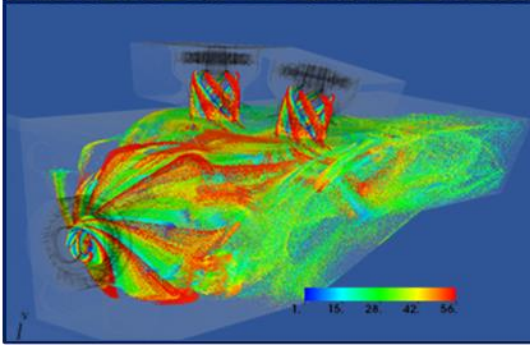
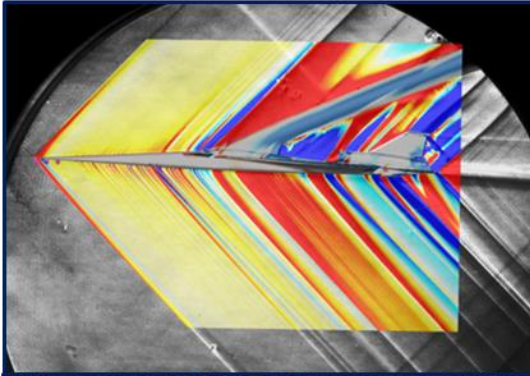


NASA Commercial Supersonic Technology Project Overview and Quesst Mission Updates



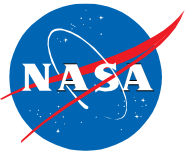
Acoustics Technical Working Group
March 18, 2025



Lori P Ozoroski
Manager, Commercial Supersonic Technology Project
NASA Langley Research Center

Illustration Credit: Lockheed Martin

Commercial Supersonic Technology Project



The Commercial Supersonics Technology Project is the leader for tools and technologies to help achieve practical, affordable commercial supersonic air transport

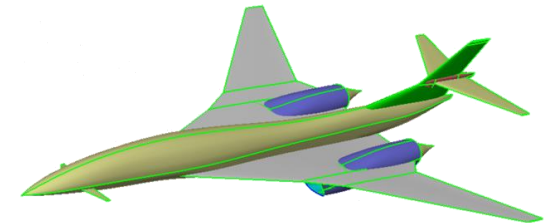
Near-term focus is on overcoming the technical and regulatory barriers to quiet supersonic flight over land

Critical Commitment: Deliver data describing community response to sounds from quiet supersonic aircraft to enable ICAO development of an international standard for acceptable sound levels from supersonic flight over land.

CST is assessing and developing tools and technologies that enable a nearer-term market leader commercial supersonic aircraft in addition to increasingly capable follower aircraft



