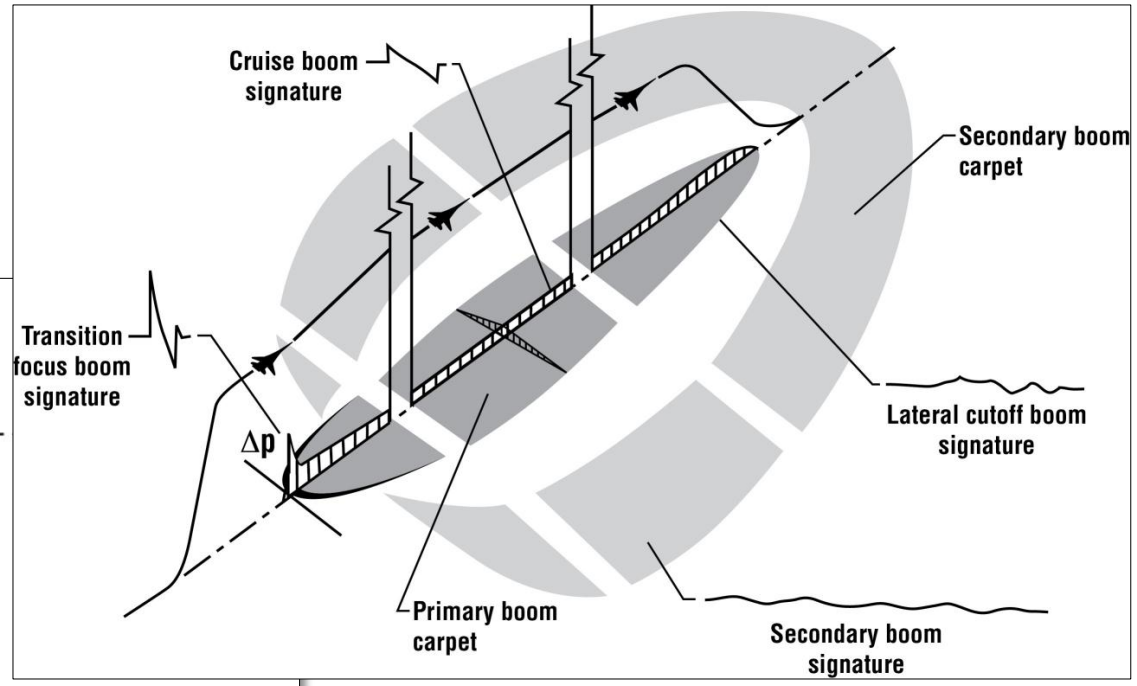
- Future supersonic aircraft will not only be able to fly overland without creating an “unacceptable situation” but compared to Concorde and SST will be efficient, affordable and environmentally responsible

Image Credit :Lockheed Martin

Sonic Boom 101

Sonic Boom With Atmospheric Effects





Boom Signature Carpet

Overview of X-59 QueSST Aircraft Features

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

External and forward visions systems for forward visibility

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

Long nose to shape forward shock

Fixed canard for nose-up trim at low-boom design point

Large, unitized skins reduce parts count and manufacturing cost

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T-tail to minimize aft shock

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

Wing shielding to minimize impact of inlet spillage on sonic boom

Single GE-F414 engine with standard nozzle to minimize cost and schedule

Conventional tail arrangement to simplify stability and control considerations

Design Parameters

- **Length: 96.8 ft**
- **Span: 29.5 ft**
- **Speed: Mach 1.4 (925 mph)**
- **Altitude: 55,000 ft**

Image Credit :Lockheed Martin

Low-Boom Flight Demonstration Mission Overview

First Flight
Summer 2022

Phase 1 – Aircraft Development

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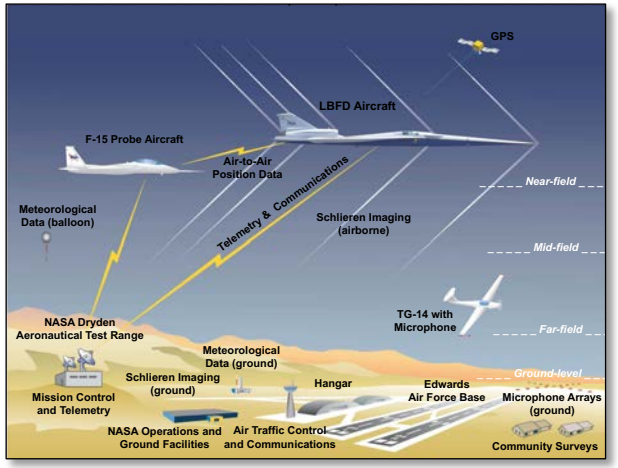
- Detailed Design
- Fabrication, Integration, Ground Test
- Checkout Flights
- Subsonic Envelope Expansion
- Supersonic Envelope Expansion



