NASA's QueSST Mission and X-59 Aircraft

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Presentation Topics

- Overview: NASA's Aeronautics Strategy
- Barriers to Successful Supersonic Commercial Aircraft
- Sonic Boom 101
- Quesst Mission Overview
- X-59 Aircraft
  - Features and Design
  - Fabrication and Integration
  - Ground Testing
- Supporting Technologies and Flight Systems
- Closing Remarks

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

Barriers to Commercial Supersonic Flight

Sonic Boom Noise and Overland Flight Prohibitions

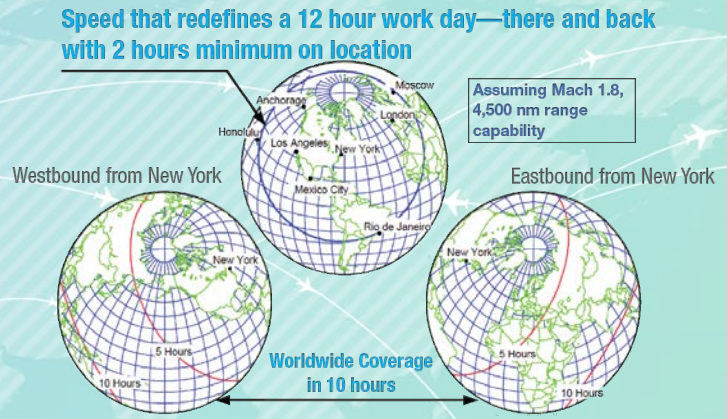
The government plays a central role in overcoming the key barrier that is essential to enable this new market

- 1st supersonic flight: 1947
- Introduction of supersonic commercial transports in 1970s brought the problem of sonic boom noise to public attention & showed sonic boom noise to be unacceptable
- Supersonic overflight restrictions followed
  - US: FAA Regulation (FAR) prohibits supersonic flight over US
  - Worldwide: ICAO Assemble Resolution – “No unacceptable situation for the public due to sonic boom”
- Restriction dramatically limited market potential for supersonic commercial flight
- The creation of a market for supersonic commercial aircraft requires eliminating sonic boom as a barrier to overland flight

Innovation in Commercial Supersonic Flight

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

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



- 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

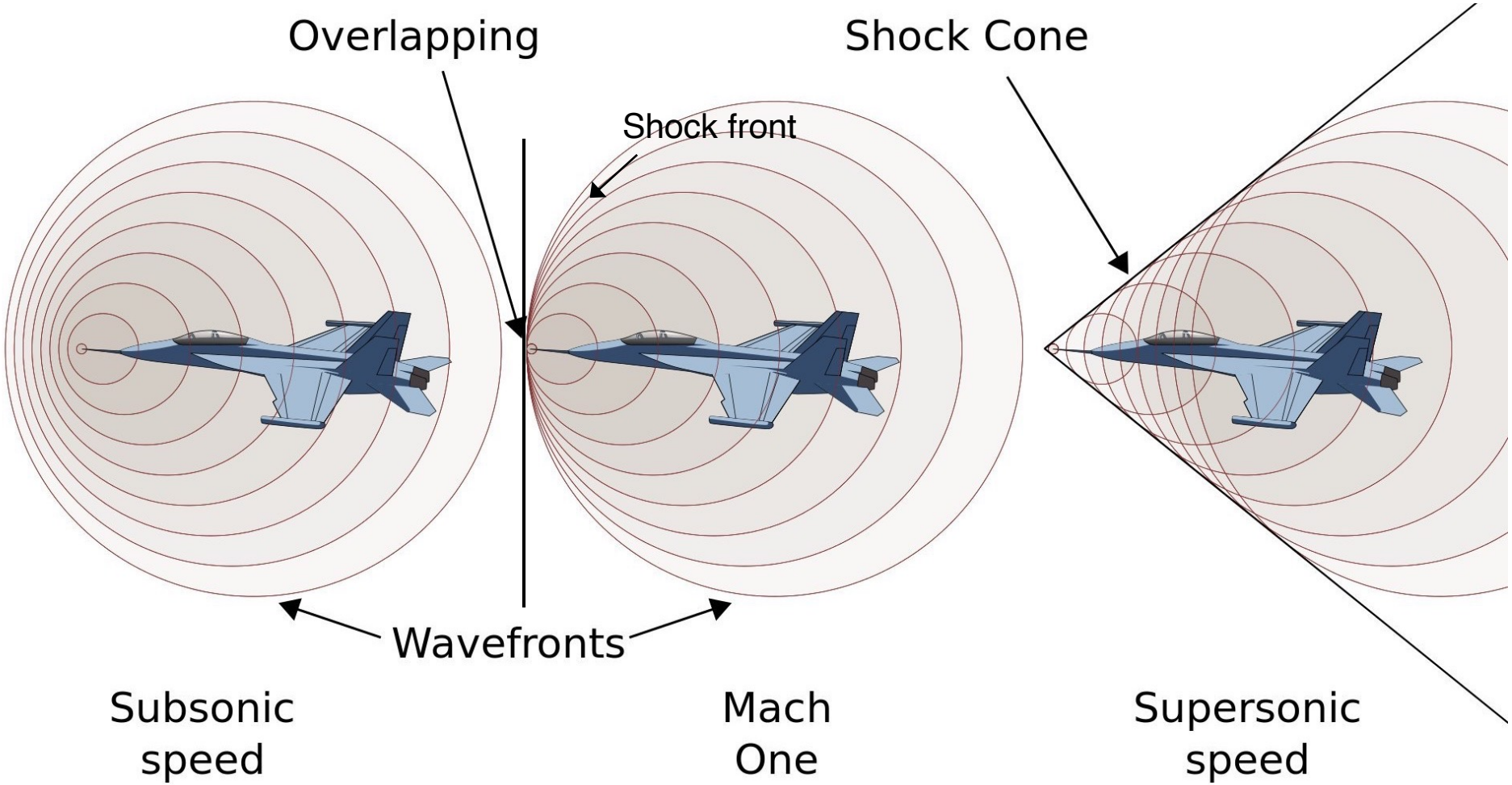
Overcoming the Barrier to Overland Supersonic Flight

The Quesst 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

Image Credit: Lockheed Martin

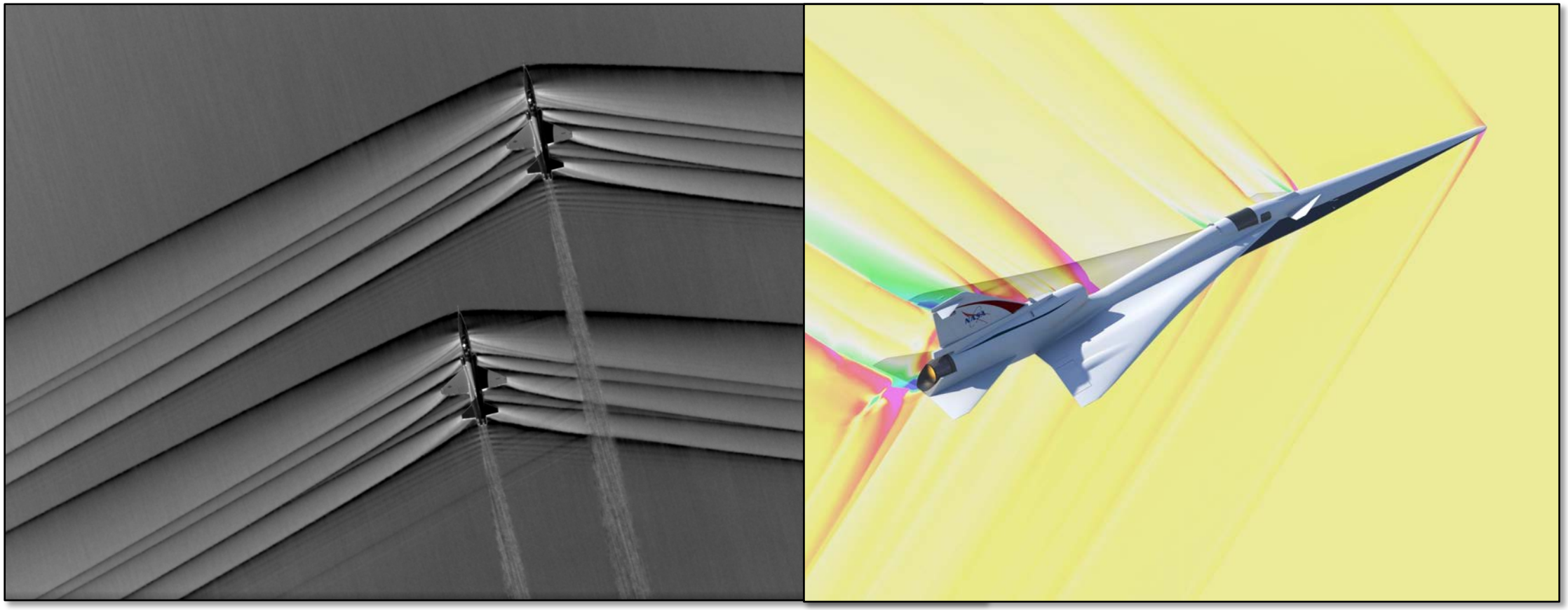
What Makes a Sonic Boom?