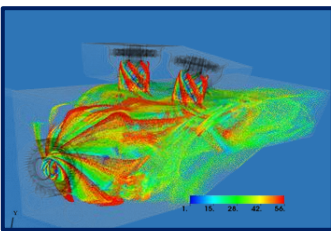
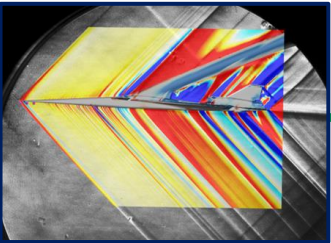
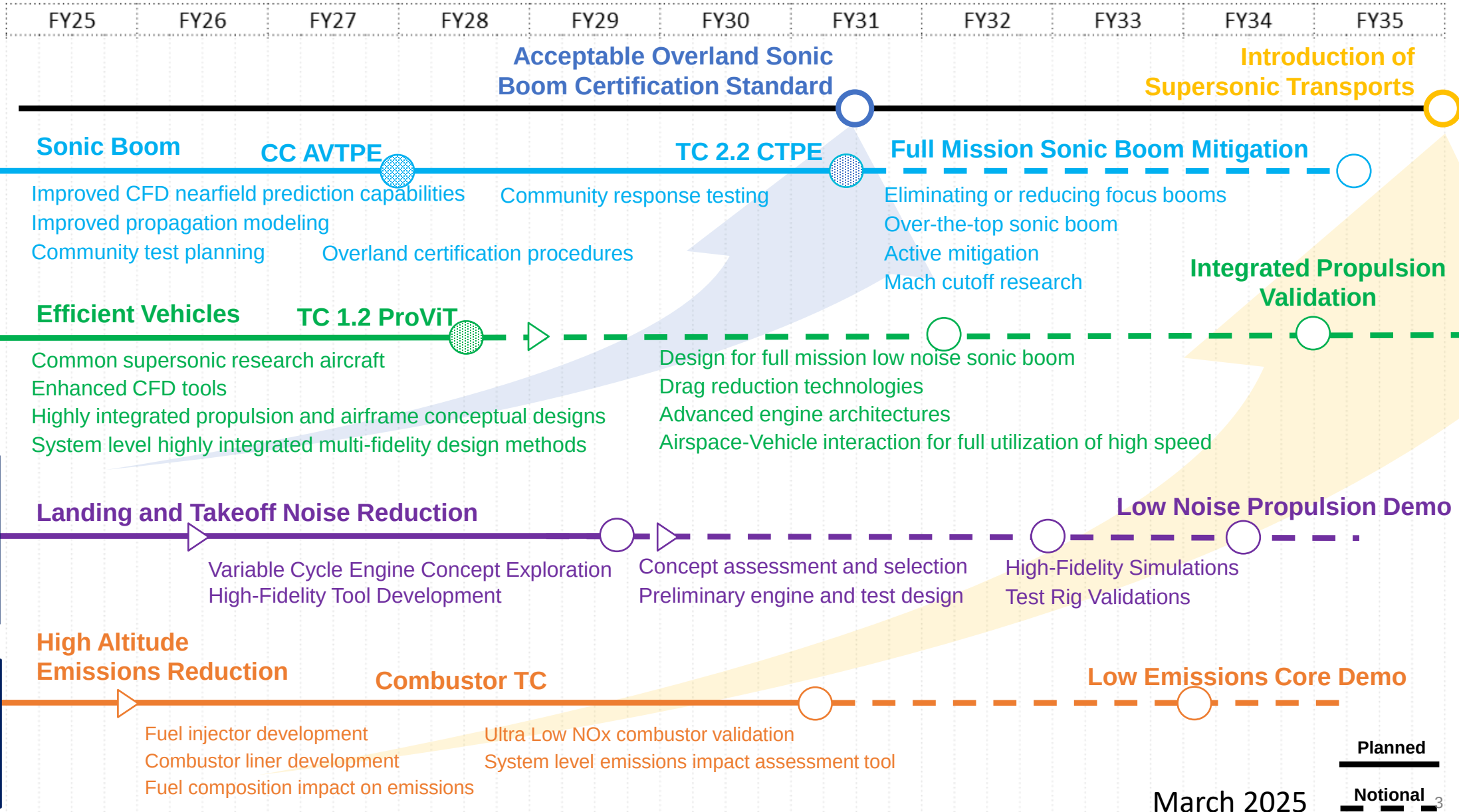
Acoustic Validation &
Community Response Testing