Start
Spring 2023

Phase 2 – Acoustic Validation

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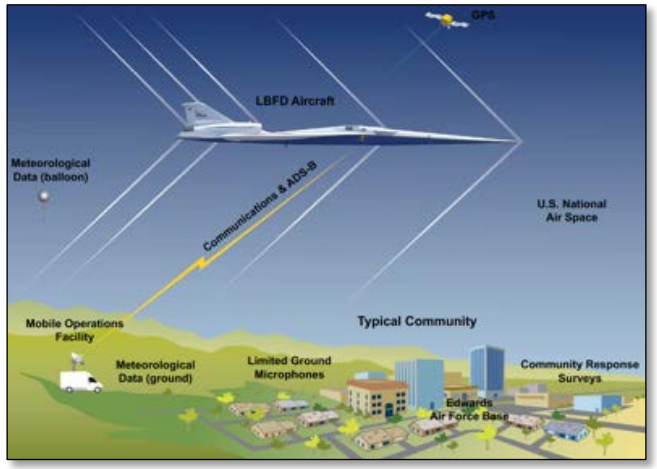
- In-flight and ground measurement capabilities
- Aircraft Operations / Facilities



Phase 3 – Community Response

- Initial community response overflight study based at NASA AFRC
- Multiple campaigns (3 to 4) over representative communities across the U.S.

Start
Spring 2024

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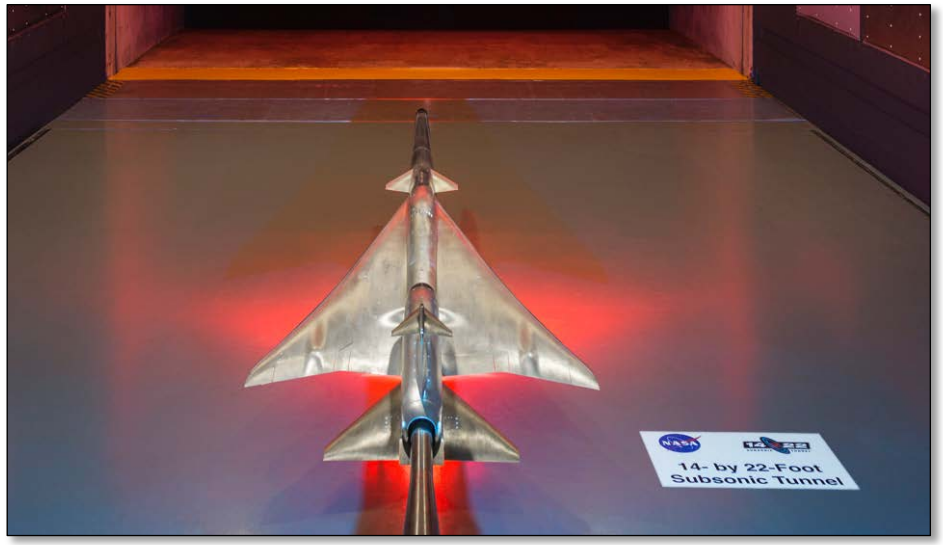
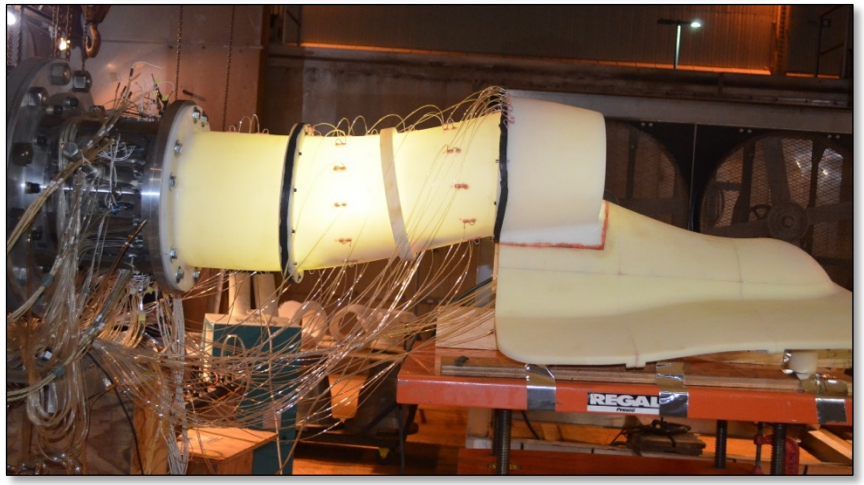
Systematic Approach Leading to Community Testing

X-59 QueSST Aircraft Wind Tunnel Validations

Low-and high-speed aerodynamic and Propulsion Airframe Interaction (PAI) wind-tunnel tests validate predictions and ensure readiness of the design

