Status and Plans for NASA's Quiet SuperSonic Technology (QueSST) Aircraft

David Richwine

NASA Aeronautics Research Mission Directorate

Overcome the sonic boom barrier and open the door for the development of a new generation of environment-friendly supersonic civil transport aircraft

AIAA Aviation Conference
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Washington, DC

Credit: Lockheed Martin Corporation

Outline

- Introduction
- Market
- Technology Readiness
- Sonic Boom
- Background
- Goals
- Concept of Operations
- Mission Requirements
- Other Requirements
- Collaboration Opportunities
- Summary

Introduction - QueSST

Overcome the sonic boom barrier and open the door for development of a new generation of environment-friendly supersonic civil transport aircraft

Credit: Lockheed Martin Corporation

Overall Requirement

- Demonstrate that noise from sonic booms can be reduced to a level acceptable to the population residing under future supersonic flight paths.
- Create a community response database that supports an International effort to develop a noise based rule for supersonic overflight

Approach

- Partner with regulatory agencies and communities to create a roadmap for community response study and rule development
- Revitalize the excitement of manned X-Planes using a focused and cost-effective approach to design and operate a low boom research aircraft
- Partner with industry and government agencies to formulate, obtain approval, and execute QueSST

Market Growth & Economic Benefit

- QueSST will pave the way for the development of a noise design standard for overland flight and new generations of supersonic civil aircraft.
- Initial market is supersonic business jets (350+ aircraft) followed by supersonic commercial transports as technology matures. Supersonic civil aircraft market could grow to over 1000 aircraft
- Economic benefit from manufacturing and employment alone is substantial. The additional economic benefit to business and leisure passengers is difficult to quantify, but would also be substantial on a global scale.

Credit: Gulfstream Aerospace Corporation
Ref. AIAA 2003-2555

Credit: The Boeing Company

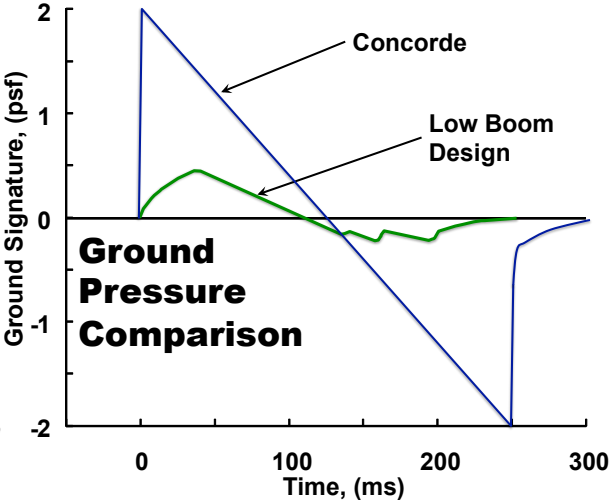
Technology is Ready for Flight Demonstration

Recent NASA-led research has capitalized on 40+ years of investment to produce breakthroughs in boom noise reduction

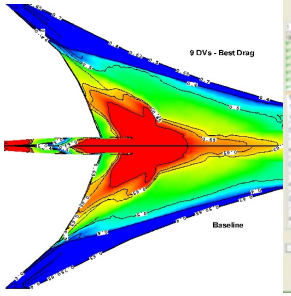
Field studies show the potential for acceptable low boom noise

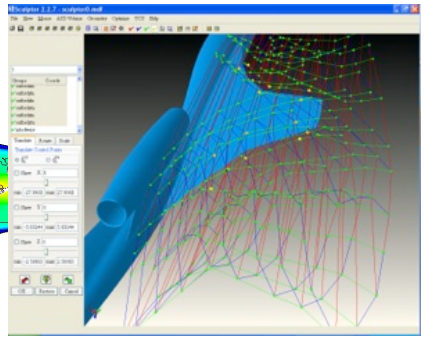
Low-Boom Flight Simulation using F-18 Dive Maneuver

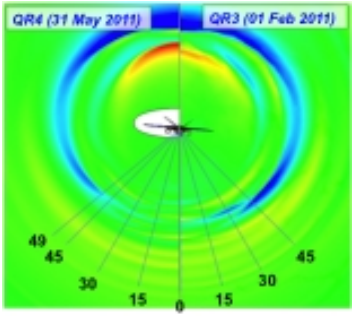
Sonic Boom Acceptability Studies using Ground Simulators and in the Field