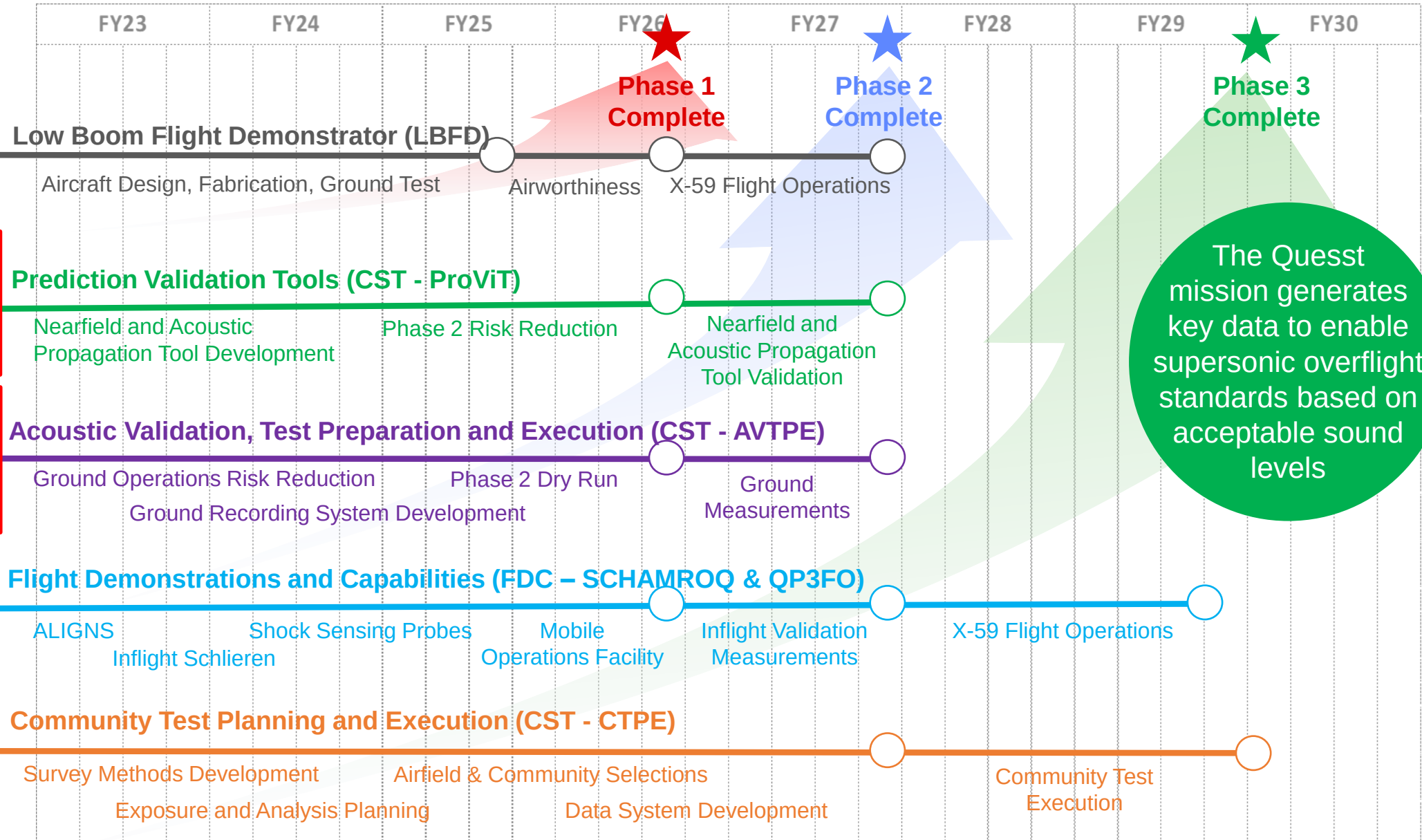
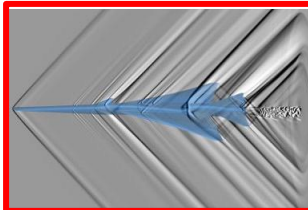
Future concept driven
technology development

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

Commercial Supersonics: Integrated Research Plan



Quesst Mission Phases



The Quesst mission generates key data to enable supersonic overflight standards based on acceptable sound levels