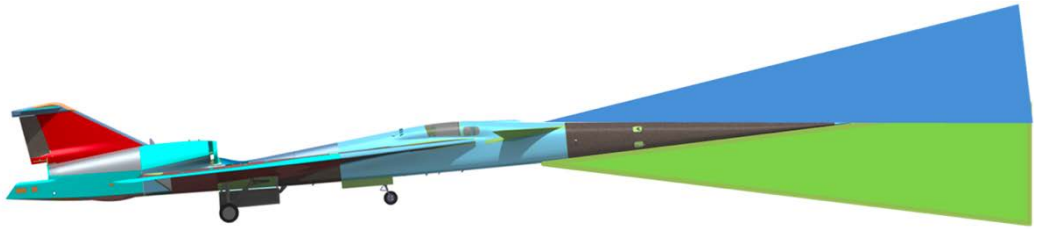




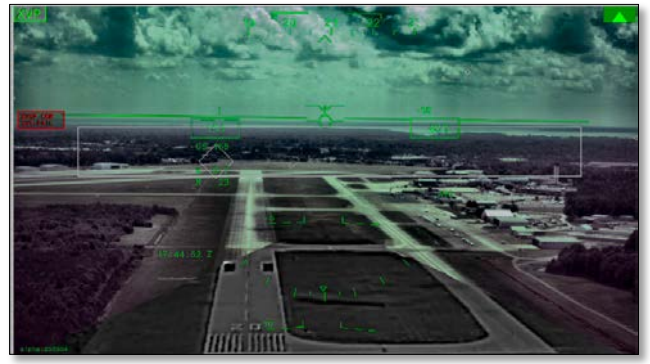
Credit: Lockheed Martin

X-59 eXternal Vision System (XVS)

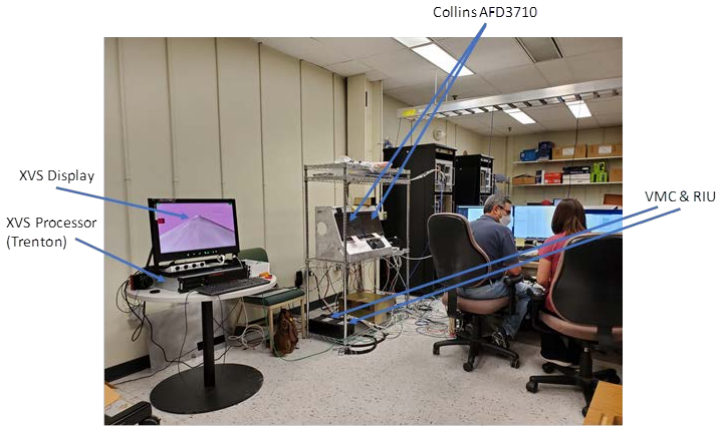
- XVS is designed to provide forward vision for X-59
  - Enhances mission performance for the community test phase
- System components
  - NASA developed 4k camera system
  - Display with integrated symbology
  - Commercial Enhanced Vision System (EVS) camera components
- System performance verified
- Final component checkout, qualification and delivery for installation into X-59 aircraft
- NASA has maintained continuous engagement with FAA to ensure seamless NAS operations



