National Aeronautics and Space Administration

Status and Plans for NASA's Low Boom Flight Demonstration

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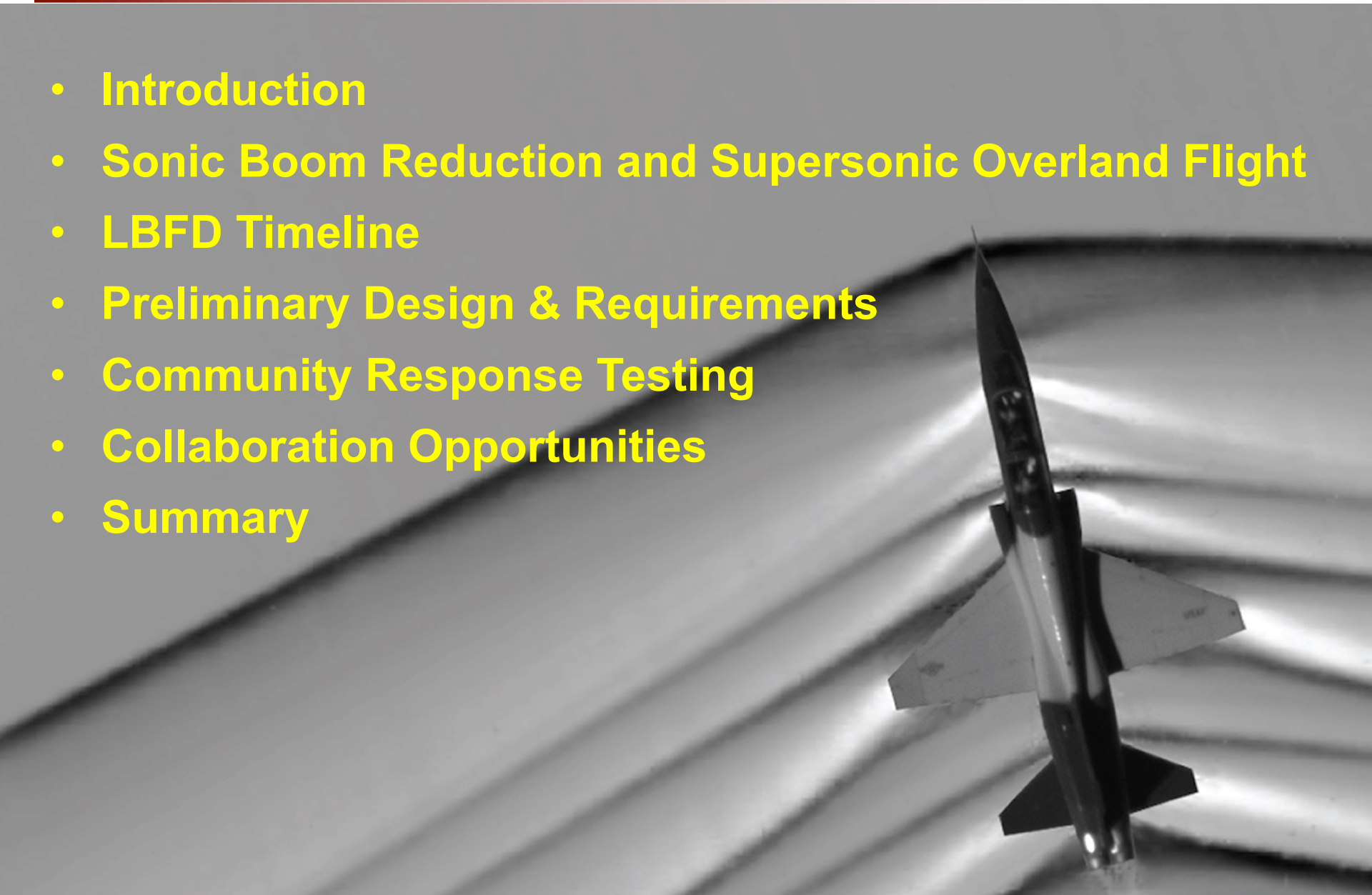
Outline



- Introduction
- Sonic Boom Reduction and Supersonic Overland Flight
- LBFD Timeline
- Preliminary Design & Requirements
- Community Response Testing
- Collaboration Opportunities
- Summary

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 US to support a positive balance of trade

- New supersonic products lead to more high-quality jobs in the US.
  - 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 regulation change that is essential to enabling this new capability.