New advances in modeling tools allow us to design new low-boom configurations

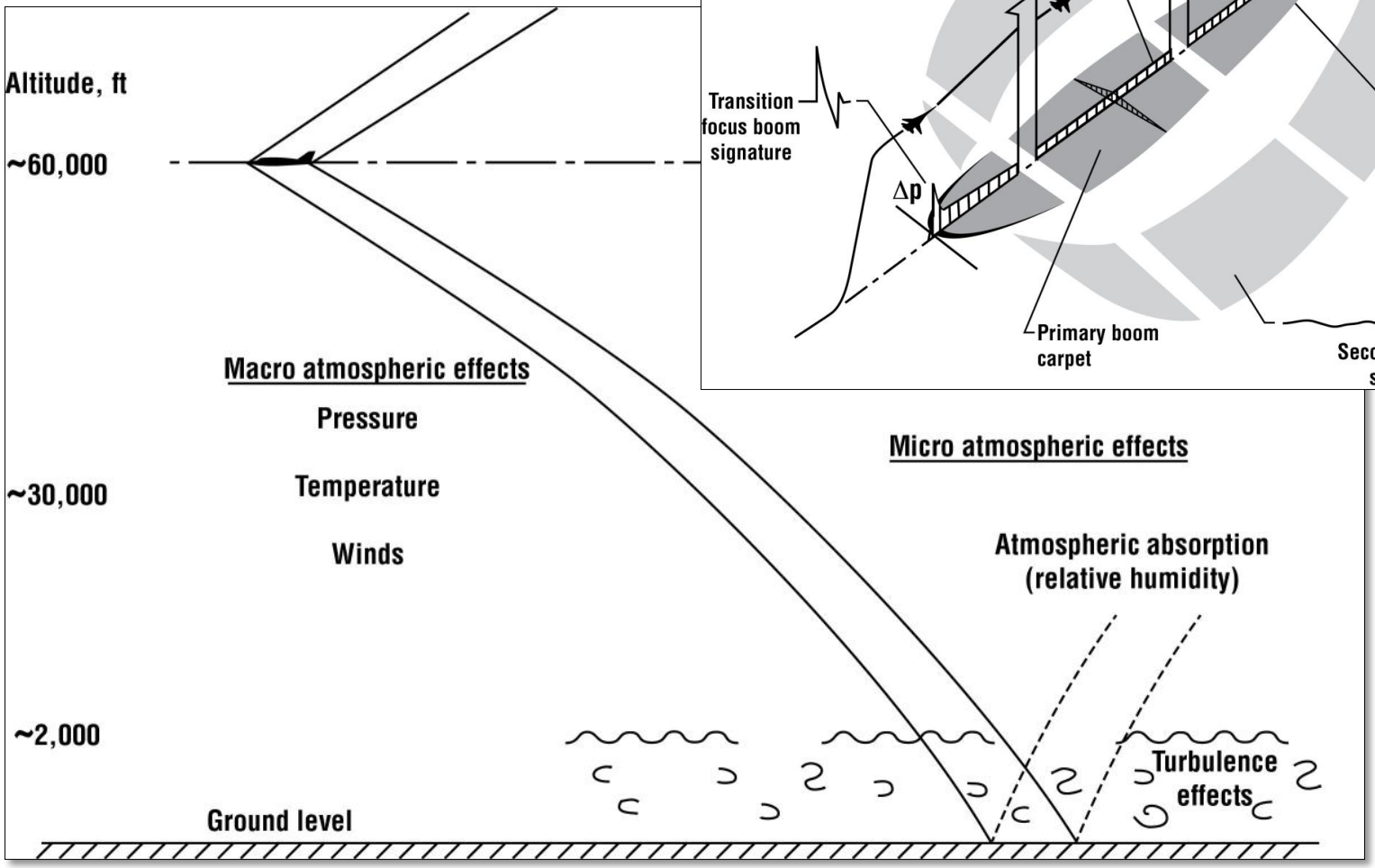


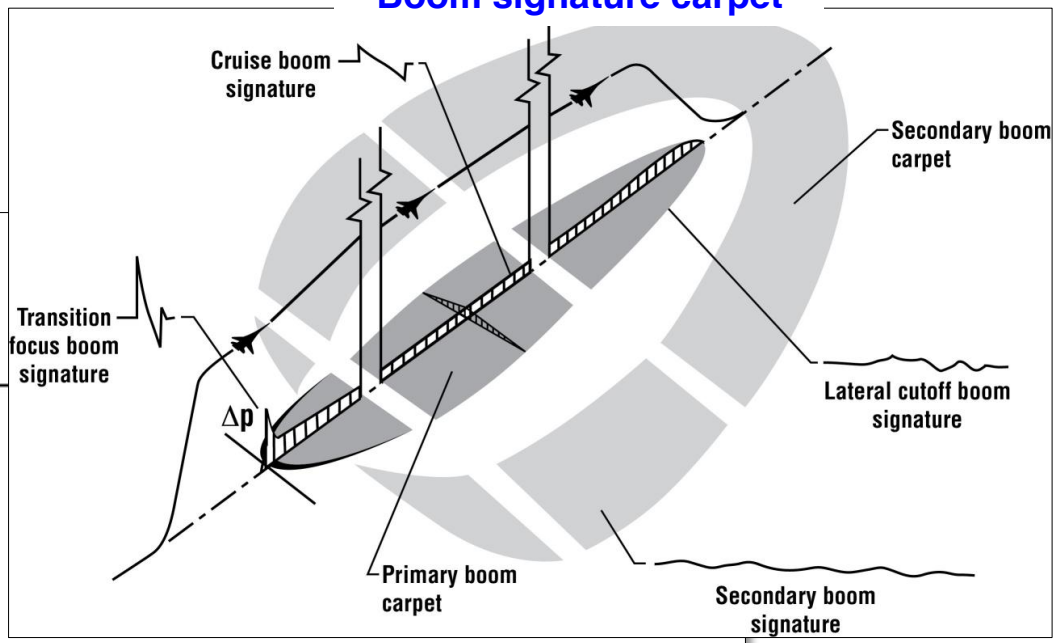




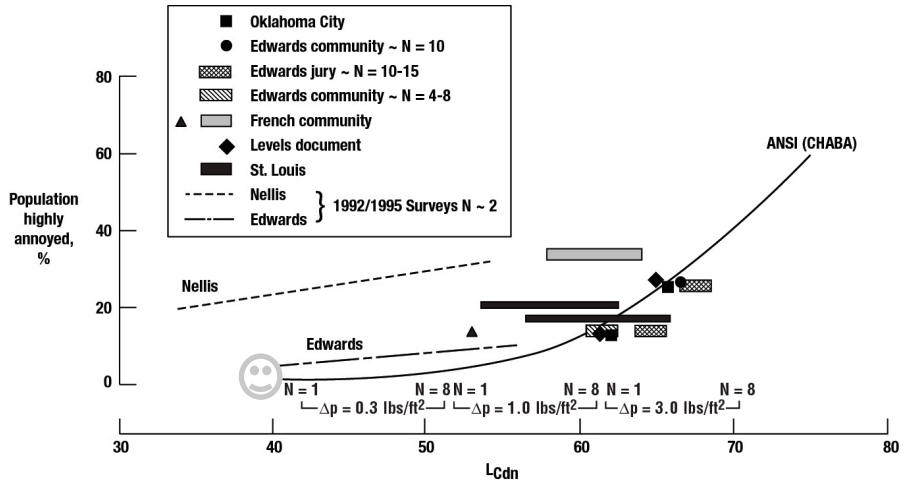
Extensive wind tunnel tests indicate that these new designs show the low-boom characteristics that we predict