Concept View of X-59 Cockpit

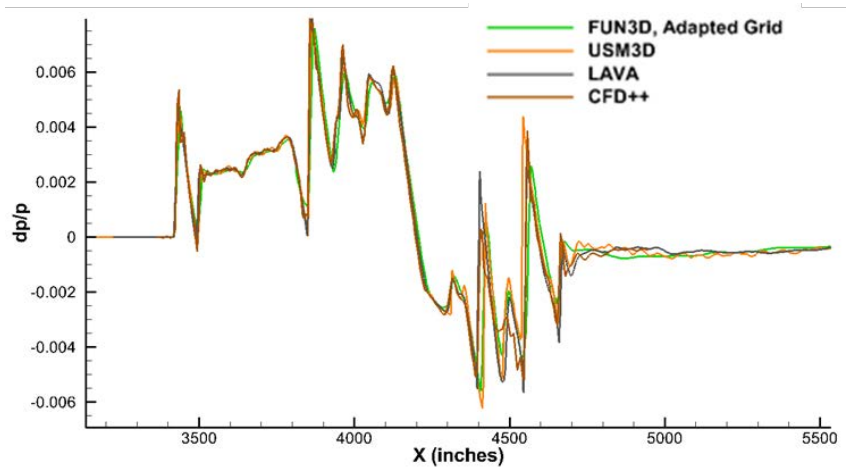


XVS Image During Flight Test

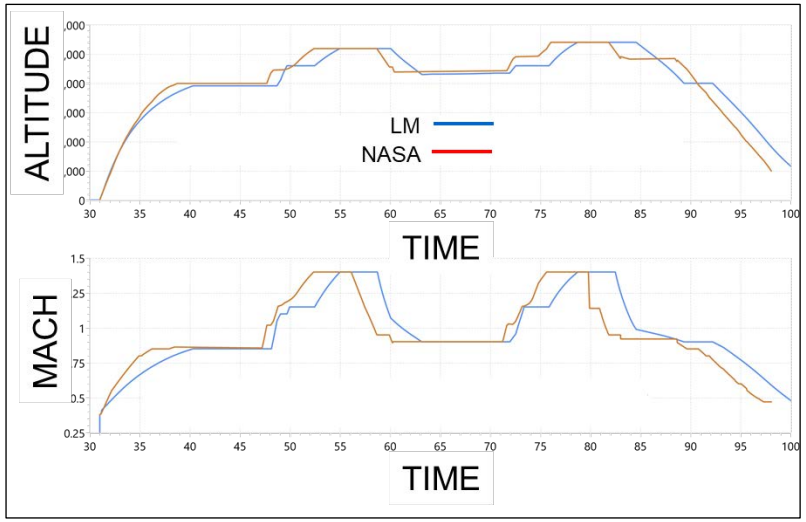


XVS Flight and Integrated Ground Test

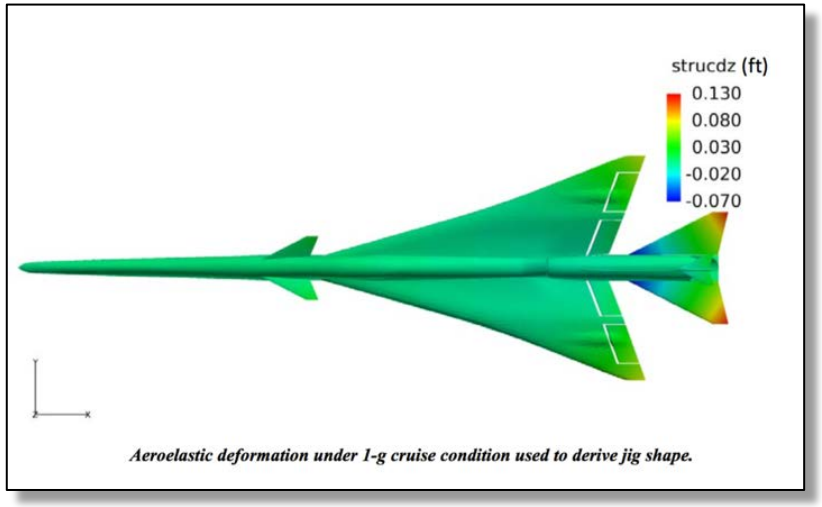
X-59 QueSST Aircraft Assessments



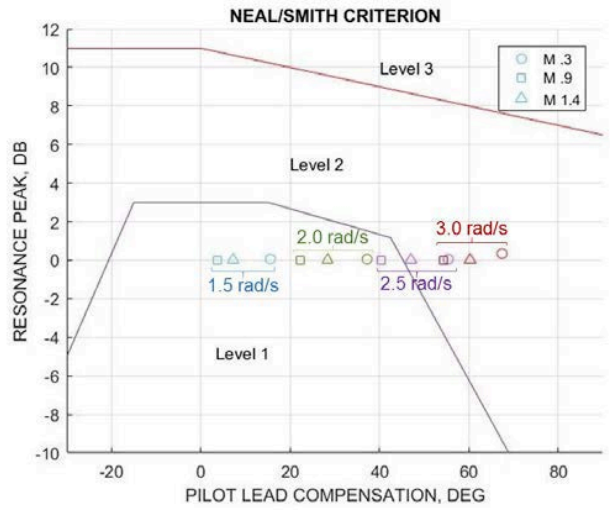
Sonic Boom



Mission Performance



Structural Modeling

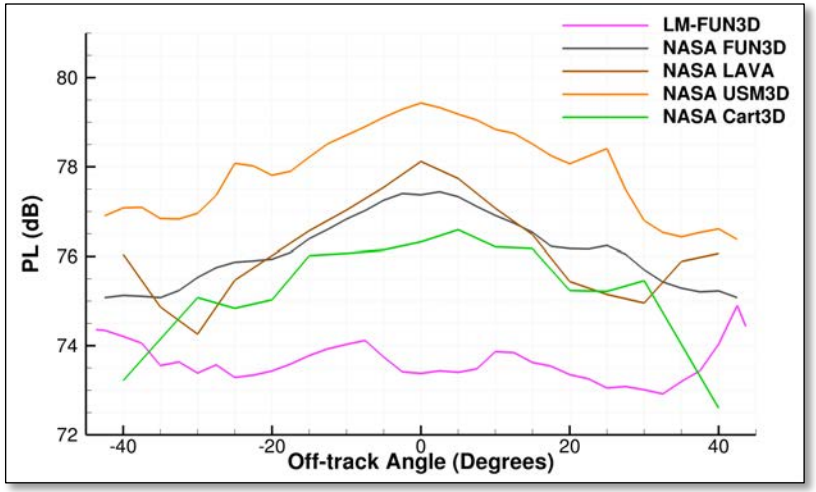


Handling Qualities

Prediction Tools and Validation

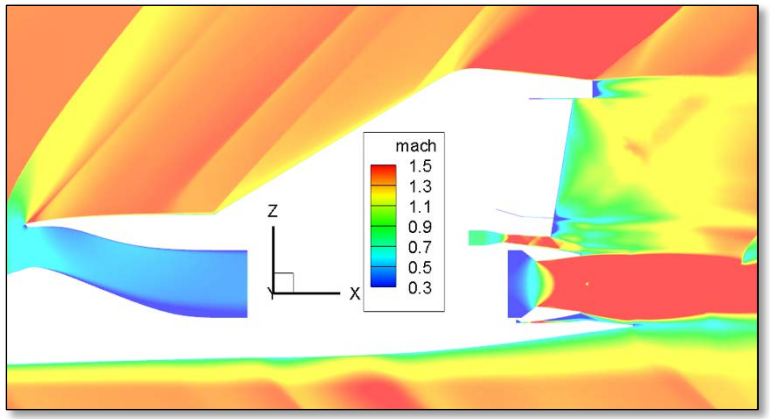
Challenge

In preparation for community response testing, NASA will provide a suite of prediction tools to support timely and accurate validation of the