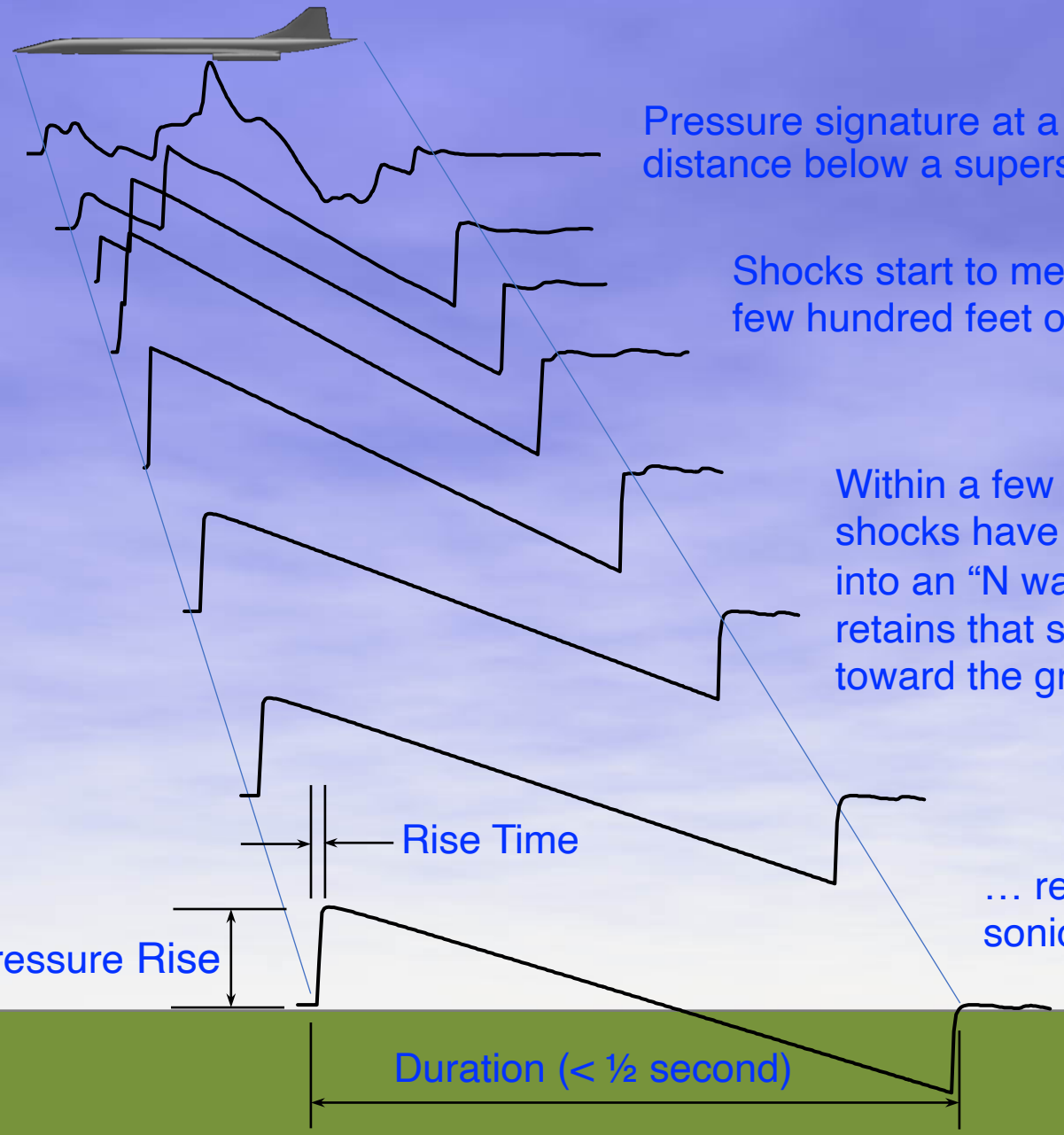
- Conical shock wave produces sonic boom at ground which moves with the airplane
- Boom is created over entire length of supersonic flight path, just as a boat wake is continuous

Sonic Boom 101

The X-59's design shape prevent shockwaves from coming together, reducing the loud sonic boom to a barely audible thump.



Sonic Boom Basics: N-Wave Sonic Boom



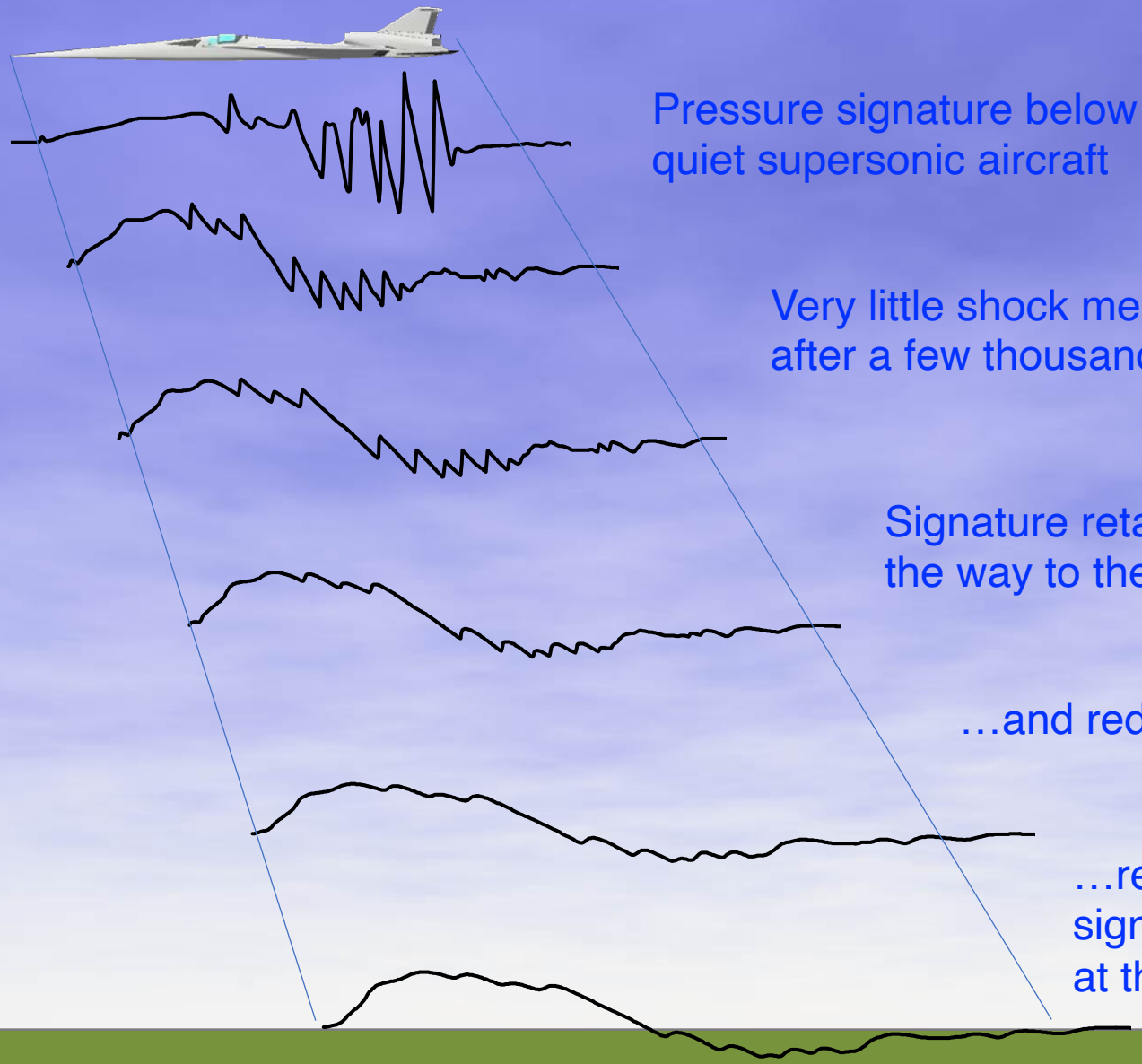
Pressure signature at a short distance below a supersonic aircraft

Shocks start to merge within a few hundred feet of the aircraft

Within a few thousand feet, the shocks have completely merged into an “N wave” and the signature retains that shape as it travels toward the ground …

… resulting in a LOUD sonic boom at the ground

Sonic Boom Basics: Shaped Pressure Signal



Pressure signature below a quiet supersonic aircraft

Very little shock merging after a few thousand feet

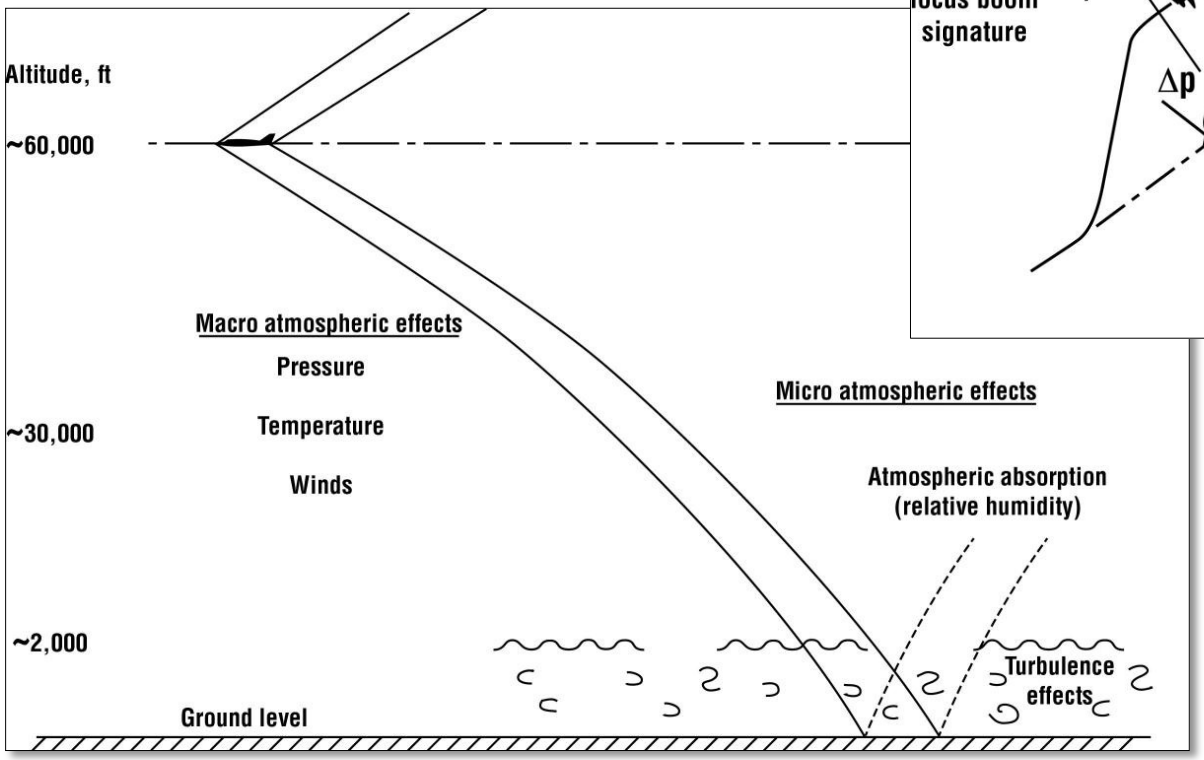
Signature retains its shape all the way to the ground…