X-59 Development Status

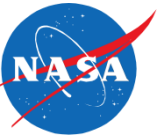


Photo Credit: Lockheed Martin

First flight planned for 2025

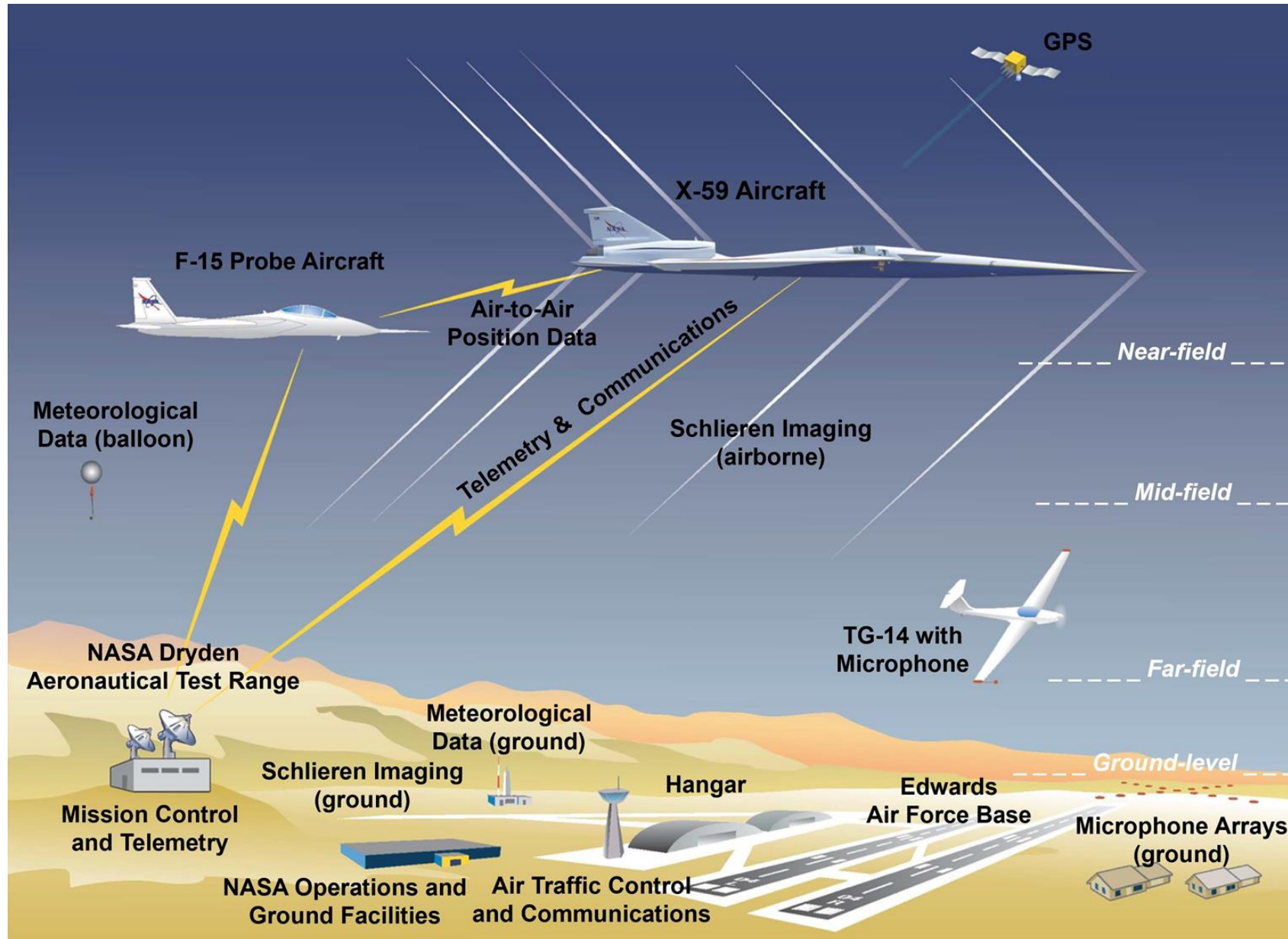
Rollout 2024

Engine Testing 2025



Photo Credit: Lockheed Martin

Quesst Phase 2 Concept of Operations



Phase 2 Risk Reduction Testing



Carpet Determination In Entirety Measurement (CarpetDIEM) III was the third in a series of risk reduction efforts aimed at preparing the team for Dry Run and Phase 2 ground & flight operations