From Boom to Thump:
The Quiet Supersonic Design Technical Challenge

Objective

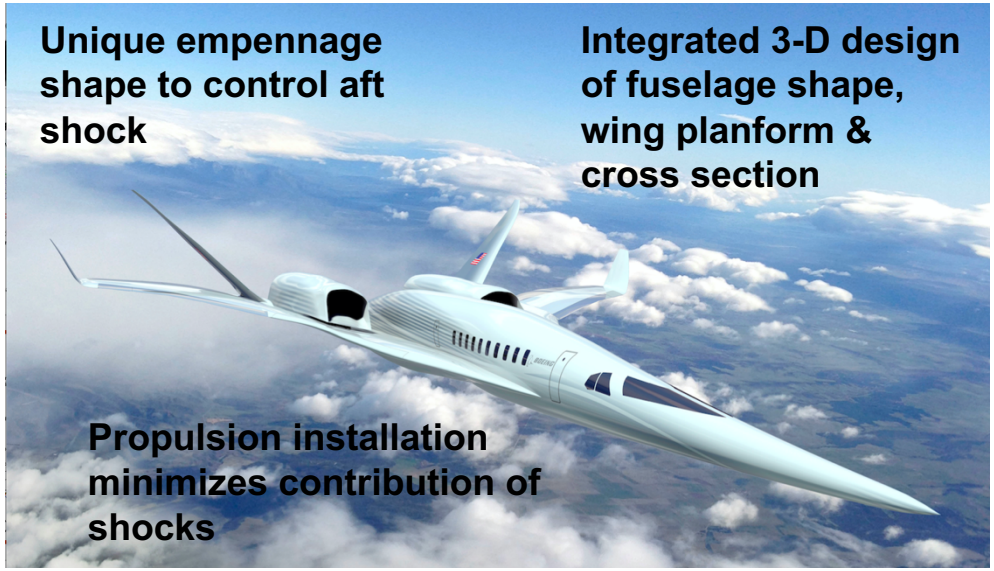
- Develop and validate tools and design approaches to enable the development of supersonic airliners with very little perceived supersonic noise: 60 dbA ~ 35 less than Concorde or typical military aircraft

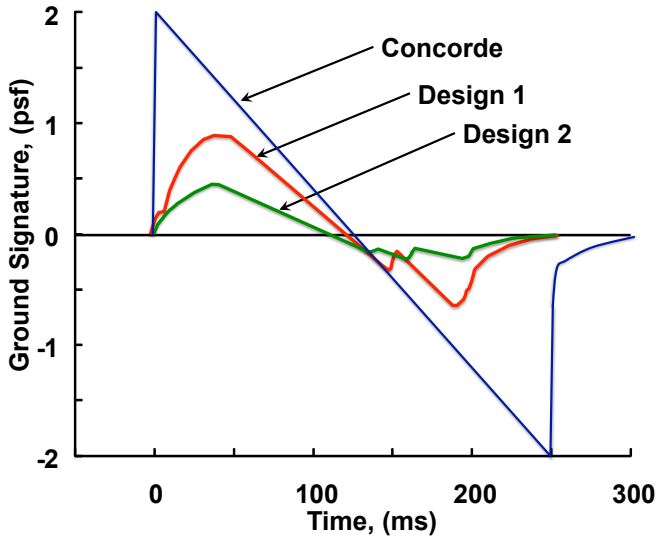
Approach

- Build on 40+ years of research in sonic boom minimization
- Improve usability, accuracy and speed of high fidelity analysis tools for inclusion in the design process
- Develop new near-field & ground signature design targets that produce less noise, and allow more flexibility in the design process
- Conduct validation studies in wind tunnels and in flight