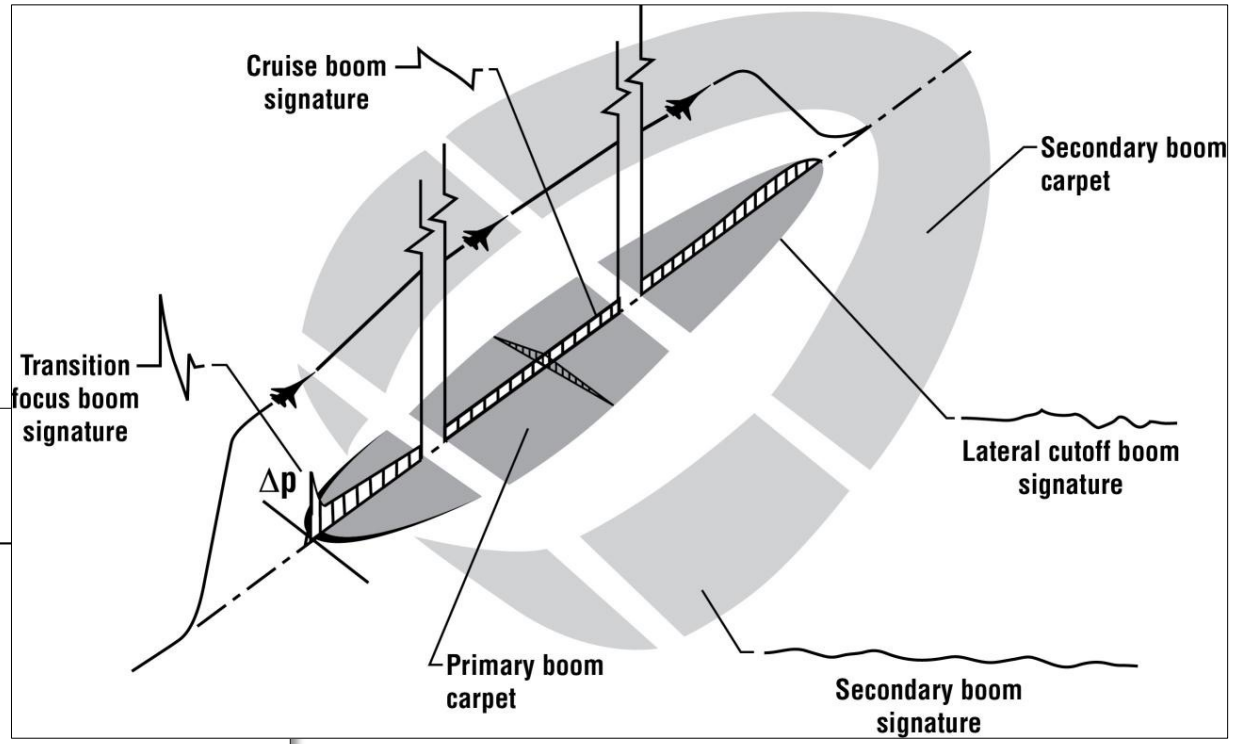
…and reduces in strength…

…resulting in a significantly quieter sound at the ground

Sonic Boom 101

Sonic Boom With Atmospheric Effects



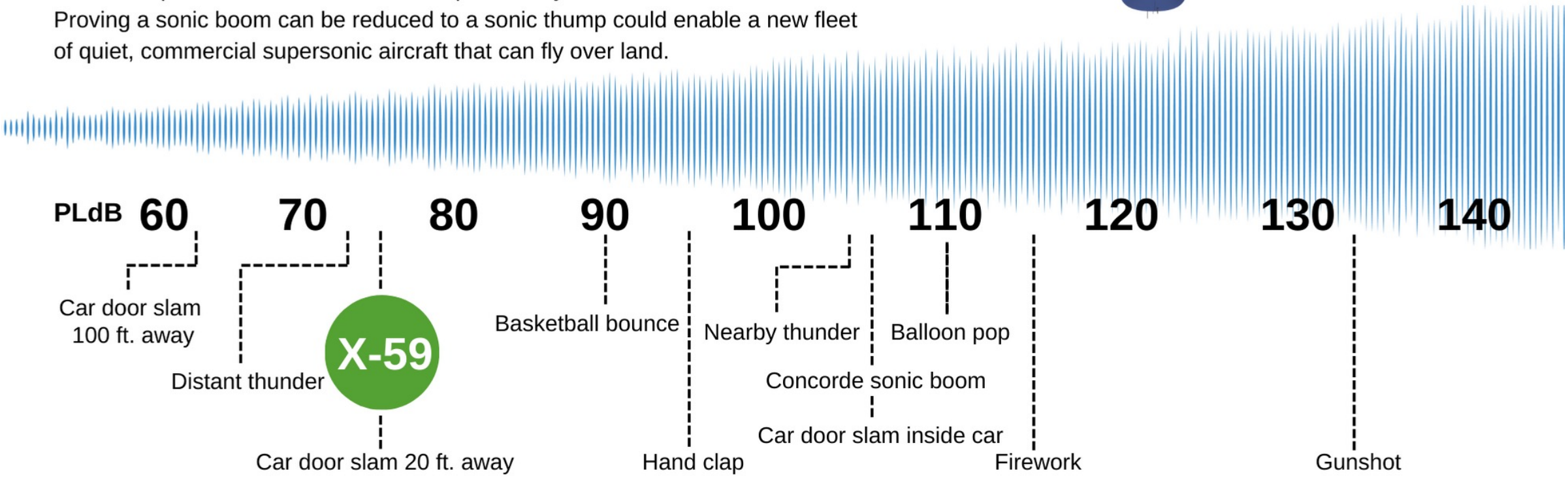


Boom Signature Carpet

Sonic Thump

Just how quiet will NASA's X-59 be?

NASA's single-seat X-59 experimental aircraft will produce a barely audible sonic thump to people on the ground when cruising at supersonic speeds. In technical terms, the X-59's sonic thump will be around 75 Perceived Level decibels (PLdB) or less. PLdB is one of numerous scales, in decibels, that is used to understand human response to sounds and is used particularly for short duration sounds. Proving a sonic boom can be reduced to a sonic thump could enable a new fleet of quiet, commercial supersonic aircraft that can fly over land.



Overview of X-59 Aircraft Features

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

Long nose to shape forward shock

External and forward visions systems for forward visibility

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

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

T-tail to minimize aft shock

Large, unitized skins reduce parts count and manufacturing cost

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

Conventional tail arrangement to simplify stability and control considerations

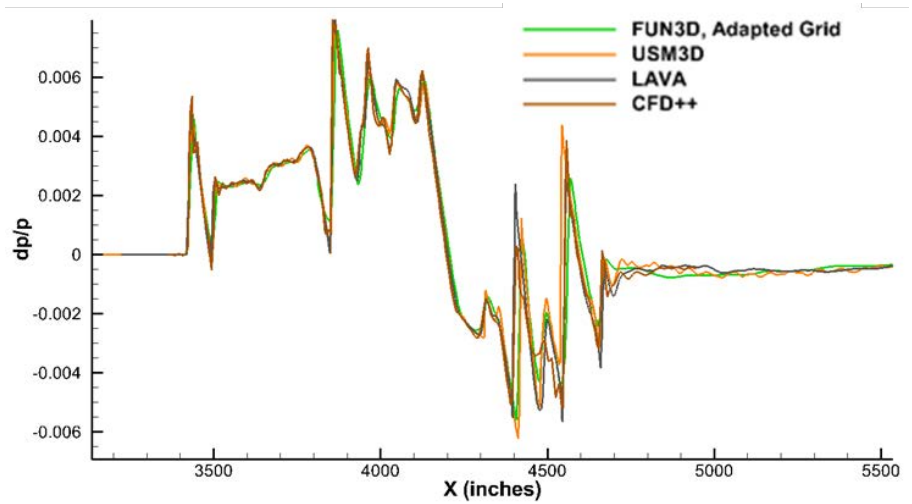
Single GE-F414 engine with standard nozzle to minimize cost and schedule