Scope and Objectives

Primary: Develop and test stakeholder coordination, logistics, and operations plans for large-scale, long-term sensor deployment at the Quesst Phase 2 sonic boom measurement test site

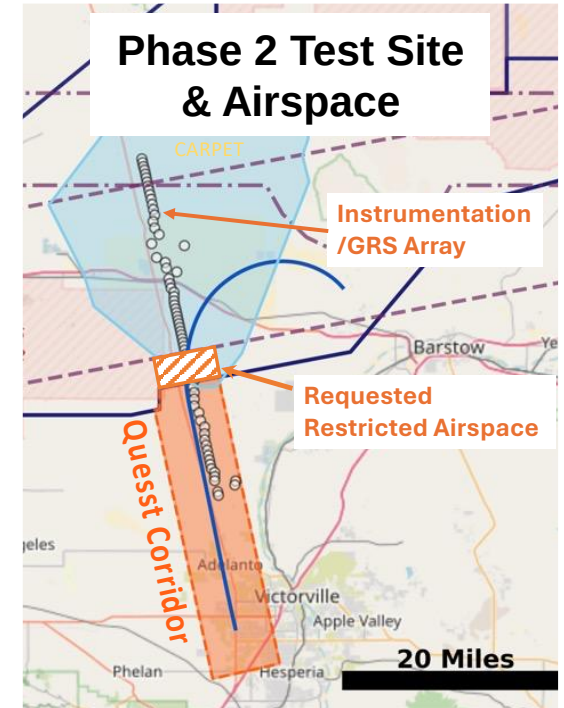
- 30 nmi sensor array with over 100 discreet instrumentation locations
- Specialized supersonic airspace for X-59 operations (“Quesst Corridor”)

Secondary: Evaluate new state-of-the-art ground recording system (GRS)