Technical Challenge completed in FY 2015

- Breakthrough technology development validated in wind tunnels, ready for flight demonstration





The Next Step

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

- 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
- Partner with regulatory agencies and communities to create a roadmap for community response study and rule development

LBFD Supports NASA Strategic Thrust in Commercial Supersonic Flight

AERONAUTICS STRATEGIC THRUST

Strategic Thrust 2: Innovation in Commercial Supersonic Aircraft

AERONAUTICS OUTCOME

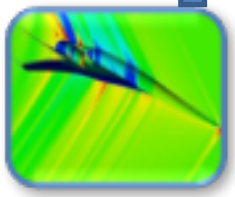
Outcome (2015 – 2025): Supersonic Overland Certification Standard Based on Acceptable Sonic Boom Noise

AERONAUTICS RESEARCH THEMES

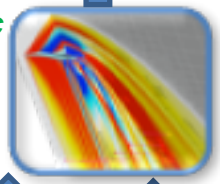
Integrated Design Solutions for Revolutionary High Speed Aircraft
Research and development of validated analysis tools and technologies that enable the low-sonic boom design of supersonic aircraft

Understanding & Measuring Community Response to Sonic Booms
Research, development, application of validated methodologies for a field study of community response to enable development of overland sonic boom standards

Technical Challenges *CST*



Low Sonic Boom Design Tools



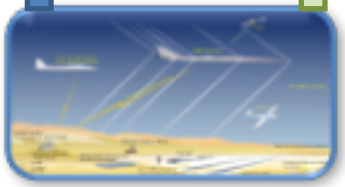
Integrated Low Boom Aircraft Design

Sonic Boom Community Response Metric & Methodologies

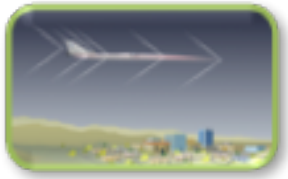
Sonic Boom Community Test Readiness

Goals *LBFD*

Design and build LBFD aircraft with low-noise sonic boom signature characteristics (Phase 1)