Sonic Boom 101

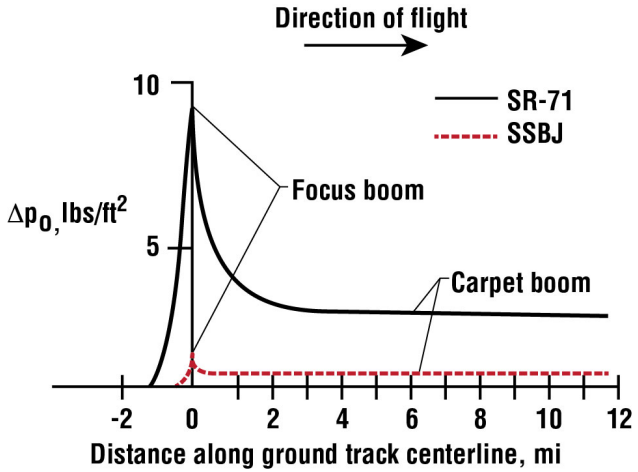




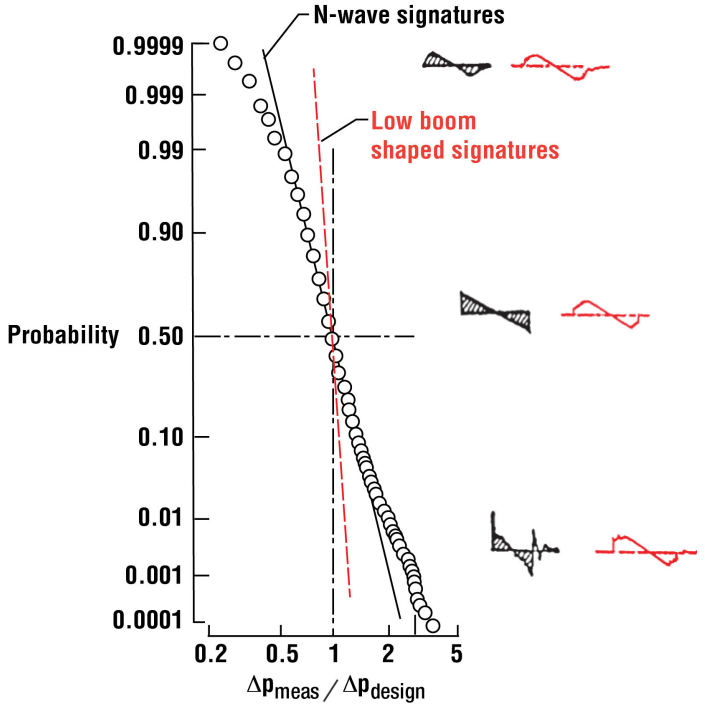
Commercial Supersonic Overland Flight
Top Concerns



Establish community acceptance to cruise booms

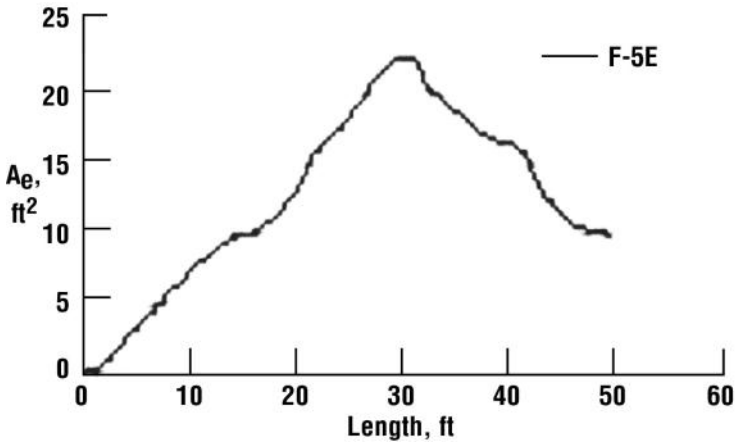


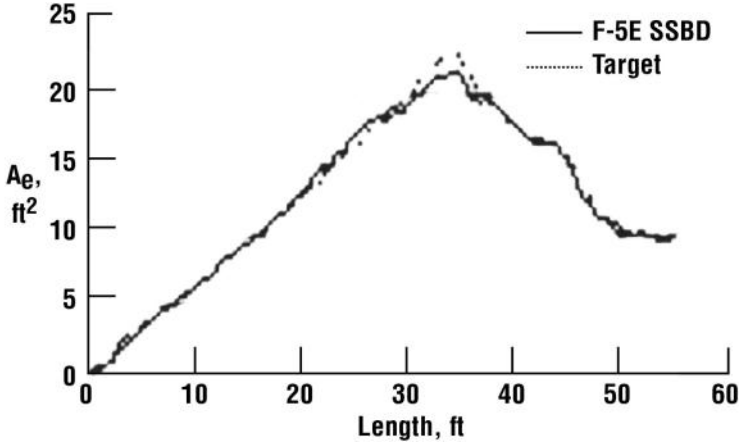
Minimize the transition focus boom region



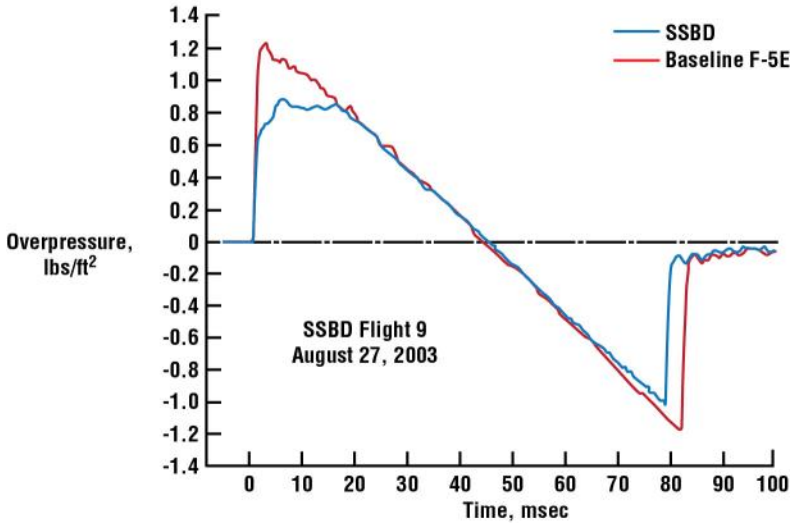
Understand the signature distortion due to atmospheric effects