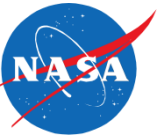
- GRS capabilities include remote triggering, extended deployment, ruggedization, and high-quality low-boom (thump) measurements

Significance

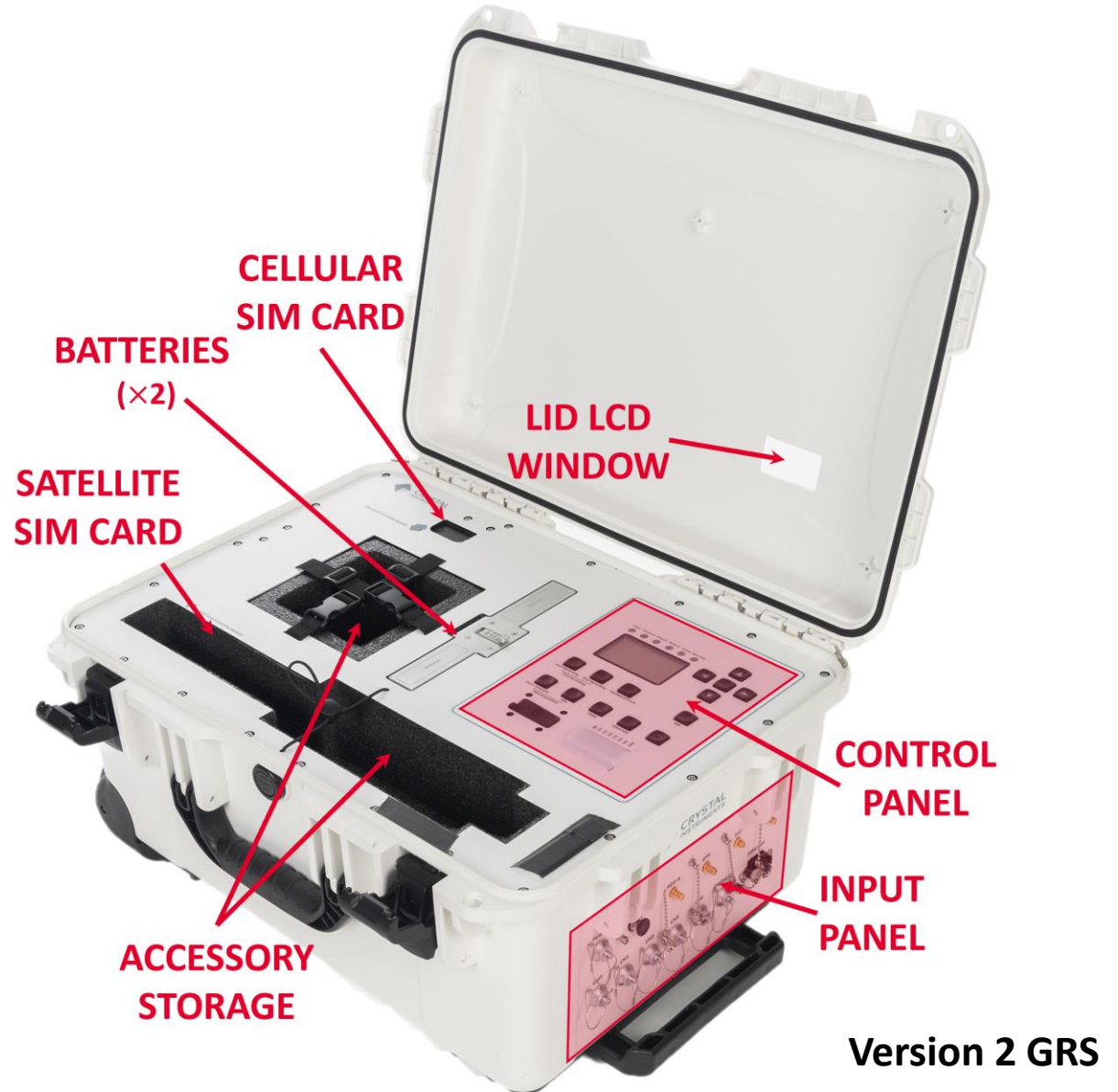
- Challenges & lessons learned being addressed prior to Dry Run
 - Triggering, communications, safety, damage from Wildlife
- Significant step toward Phase 2 readiness