Acquire sonic boom signature data



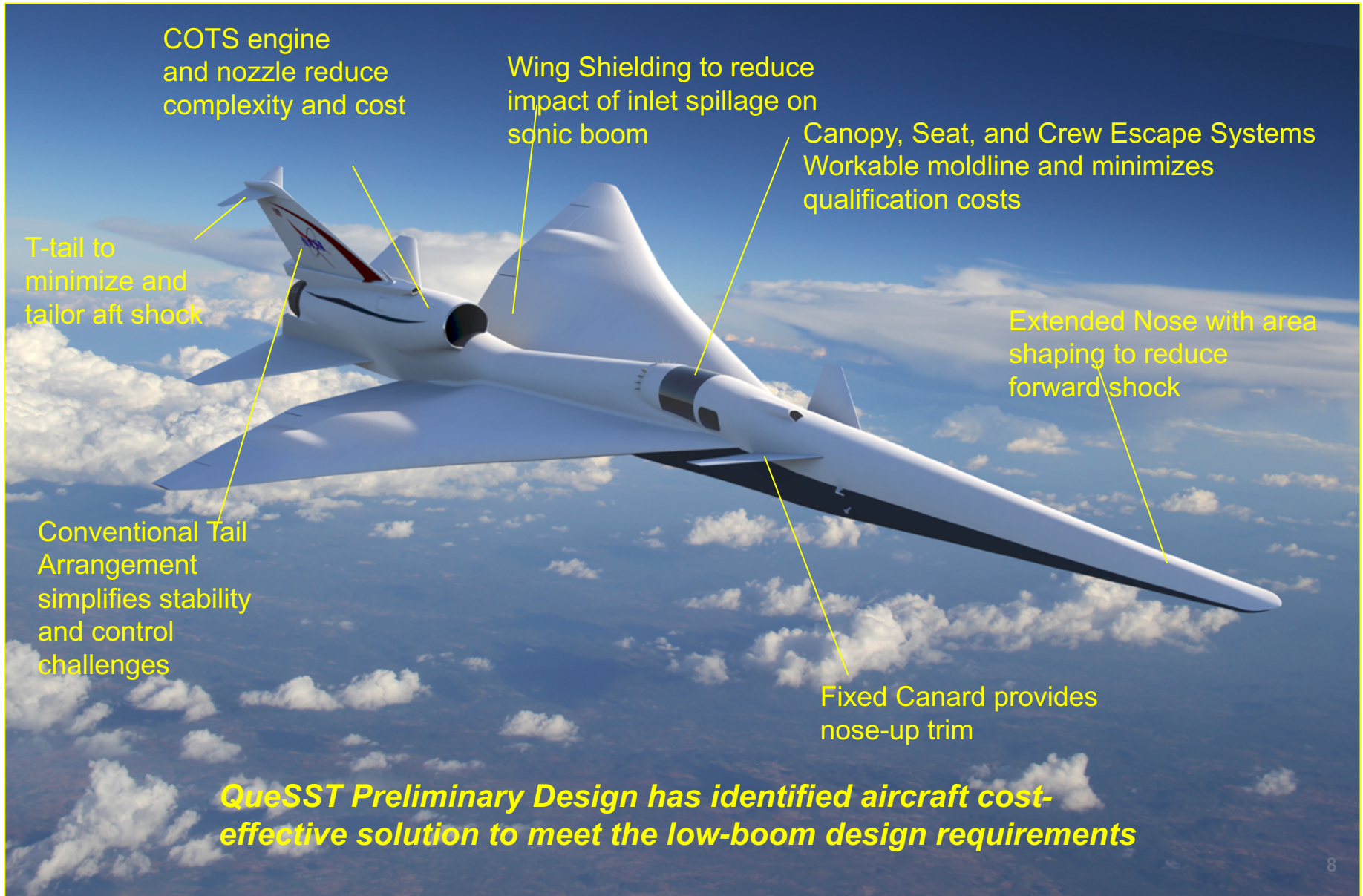
Demonstrate that LBFD aircraft produces predictable range of low-noise sonic boom signatures

LBFD Timeline

2013 - 2014	Concept Exploration Studies
2014 - 2015	Concept Refinement Studies
Feb 2016	QueSST Preliminary Design contract awarded to Lockheed-Martin as part of NASA's New Aviation Horizons Initiative
Jun 2017	Preliminary Design Review
Jun 2017	**LBFD Design/Build/Test Draft RFP released**
Aug 2017	LBFD Design/Build/Test RFP release anticipated
1st qtr CY 18	LBFD Design/Build/Test contract award
3rd qtr CY 19	Critical Design Review
1st qtr CY 21	First flight
4th qtr CY 21	Envelop expansion complete
3rd qtr CY 22	Low boom acoustic signature validation complete
1st qtr CY 23	*Initial community response test (based at NASA AFRC)*
2023 - 2025	*Community response tests in US (remote based)*

Dates in blue test are estimated and dependent on approval and funding
Italic text denotes element of the LBFD project follow on

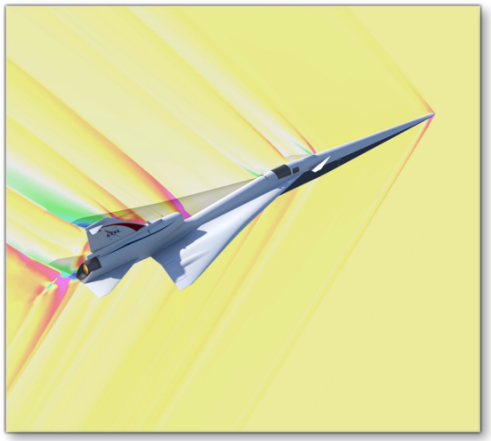
Overview of QueSST Aircraft Design Features