acoustic performance of the X-59 aircraft, rapid pre-flight exposure planning for Community Testing, and provide a foundation for future configuration design and certification analysis of supersonic aircraft.



Sonic Boom Prediction

High Fidelity CFD

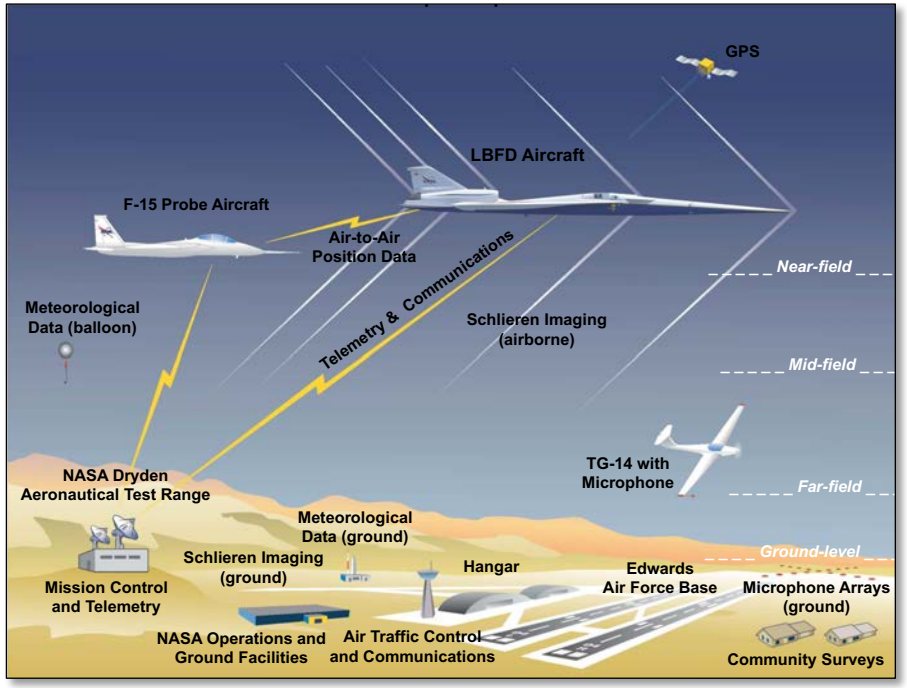


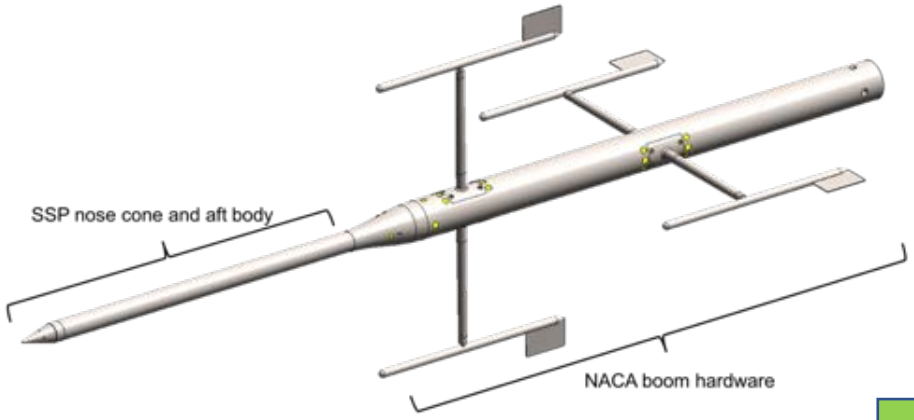
Uncertainty Quantification

Acoustic Validation Test Planning and Execution

Challenge

- Develop and demonstrate LBFD mission Phase 2 capabilities to safely measure in-flight:
  - Near-field acoustic characteristics of the LBFD aircraft
  - Atmospheric effects on the far-field acoustic pressure signatures