Shaped Sonic Boom Demonstration (SSBD)





First measurement of shaped sonic boom



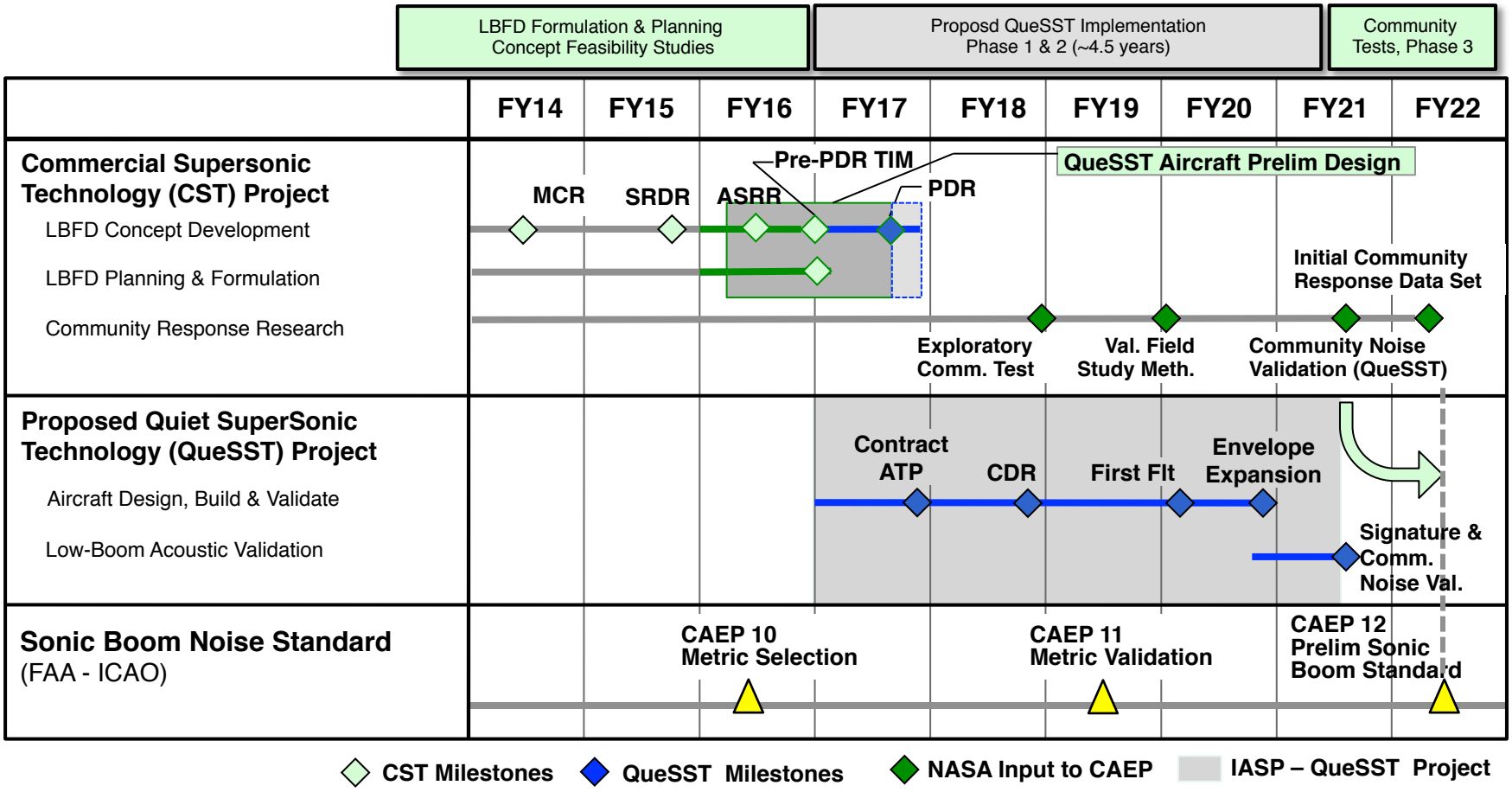
SSBD (2003) - First flight demonstration of a shaped sonic boom!

Background Information

- In recent years, NASA has conducted various supersonic design and feasibility studies ranging from demonstrator to full-scale commercial aircraft
- Low-Boom Flight Demonstration (LBFD) Concept Formulation Studies - 2013 – 2014
- LBFD Concept Refinement Studies - 6/2014 – 10/2015
  - Refined/mature concepts/designs by both the Lockheed Martin and Boeing teams that met NASA's overall mission and airworthiness requirements
- QueSST proposed as part of NASA's New Aviation Horizons (NAH) Initiative
- LBFD/QueSST Preliminary Design task order awarded to Lockheed Martin on 2/29/2016
- Kickoff Meeting - 03/15/2016
- Aircraft System Requirements Review (ASRR) – 6/1/2016

Credit: Lockheed Martin Corporation

Overview of Proposed Schedule



CAEP – Committee on Aviation and Environmental Protection
ICAO – International Civil Aviation Organization
ATP – Authority to Proceed
SRDR – Systems Requirement and Definition Review
ASRR – Aircraft Systems Requirement Review

Proposed QueSST Goals

NASA ARMD Strategic Implementation Plan – Strategic Thrust 2

"Industry Innovation in Commercial Supersonic Aircraft"