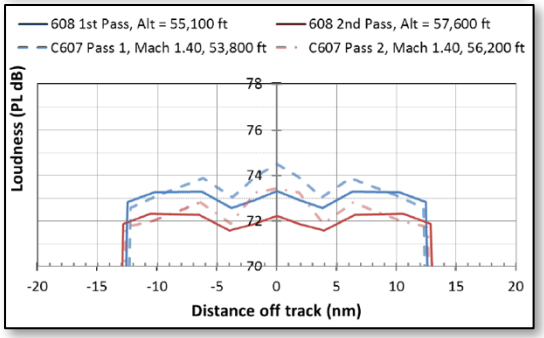


QueSST Preliminary Design has identified aircraft cost-effective solution to meet the low-boom design requirements

QueSST Preliminary Design Elements

REVIEWS / MILESTONES
Aircraft System Requirements Review (ASRR)
Configuration Release A / Trade Studies and Assessments
Pre-PDR Technical Interchange Meeting
NASA Flight System(s) Conceptual Design Reviews, Workshops, Working Groups
Configuration Release B / Trade Studies and Assessments
High-Speed Wind Tunnel Tests in GRC 8x6 (Aero & PAI)
Preliminary Design Review





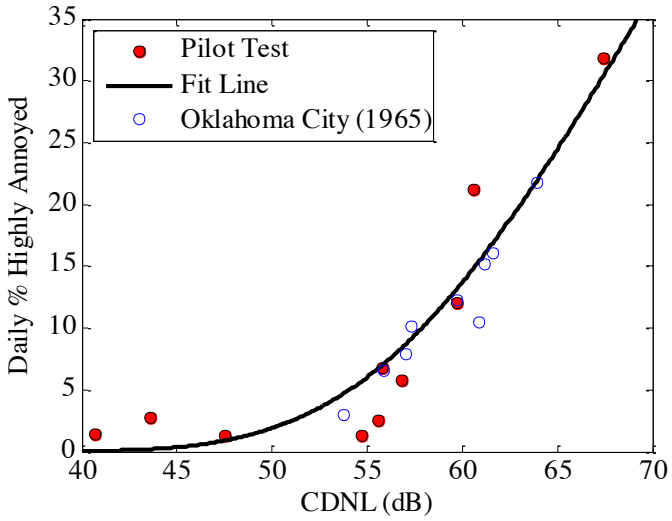
LBFD/QueSST Design Requirements
Linkage to Community Test Requirements

	Sonic Boom Characteristics
1	The QueSST aircraft shall generate a predicted undertrack sonic boom ground signature with **peak acoustic energy occurring at a frequency no greater than 10 Hz**, at design supersonic cruise, with static rigid-body trim conditions.
2	The QueSST aircraft shall generate a fully shaped (forward and aft) sonic boom ground signature, at design supersonic cruise, static rigid-body trim conditions, with a predicted maximum calculated **loudness level of less than or equal to 75 PLdB** throughout the lateral limits (± 40 deg) of the nominal supersonic cruise boom carpet.
3	The QueSST aircraft shall be able to generate repeatable **variations** in the predicted ground carpet signature between **70 - 80 PLdB** within the lateral limits (± 40 deg) of the nominal supersonic cruise boom carpet.
4	The QueSST aircraft predicted undertrack sonic boom ground signature shall **not exceed a mean value of 76 PLdB and not vary more than 1.4 PLdB RMS** about that mean value during a single design supersonic cruise pass due to predicted deviations in the aircraft state and configuration under random atmospheric turbulence at a RMS turbulence amplitude of 1 ft/sec.
	Mission Performance & Operation
6	The QueSST aircraft shall perform a minimum of **two supersonic cruise passes of at least 50 nm** in length, spaced a minimum of **20 minutes apart**, over a single community area during a single flight with standard day environmental conditions.
7	The QueSST aircraft shall perform a minimum of **three flight operations** of the baseline mission, from engine startup to engine shutdown, **over a 9-hour time span**.
8	The QueSST aircraft shall be equipped to perform **day and night flight operations i**n the public airspace.
12	The QueSST aircraft shall perform the baseline mission using QueSST-specific **hot day** environmental conditions for mission performance.