Design Parameters

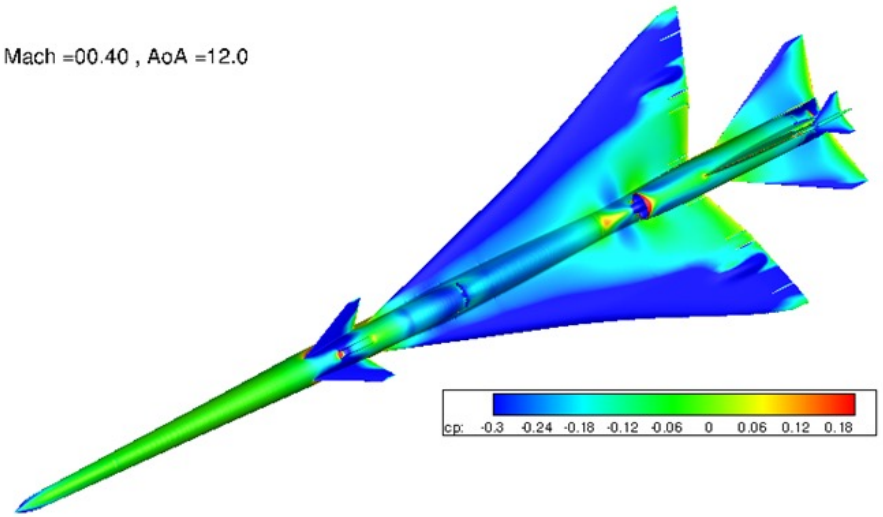
- **Length: 99 ft**
- **Span: 29.5 ft**
- **Speed: Mach 1.4 (925 mph)**
- **Altitude: 55,000 ft**

Image Credit: Lockheed Martin

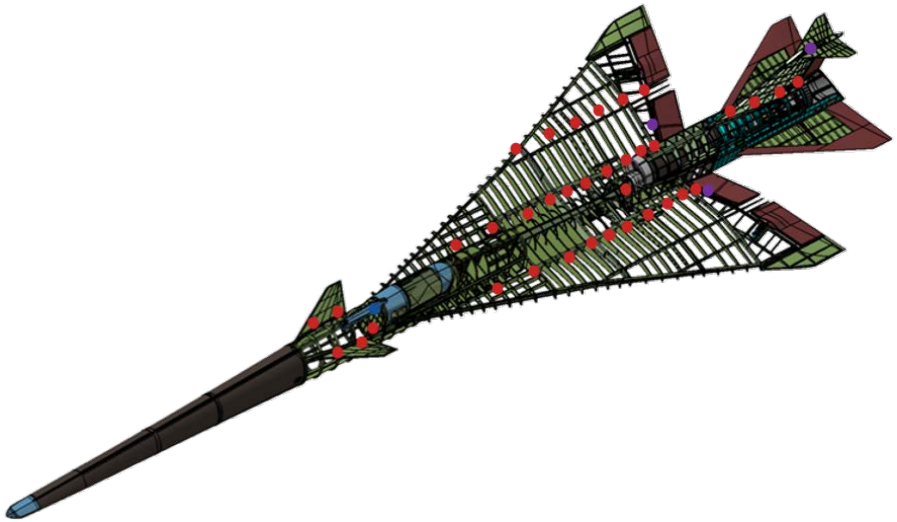
X-59 Aircraft Assessments



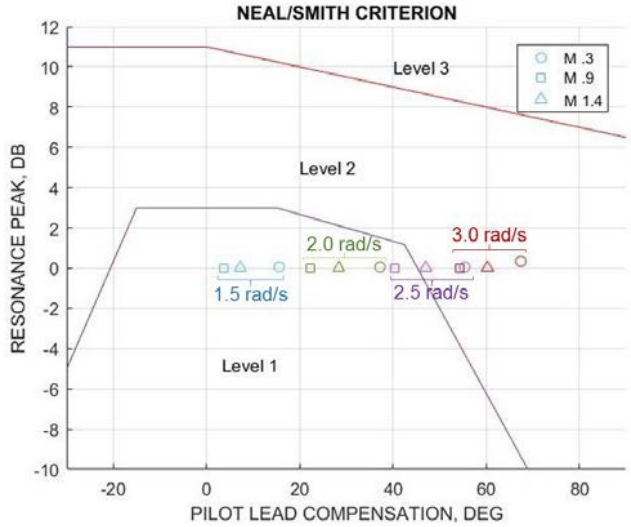
Sonic Boom



Aerodynamic Performance



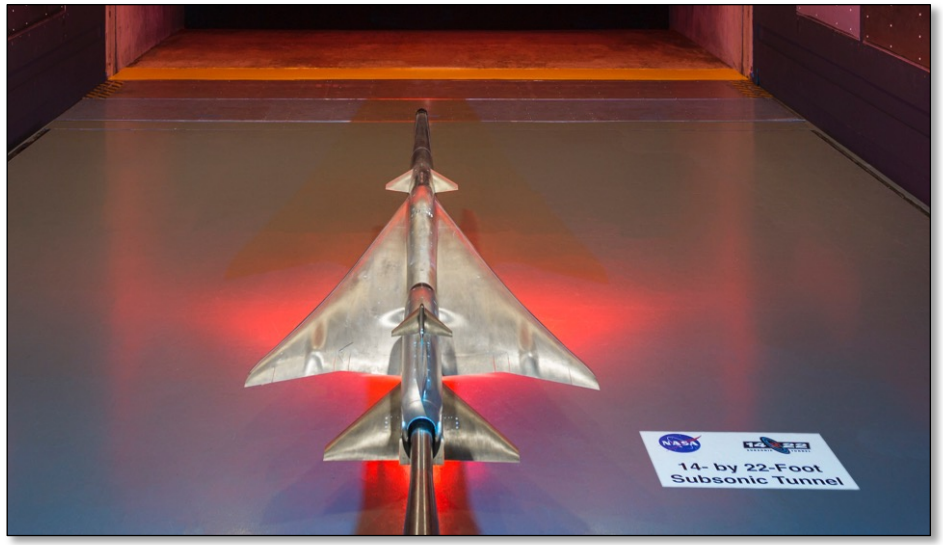
Structural Modeling

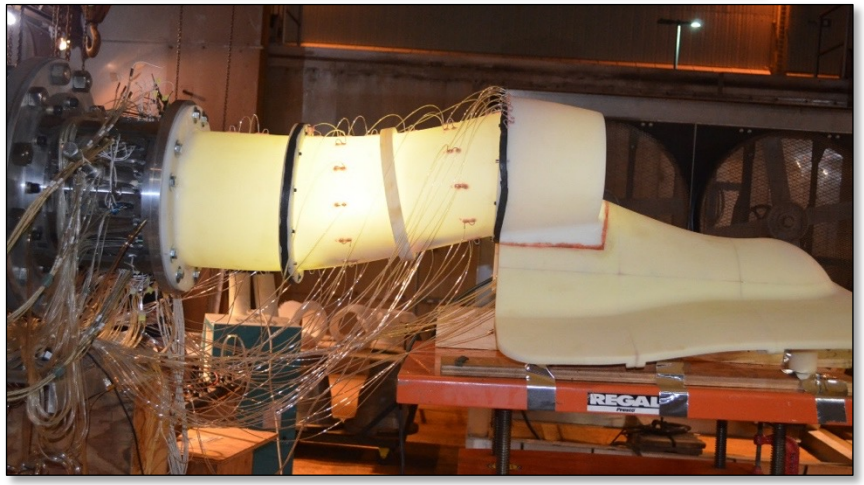


Handling Qualities

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

Quesst Mission Overview

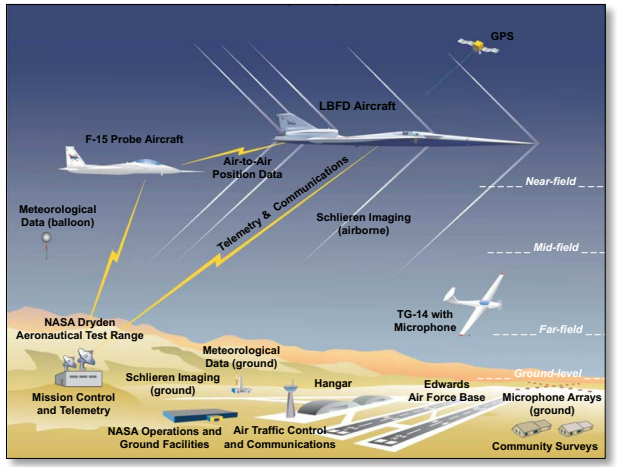
Credit: Lockheed Martin

First Flight
Late 2022

Phase 1 – Aircraft Development

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

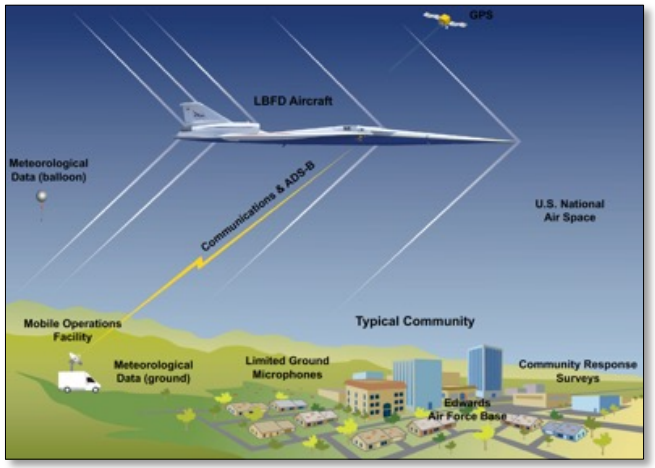
Systematic Approach Leading to Community Testing