Shock Sensing Probe

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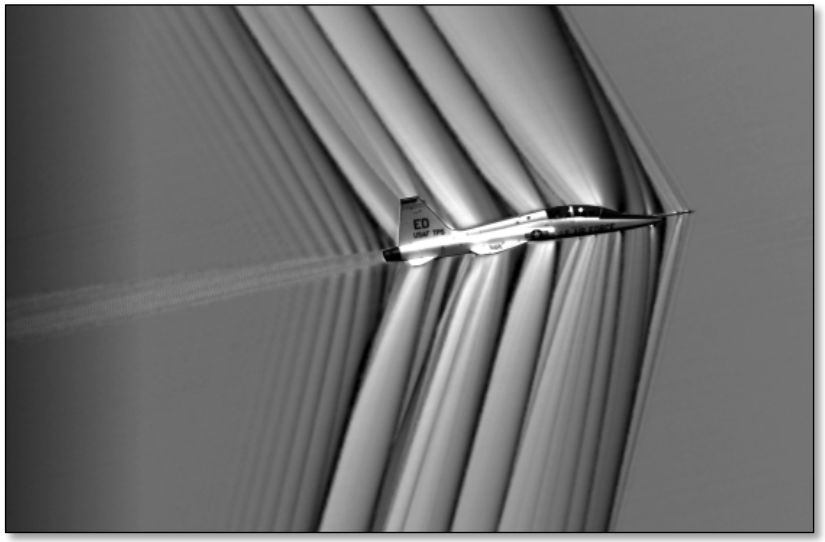

Advanced Air-Air Schlieren Imaging

Community Test Planning and Execution

Challenge:

- Create a robust community response relationship for annoyance vs appropriate noise metrics
- Large populations, large number of representative responses.
  - 10k to 100k, depending on survey method employed
  - Varied community settings
- Range of 6-8 daily exposures required
- 4-5 test campaigns in different locations around U.S.
- Engage the international research & regulatory community to ensure data acceptance

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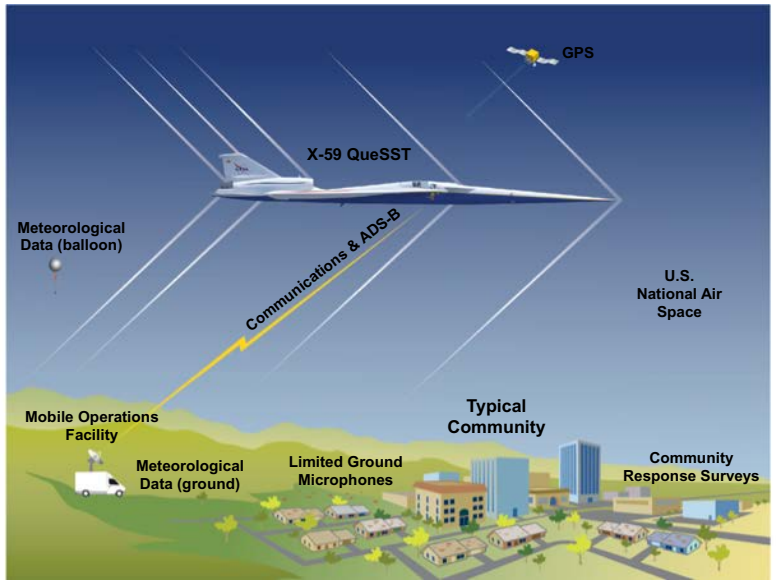