Ground Recording System (GRS)



- New recording system designed/built by Crystal Instruments Corp. to NASA-set requirements
- Dual analog-to-digital converter (ADC) used to acquire data from 4 microphone channels
- Texas Instruments DaVinci dual-core processor for onboard processing tasks
- Version 2 GRS (shown at right) possess satellite and cellular communication modules
 - Version 1 GRS used in CarpetDIEM – only lacks comm modules

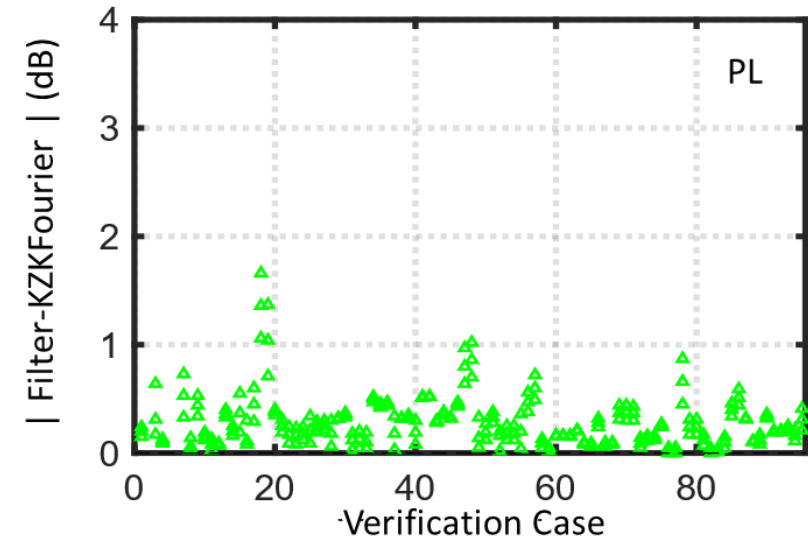


Propagation Modeling Improvements



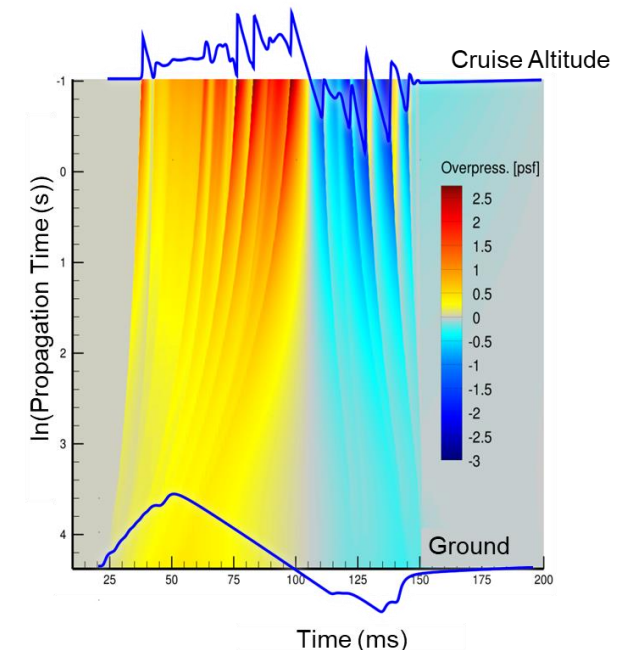
PCBoom Solver

- Latest version: **v7.4.1**
- Fully integrated KZK formulation based turbulence filters with enhanced Burgers' solver
- KZK filters updated for X-59 waveforms
- Enhanced filter outputs shown to reliably estimate actual KZKFourier implementation to $< 1\text{dB}$



sBOOM Solver

- Latest version **v2.9.1**
- Mesh converged sonic boom predictions that minimize discretization errors in farfield simulations
- Loudness predicted < 0.01 decibels for realistically complex practical examples (X-59) when analyzed at modest sampling frequencies
- Enhancements to allow coupled near-field and far-field simulations as well as reliable and robust aerodynamic shape optimization of low-boom aircraft