Start 2023

Phase 2 – Acoustic Validation

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



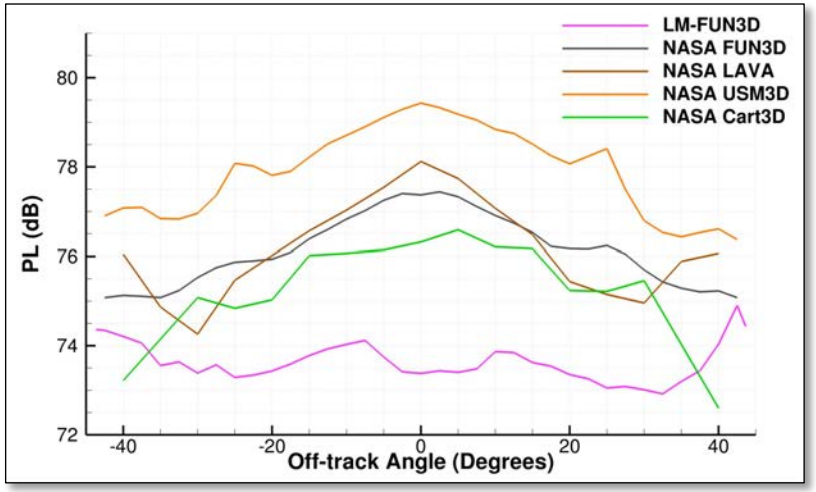
Start 2024

Phase 3 – Community Response

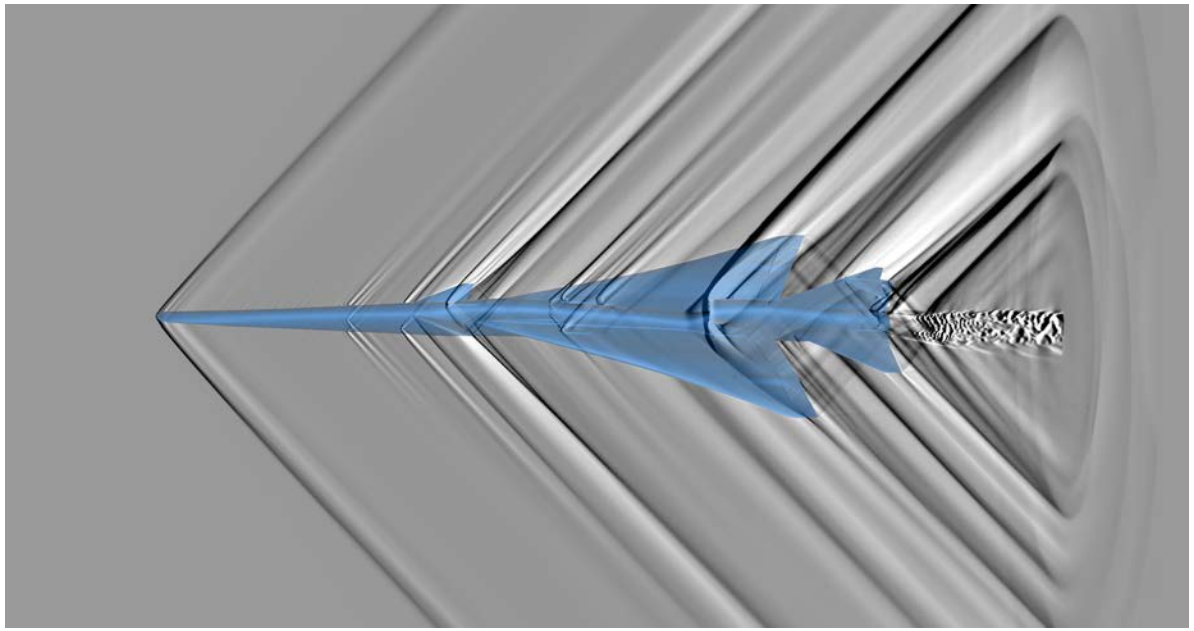
- Initial community response overflight study based at NASA AFRC
- Multiple campaigns (3 to 4) over representative communities across the U.S.

Prediction Tools and Validation

In preparation for community response testing, NASA is creating 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.



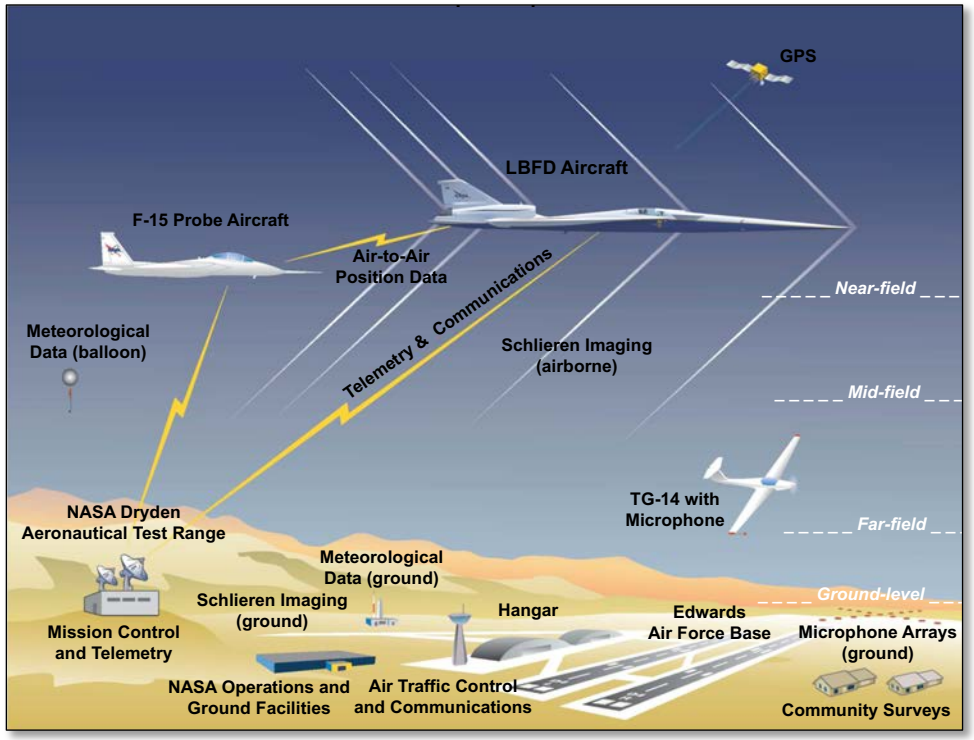
Sonic Boom Prediction



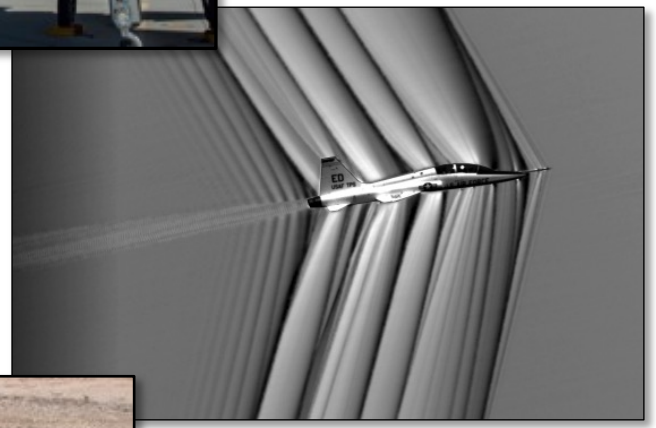
High Fidelity Computational Results (CFD)

Acoustic Validation Test Planning and Execution

- Develop and demonstrate Quesst mission Phase 2 capabilities:
  - Near-field acoustic characteristics of the LBFD aircraft
  - Atmospheric effects on the far-field acoustic pressure signatures
  - Ground measurements