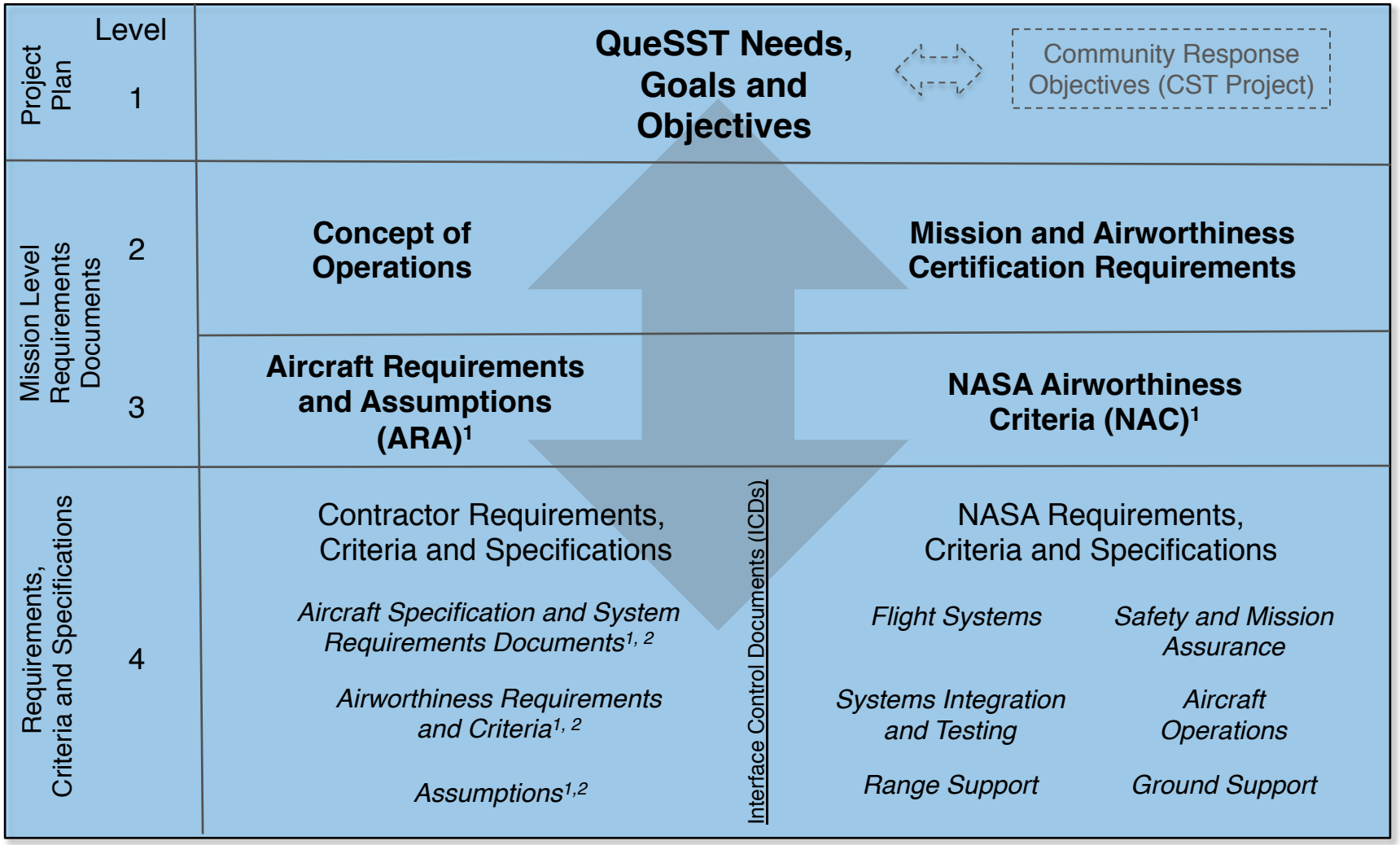
Outcome (2015–2025) – Supersonic Overland Sonic Boom Standard and Analysis Tools Based on Sound Scientific Data.

Overcome the barriers to low-noise sonic boom aircraft development and the prohibition against commercial supersonic overland flight.

- **Commercial Supersonic Technology (CST) Project Goal (for the QueSST aircraft)**
  - ***CST-Goal 1 –*** Generate a low-noise sonic boom database, including community response, which will support the ICAO/CAEP development of a certification standard for commercial supersonic overland flight.

- **QueSST Project Goals**
  - ***QueSST-Goal 1 –*** Design and build an QueSST aircraft with low-noise sonic boom signature characteristics acceptable to communities and traceable to future civil supersonic airliners.
  - ***QueSST-Goal 2 –*** Acquire sonic boom signature data that will validate low-noise sonic boom design theory and improve the understanding and prediction of atmospheric effects on low-noise sonic boom signatures.
  - ***QueSST-Goal 3 –*** Demonstrate that the QueSST aircraft will produce a predictable range of low-noise sonic boom signatures appropriate for community response testing.

Top-Level Requirements Flow



[1]Mutually agreed upon and consolidated during technical meetings (PDR, CDR, …)