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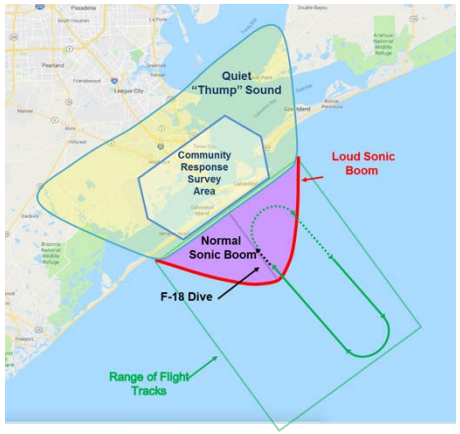
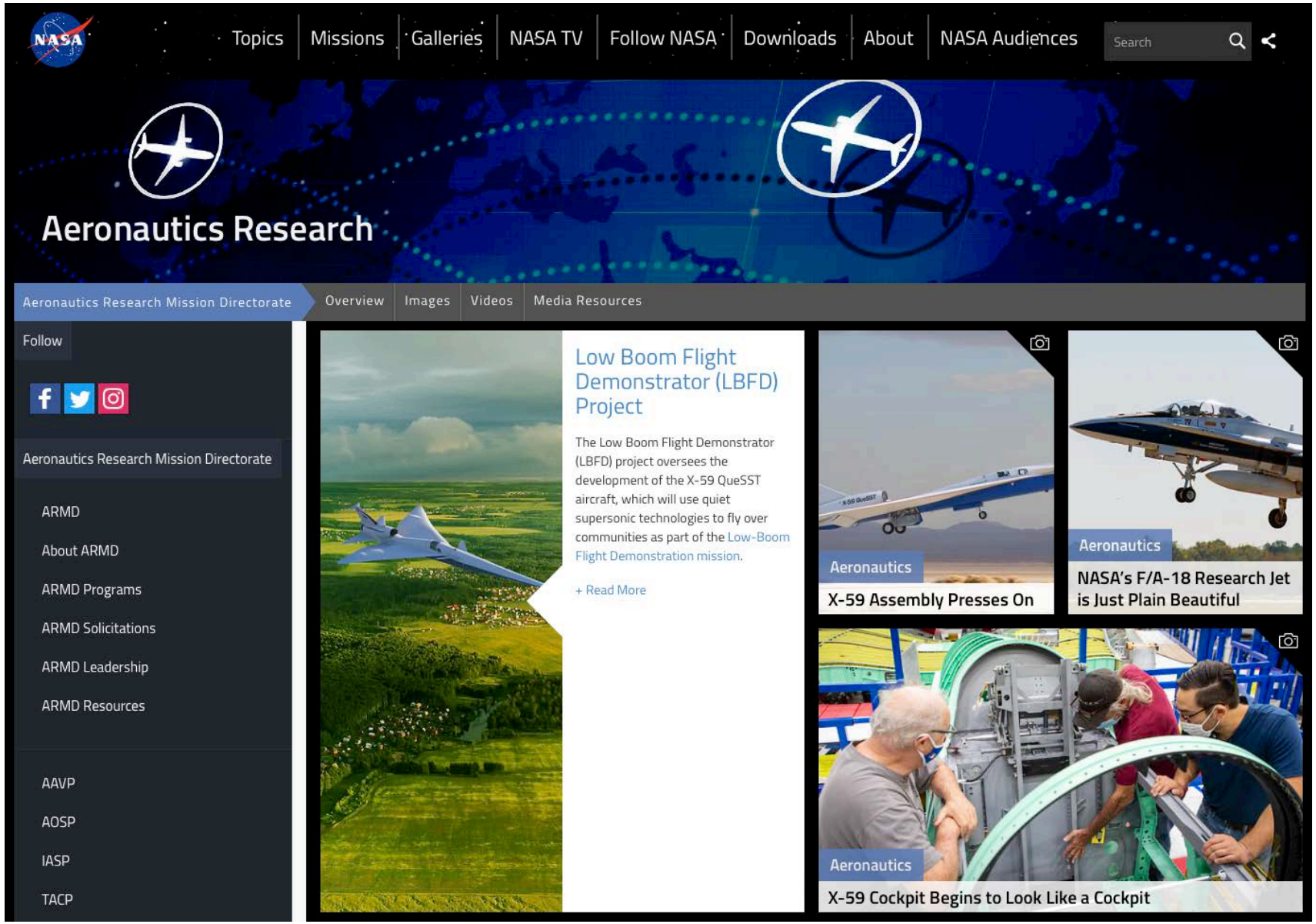