F-15 With Shock Sensing Probe

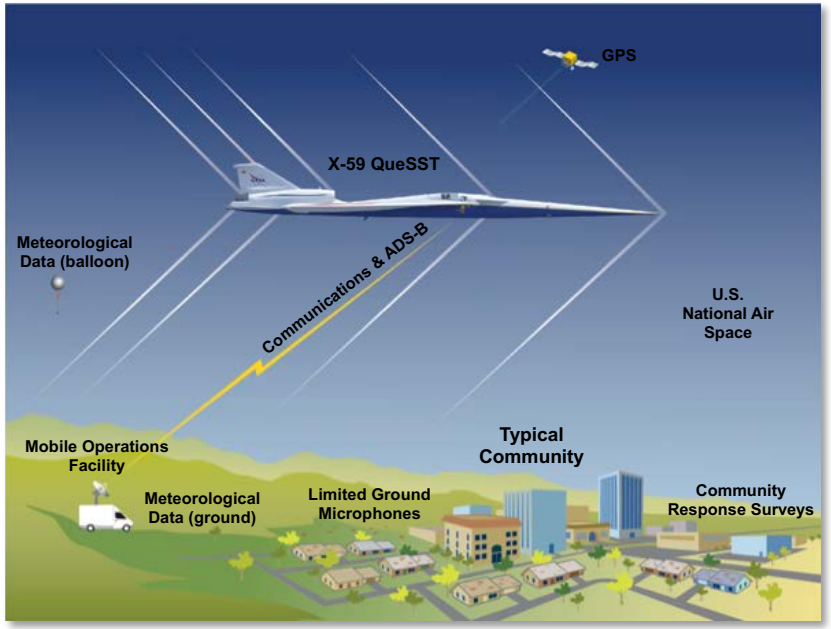


Advanced Air-Air Schlieren Imaging

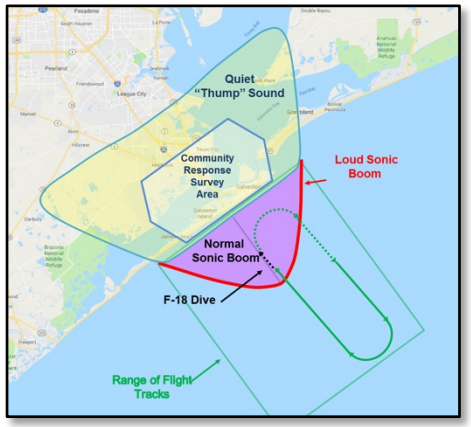
Ground Recording Systems

Community Test Planning and Execution

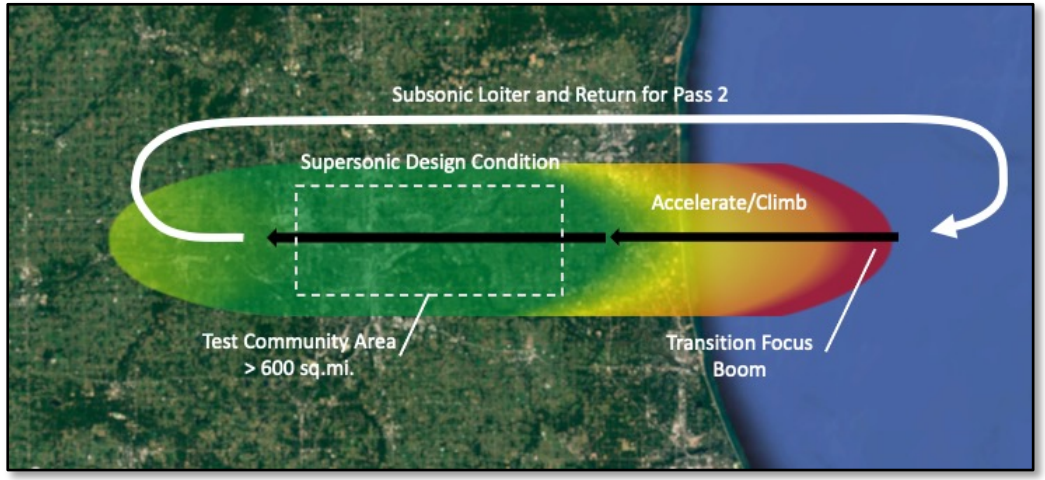
- Create a robust community response relationship for annoyance vs appropriate noise metrics
- Large populations, large number of representative responses
- 4-5 test campaigns in different locations around the U.S. with 6-8 daily exposures
- Engage the international research & regulatory community to ensure data acceptance



Typical Community Response Test



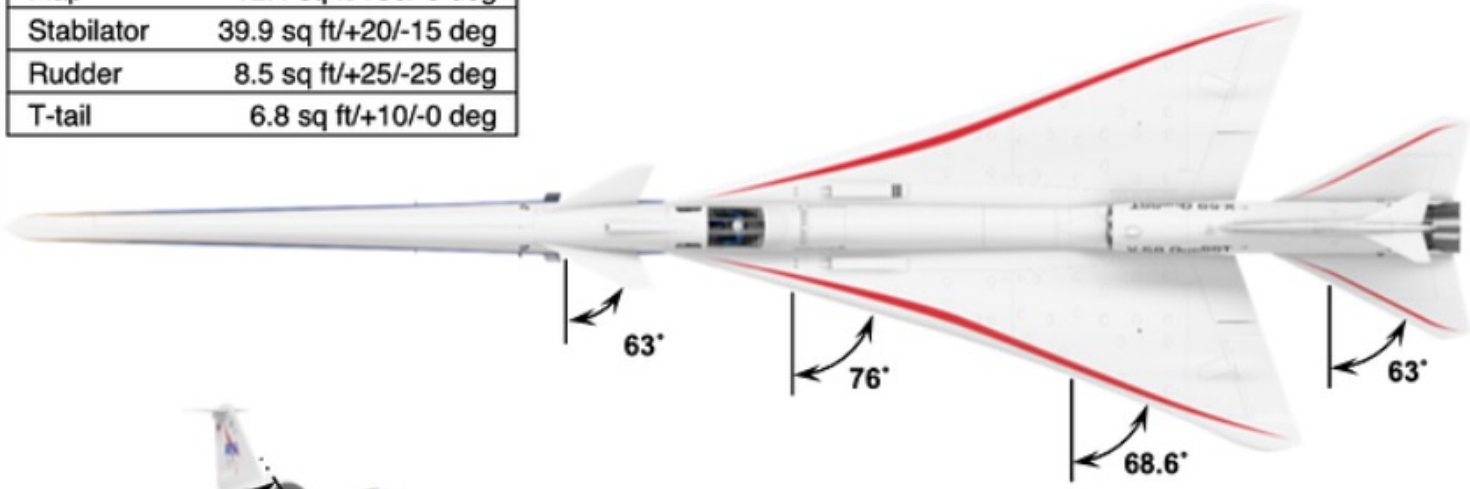
Quiet Supersonic Flight 2018
Galveston, Texas



X-59 Aircraft 3-View

Configuration C612	
MDGW	25,000 lbs
Fuel (Max)	8,700 lbs
Payload	600 lbs
Design Mach	1.4
Loudness	<75 PLdB
Engine	1xF414-GE-100
Landing Gear	F-16 Blk25 NLG F-16 Blk25 MLG

Control Surfaces	
Aileron	12.9 sq ft/+35/-25 deg
Flap	12.4 sq ft/+30/-3 deg
Stabilator	39.9 sq ft/+20/-15 deg
Rudder	8.5 sq ft/+25/-25 deg
T-tail	6.8 sq ft/+10/-0 deg



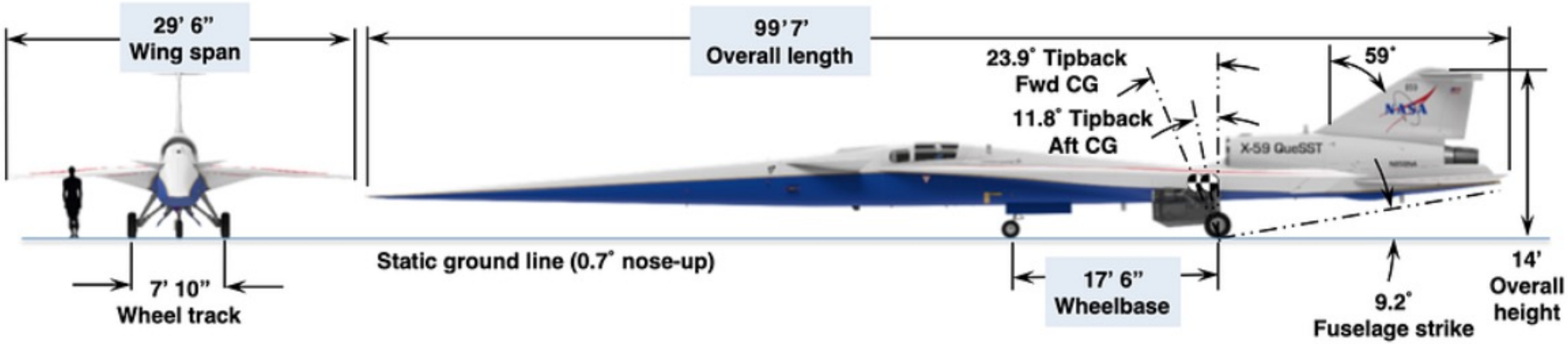
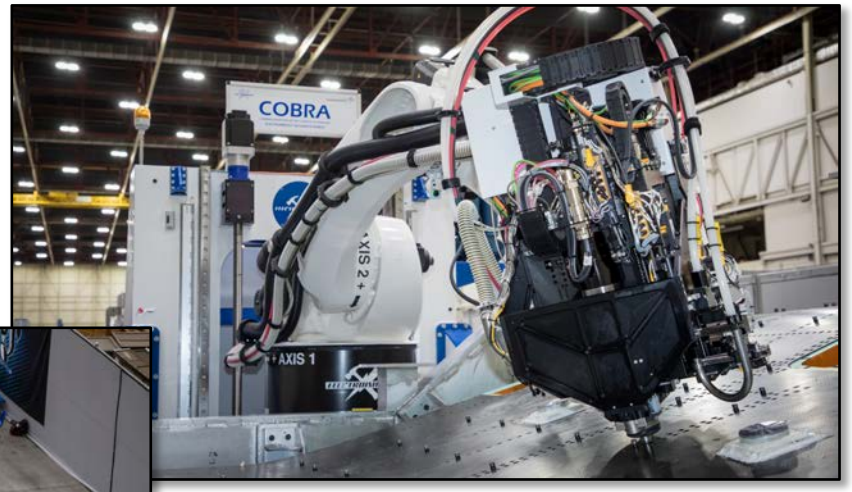
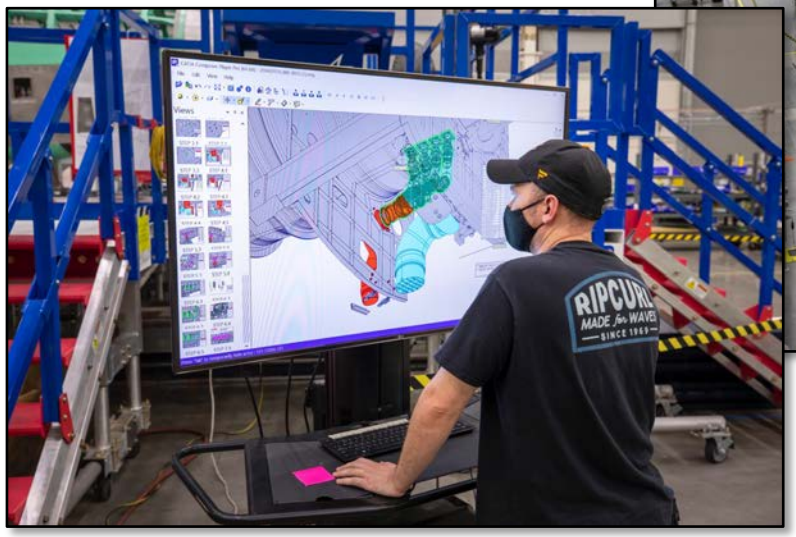