[2]Contractor controlled documents with NASA review/approval

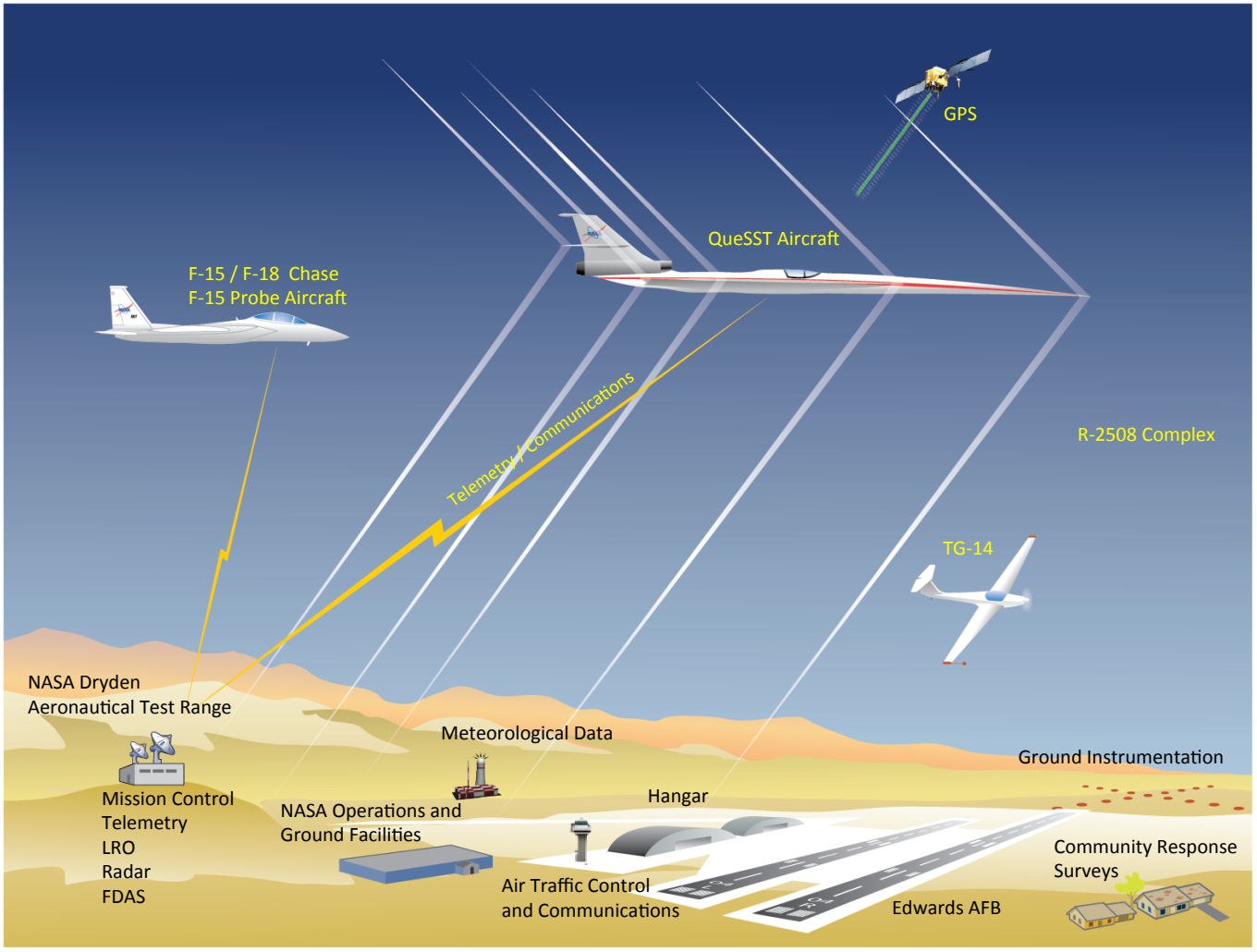
Overall Concept of Operations

Proposed QueSST Project Phases

Phase 1
Aircraft Development
- Detailed Design
- Fabrication, Integration, Ground Test
- Checkout Flights
- Subsonic then Supersonic Envelope Expansion

Phase 2
Acoustic Validation
- Near- and Far-field Measurements
- Ground Measurements
- Initial community response overflight study

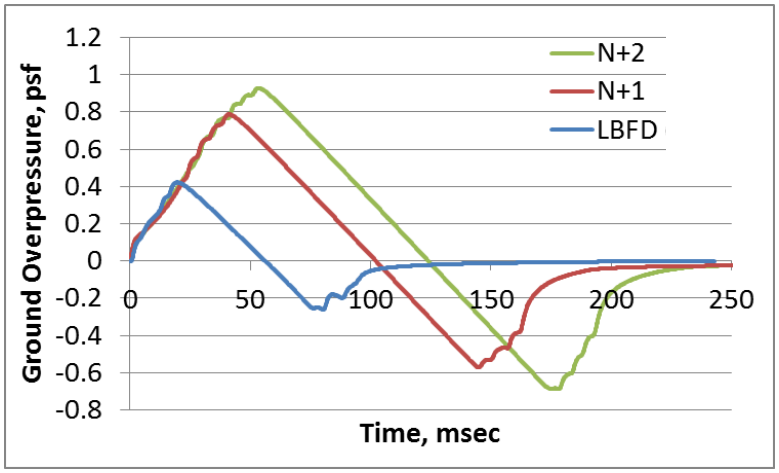
Phase 3
Community Response
- Multiple campaigns (4 to 6) over representative communities and weather across the U.S.



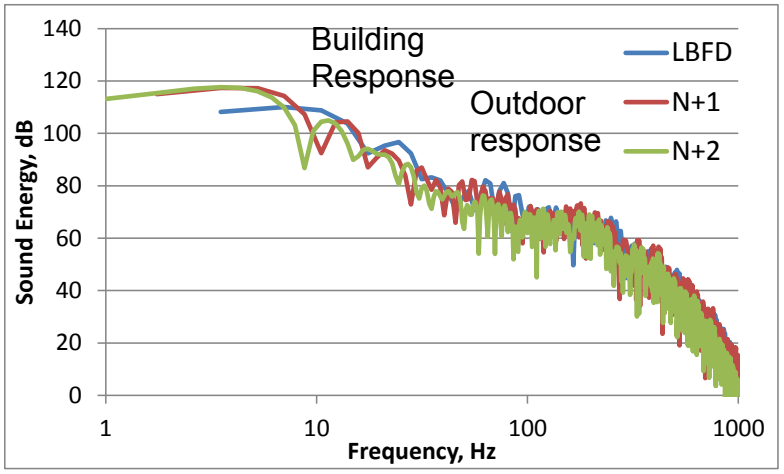
QueSST - Top-Level Mission Requirements

Req. No.	Req. Title	Mission Requirement
MR-1	Boom Traceability	Predicted sonic boom ground signature pressure time history and calculated loudness level (Perceived Level (PL), dB) shall be traceable to a civil (N+2 class) supersonic airliner.
MR-2	Shaped Signature	Fully shaped shaped sonic boom ground signature at design cruise conditions with a predicted maximum calculated loudness level of less than or equal to 75 PLdB and maximum acoustic energy at or below 10 Hz
MR-3	Boom Variability	Variations in the predicted ground carpet signature between 70 - 80 PLdB. Ground carpet signatures less than 75 PLdB may be achieved through a combination of aircraft design or flight procedures.
MR-4	Cruise Deviations	Predicted sonic boom ground signature shall not exceed a mean value of 76 PLdB and not vary more than 1.4 PLdB RMS due to predicted aircraft state deviations due to random atmospheric turbulence