Quiet Supersonic Overflight
Community Test Concepts and Objectives

Objective: Create a robust dose – response relationship for community annoyance vs appropriate noise metric(s)

- Large populations, large number of representative responses.
  - 10k to 100k, depending on survey method employed
  - Varied community settings including representative:
    - Geography and climate
    - Home and building construction
    - Community demographics, etc.



Notional Dose-Response Relationship

- A range of exposure levels will be required, possibly including normal booms
- Up to a maximum of 6-8 of daily exposures
  - Night exposures may be required
- Sufficient test duration to establish effect of repeated exposure
- Account for test aircraft operational limitations
  - Airfield facilities
  - Operations tempo

LBFD Mission Requirements and Community Test Assumptions

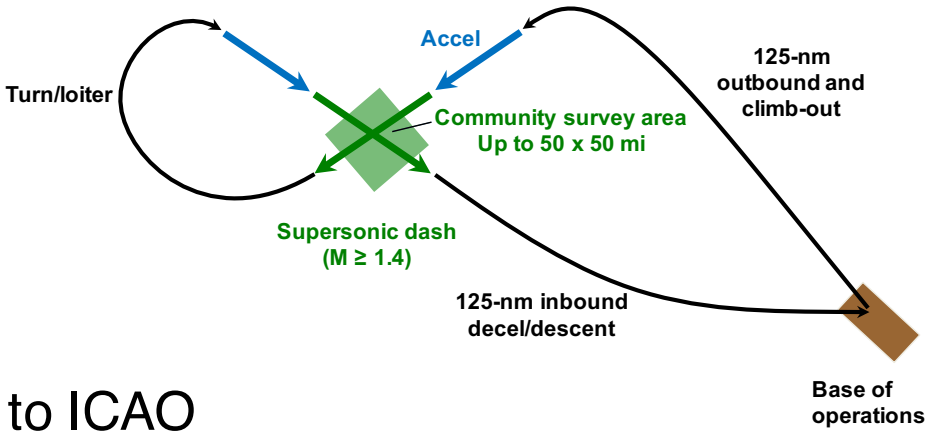
Derived Mission Requirements

No.	Sonic Boom Characteristics	No.	Performance & Operations
1	Ground Signature Traceability	6	Pass length (50 n.mi) and number per flight (2)
2	Ground Signature Loudness	7	Flight rate (3 flights in a 9 hour span)
3	Ground Signature Variability	8	Day/Night operations
4	Cruise Deviations	12	Mission Performance (hot day)

Current Assumptions for Planning

- 1 LBFD Aircraft
- Initial community test from EAFB
  - Primary focus on test techniques
  - Collect valid community response data
- 4-6 Deployed community tests
  - Different geographical locations
- 2 tests per year with yearly reports to ICAO
- Opportunities for validation and procedure development flights between deployments

Proposed Flight Track Option– Figure 8



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
  - Development of test protocols and procedures
  - Ground and atmospheric measurements
  - Development and validation of certification procedures and metrics
  - Community response testing

Summary

- NASA Aeronautics conducts research to enable supersonic flight as a future transportation capability
- Sonic boom reduction technology creates an opportunity to overcome a barrier to supersonic transportation
- NASA is planning the Low Boom Flight Demonstration as the next step in overcoming this barrier
- Preliminary Design is underway
- Detail Design/Built/Test planning and RFP development is in progress
- Community Response Test planning and risk reduction is also in progress
- NASA seeks to engage partners and the community in the next steps of LBFD

Questions?

Forum 360 Events

- **Tuesday 2:00 Supersonic Transport**
- **Friday 9:30 NASA New Aviation Horizons**

Credit: Lockheed Martin Corporation