Image Credit: Lockheed Martin

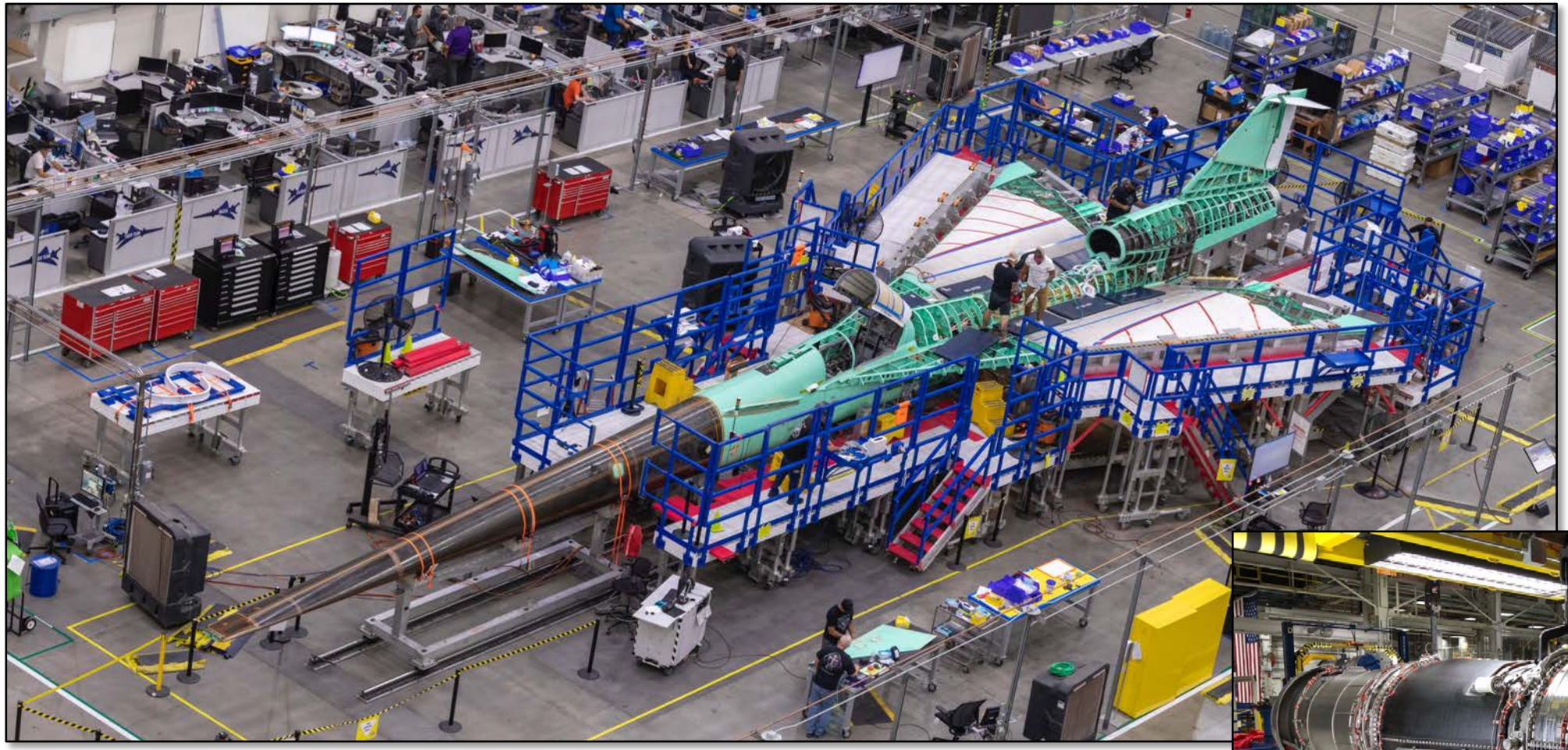
X-59 Aircraft Fabrication and Integration





Credit: Lockheed Martin

X-59 Aircraft Fabrication and Integration



Credit: Lockheed Martin

Credit: General Electric

X-59 Aircraft Ground Testing in Ft. Worth

The Long Journey

Preparing the Aircraft for Structural Testing

Credit: Lockheed Martin

X-59 Aircraft Ground Testing in Ft. Worth

Structural Testing

Fuel Systems Testing

Credit: Lockheed Martin

Cockpit Simulations

Aircraft and cockpit simulations validate aircraft designs, systems, and performance – also used for pilot training and flight planning

Credit: Lockheed Martin

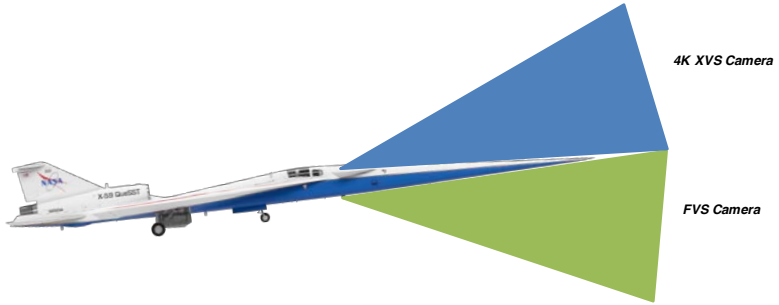
X-59 eXternal Vision System (XVS)

- 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
  - LM Forward Vision System Camera (EVS3600)
  - XVS Processor
  - UHD Display with integrated symbology

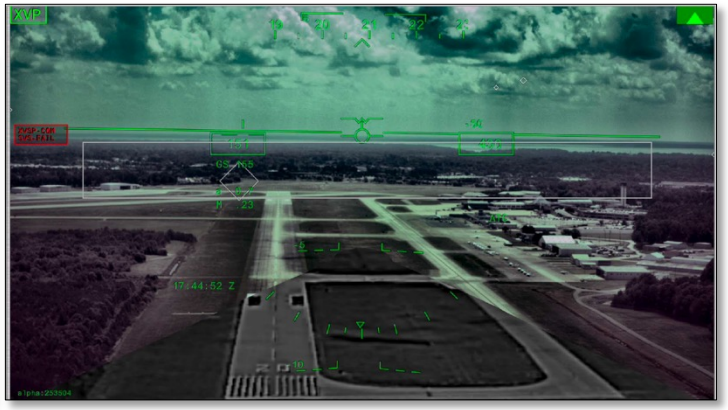
- System performance verified in flight test
  - X-59 hardware installed on NASA UC-12 aircraft
  - Several guest pilots compared normal vision and XVS on see-to-avoid and see-to-follow tasks

- Final component qualification, installation, and ground checkout in the X-59 aircraft completed



Concept Views of X-59 Cockpit

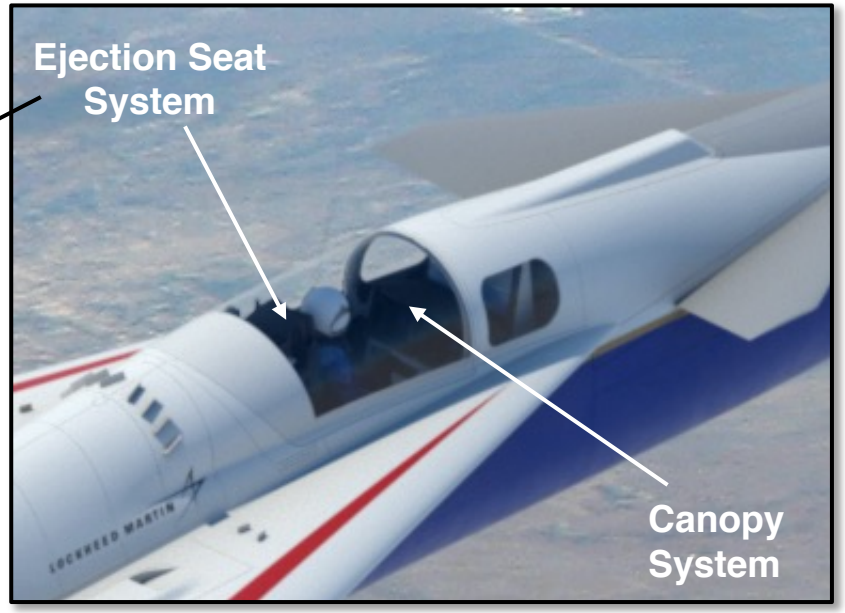
Flight Test Setup



XVS Image During Flight Test

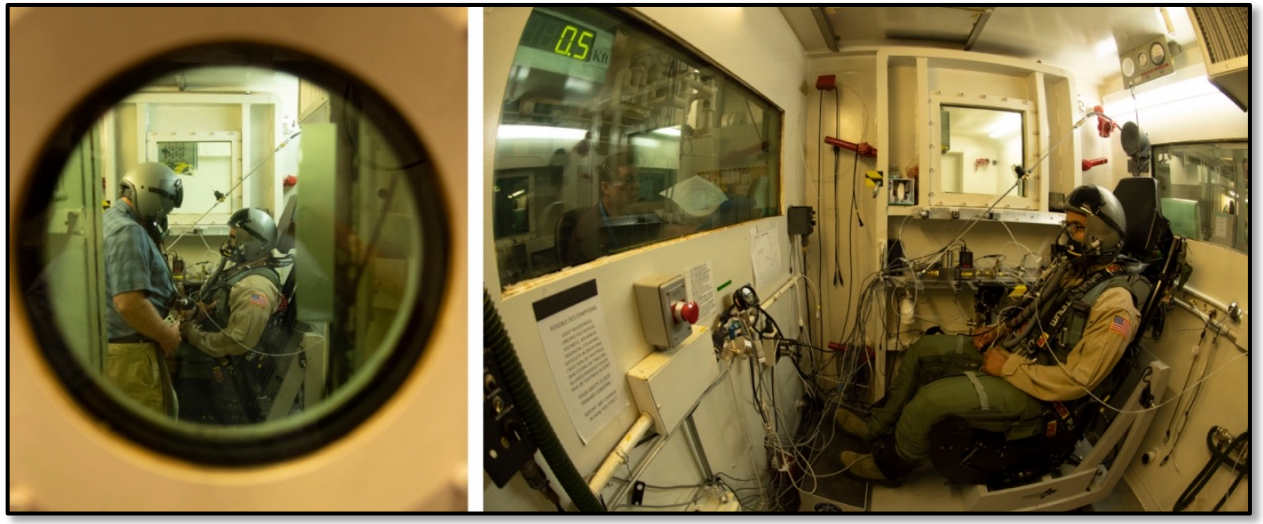
X-59 Life Support and Crew Escape Systems