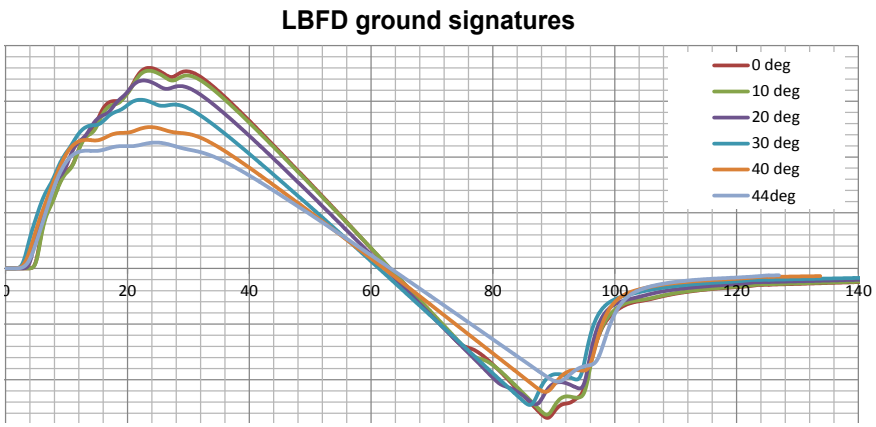
Sonic Boom Requirements

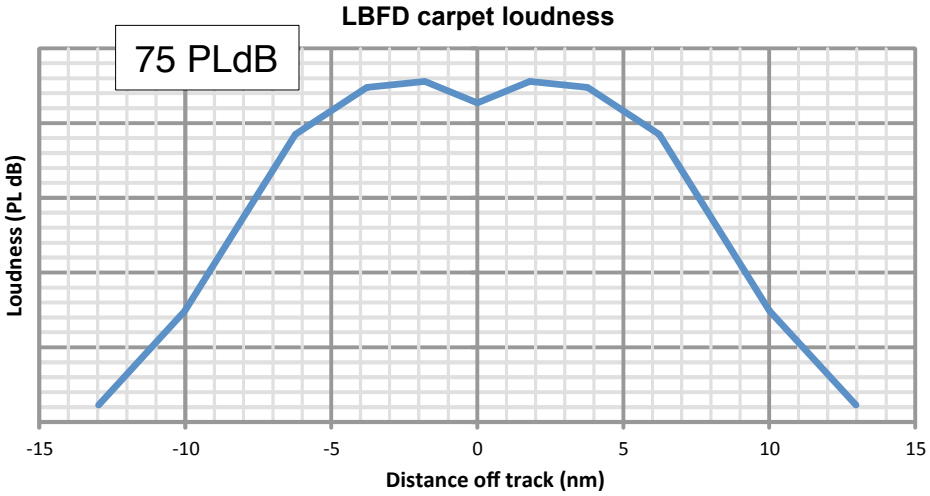


Shaped signature



Boom traceability





Boom variability / ground carpet

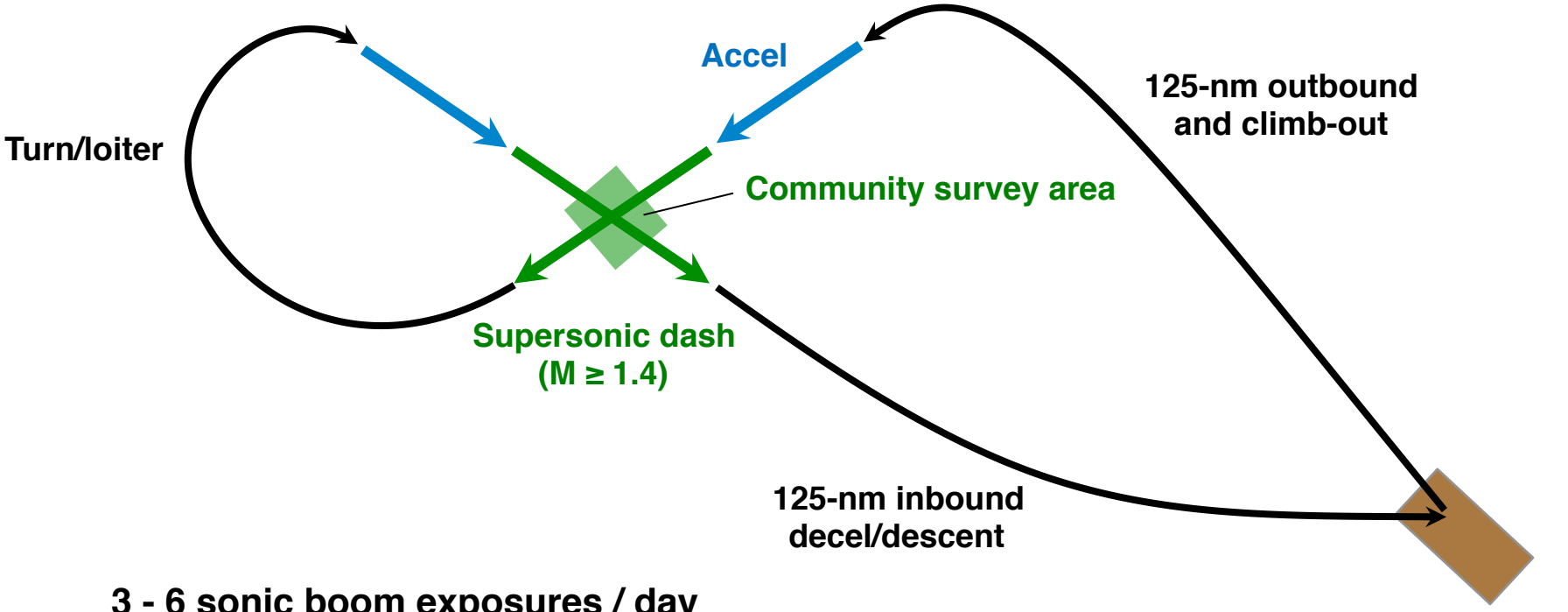
Credit: Lockheed Martin Corporation
Ref: AIAA Aviation 2014 Conference

QueSST - Top-Level Mission Requirements

Req. No.	Req. Title	Mission Requirement
MR-5	Mach Number	Cruise Mach number shall be Mach ≥ 1.4.
MR-6	Pass Length	Minimum of two supersonic cruise passes of at least 50 nm in length over a single community area during a single flight.
MR-7	Flight Rate	Minimum of three flight operations over a 9-hour time span.
MR-8	Day/Night Operations	Day and night flight operations in the public airspace.
MR-9	Flight Operations	Flight operations using Visual (VFR) and Instrument (IFR) Flight Rules with the ability to safely transit through Instrument Meteorological Conditions (IMC).
MR-10	Forward Visibility	DELETED
MR-11	Climb Rate	Sufficient thrust to concurrently accelerate and climb during the baseline mission profile supersonic acceleration/climb.