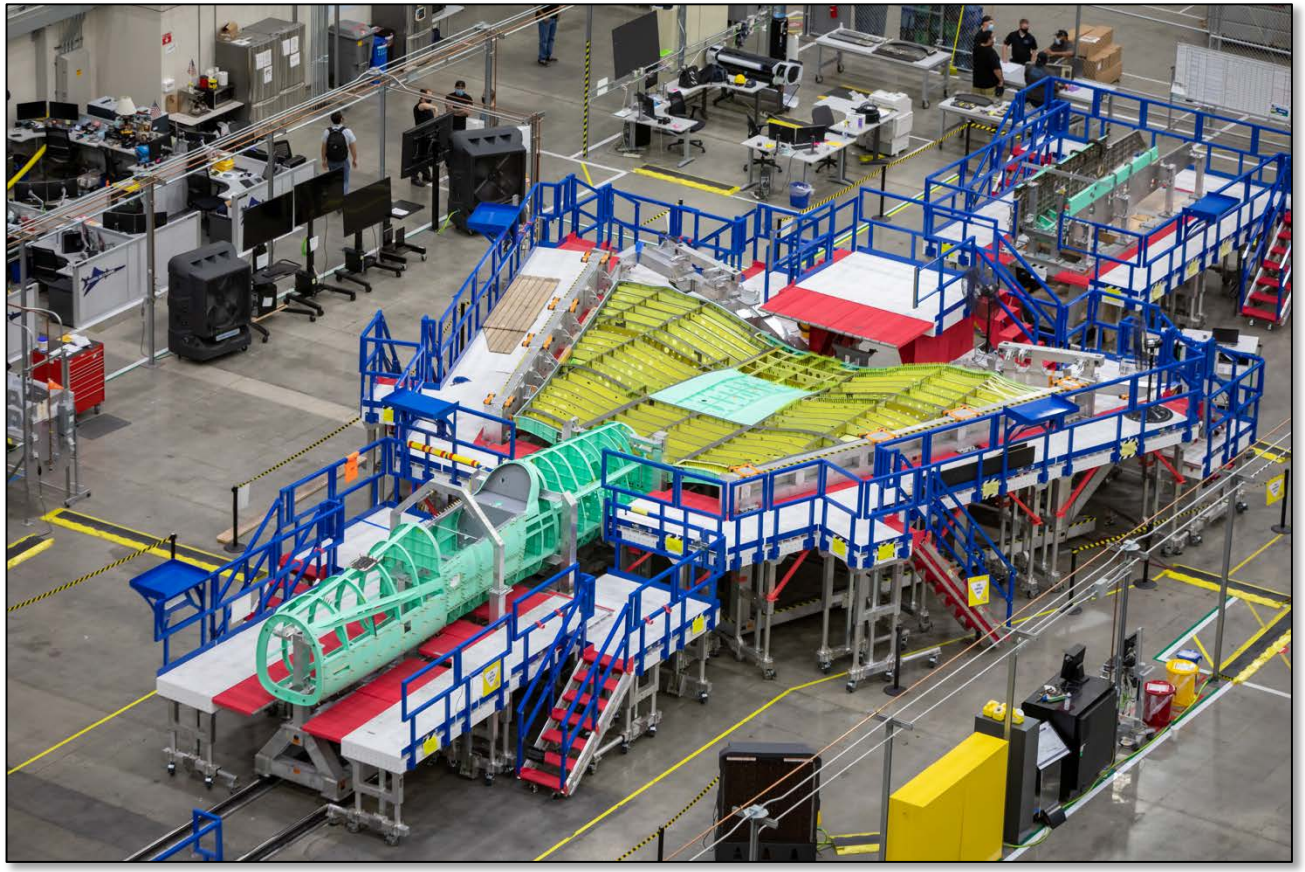
Quiet Supersonic Flight 2018
Galveston, Texas

LBFD Website



www.nasa.gov/lowboom

X-59 QueSST Aircraft Fabrication and Integration



Credit: Lockheed Martin

Aircraft Fabrication

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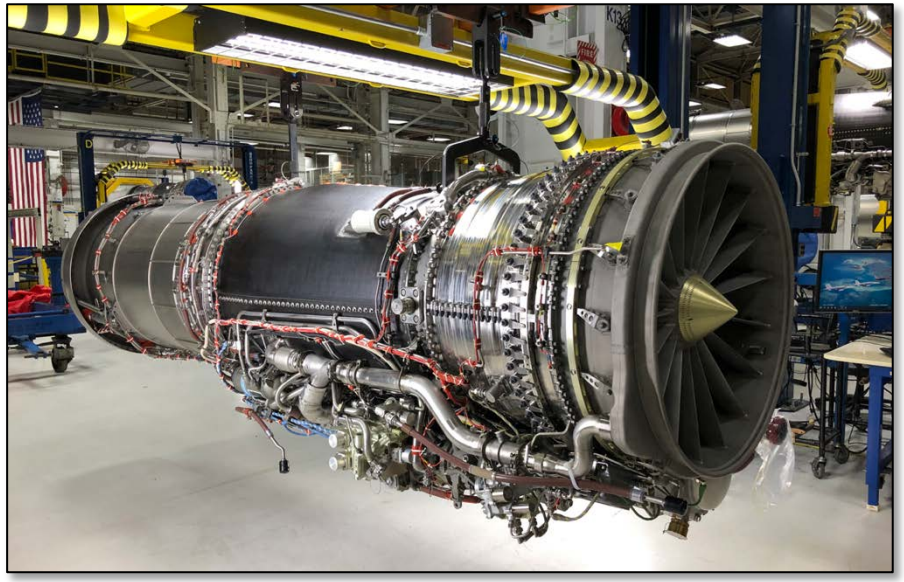

Credit: General Electric

F414-100 Engine Testing and Delivery

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