Credit: Martin Baker



NASA has worked with hardware vendors to ensure pilot safety by providing the hardware, checkout, and certification of the X-59 aircraft life support and crew escape systems

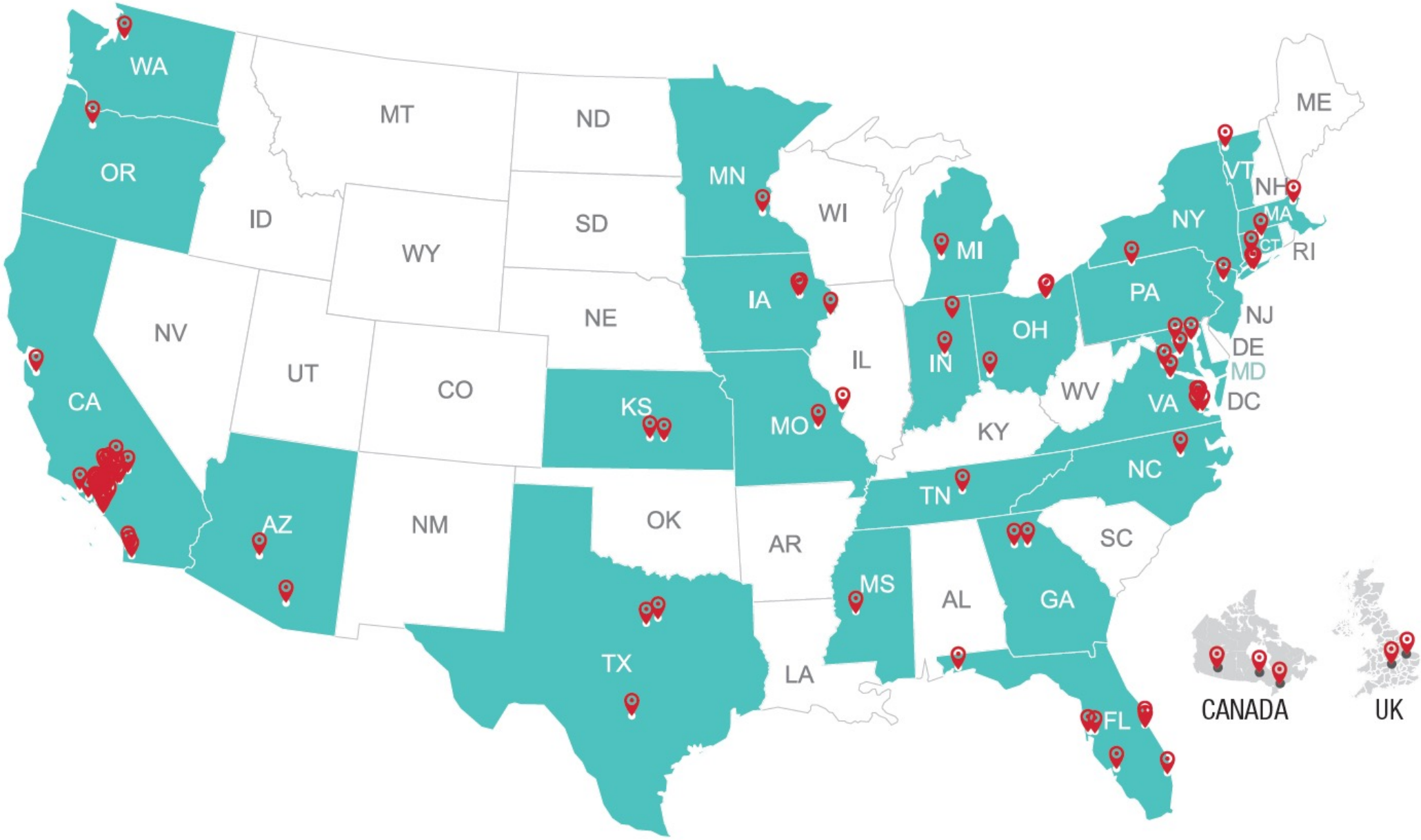
The Crew Escape System (CES) provides the pilot with an integrated ejection seat and canopy systems to ensure pilot safety during normal and emergency flight and ground scenarios.


Hypobaric Chamber Testing

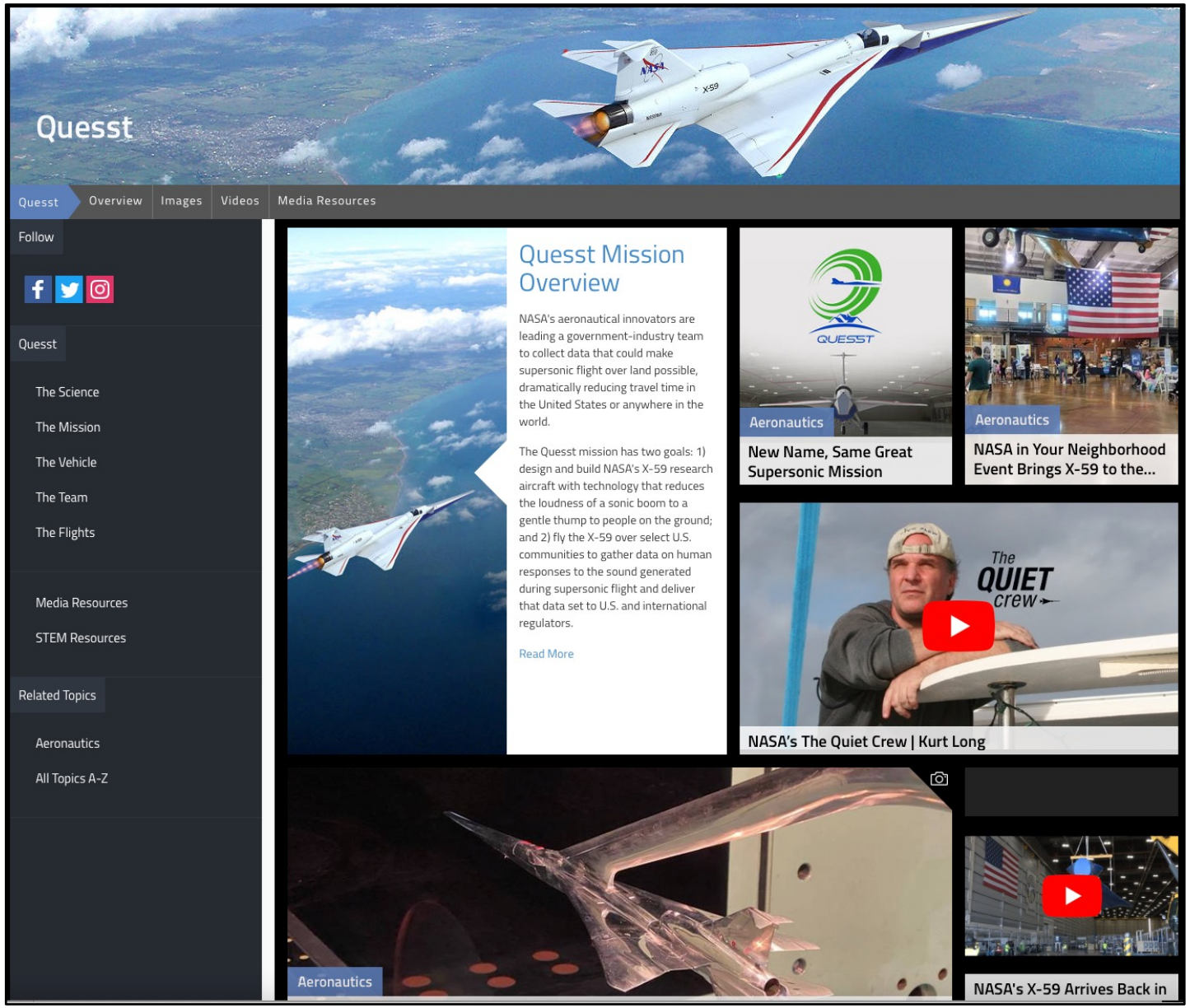
Credit: KBR

The Life Support System (LSS) provides the pilot with breathing oxygen at the right pressure, flowrate, and concentration to maintain the pilot's well-being in any scenario, from normal flight missions to in-flight emergencies. Key components of this system were tested in a hypobaric chamber to simulate reduced pressure conditions that the pilots could experience at the higher altitudes.

Companies Contributing to the X-59



Quesst Mission Web Page and STEM Engagement



https://www.nasa.gov/X59


QUESST
Any Questions?


QUESST