Phase 3 - Flight Operation Considerations

Baseline Mission – Figure 8



3 - 6 sonic boom exposures / day
Several weeks / test campaign
Several representative communities / year

Other Key Requirements

Other Key Requirements and Factors
Airworthiness Certification (flight safety)
Cost
Schedule
Risk
Maintenance and Operations

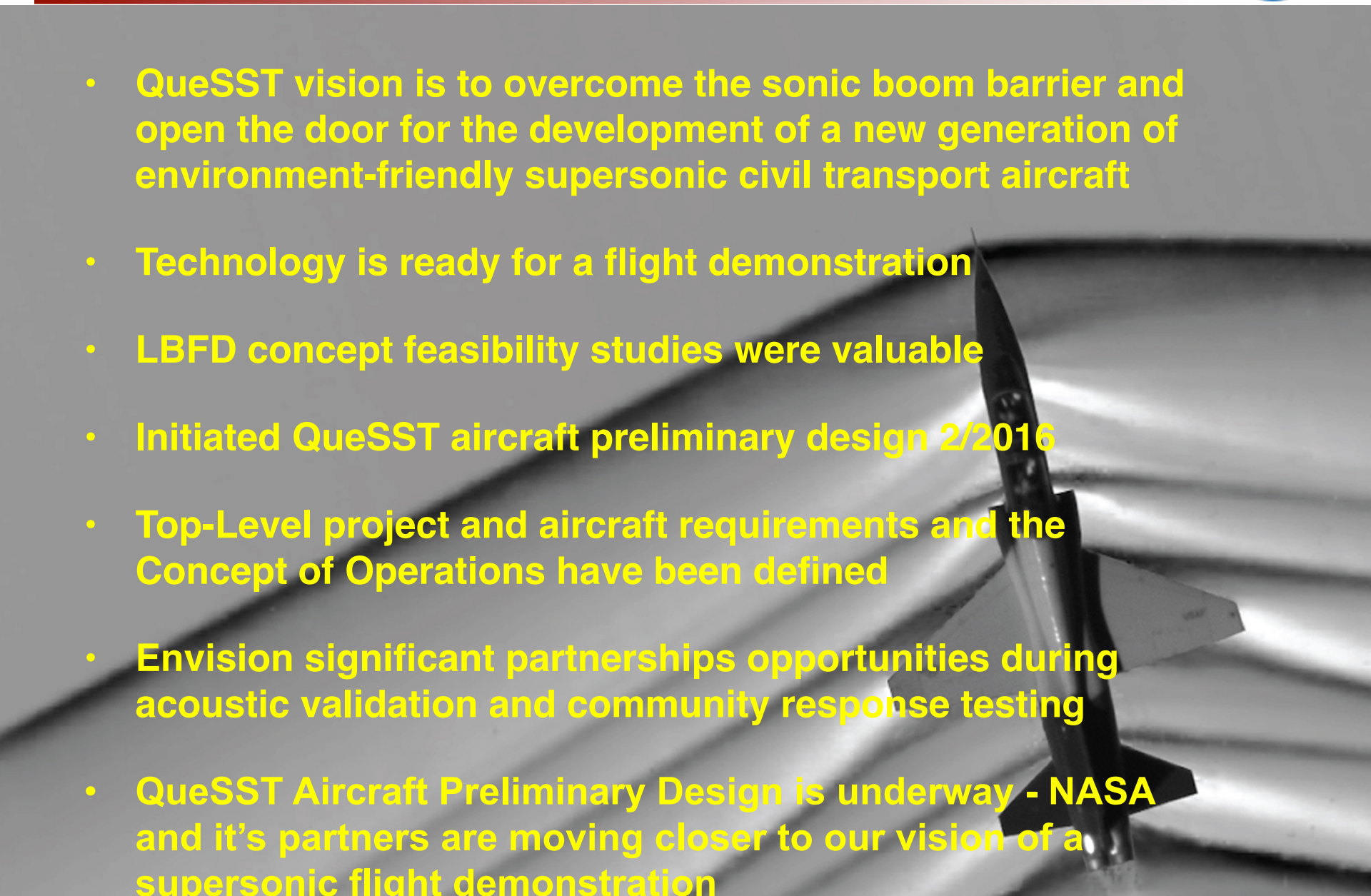
Leverage NASA's capabilities, facilities, hardware, and airworthiness certification process whenever cost-effective and feasible

Collaboration Opportunities

- NASA's overarching goal is to obtain the data required to impact regulatory change

- Envision significant NASA partnerships with industry, academia, and international partners during acoustic validation and community response testing
  - Turbulence effects and modeling
  - Ground and atmospheric measurements
  - Development of test protocols and procedures
  - Community response testing
  - Mach cut-off acoustics

Summary



- QueSST vision is to overcome the sonic boom barrier and open the door for the development of a new generation of environment-friendly supersonic civil transport aircraft
- Technology is ready for a flight demonstration
- LBFD concept feasibility studies were valuable
- Initiated QueSST aircraft preliminary design 2/2016
- Top-Level project and aircraft requirements and the Concept of Operations have been defined
- Envision significant partnerships opportunities during acoustic validation and community response testing
- QueSST Aircraft Preliminary Design is underway - NASA and it's partners are moving closer to our vision of a supersonic flight demonstration

QueSST Concept