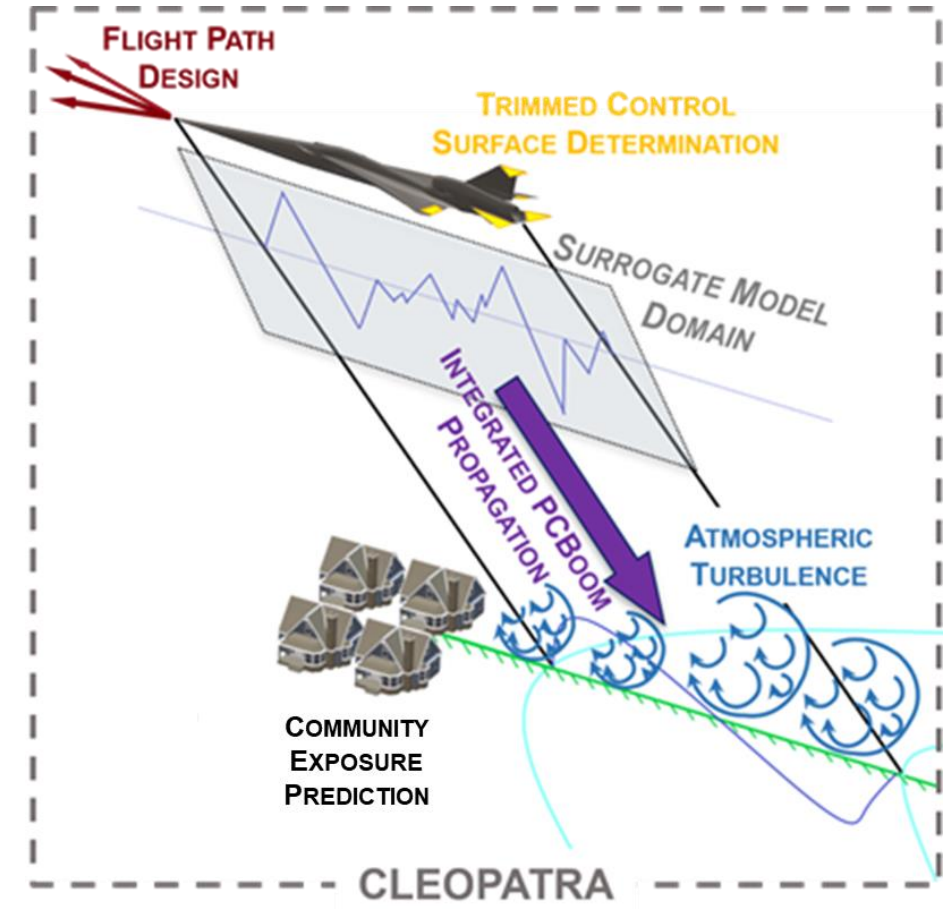


CLEOPATRA Trajectory Planning and Analysis Software

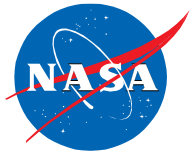
(Community Low-boom Exposure, Operations, Piloting, And Trimming Analyzer)



- CLEOPATRA is a software tool being developed for quick turn-around analysis during flights for actionable feedback and operational guidance
- CLEOPATRA integrates
 - Nearfield CFD database
 - PCBoom
 - Atmospheric turbulence model
 - Focus mitigation routines
 - Terrain
 - Real flight effects
- Will be validated in Quesst Phase 2
- Updated CLEOPATRA with validated CFD database will become a workhorse tool in Quesst Phase 3 for planning and analyzing aircraft trajectories for desired boom carpet placement and/or loudness



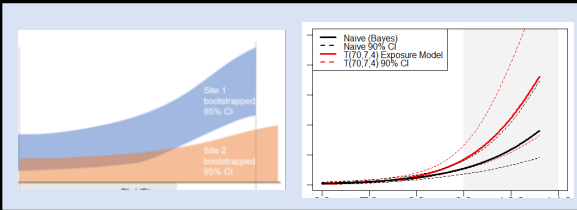
Phase 3 Stages: Planning ➡ Execution ➡ Data Delivery



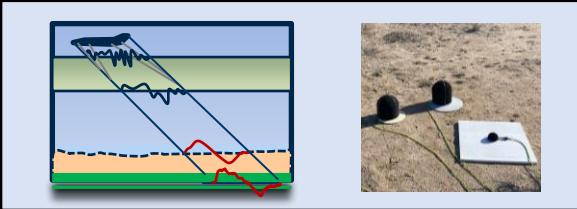
Airfield and Community Selection



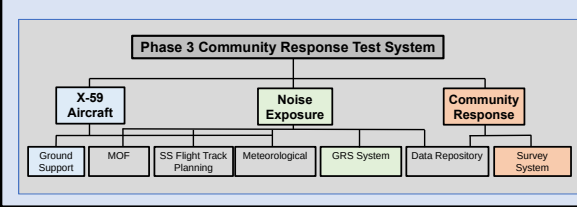
Survey Design and Analysis



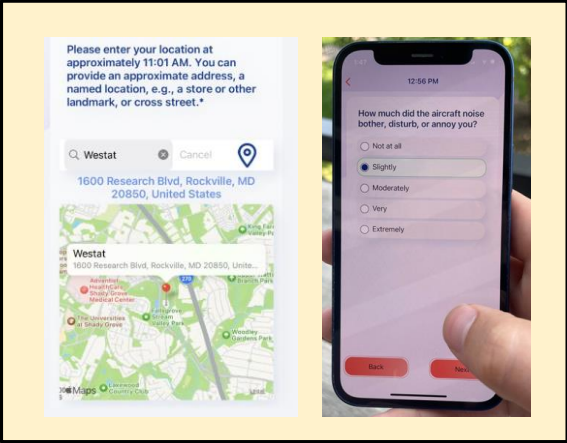
Exposure Estimation



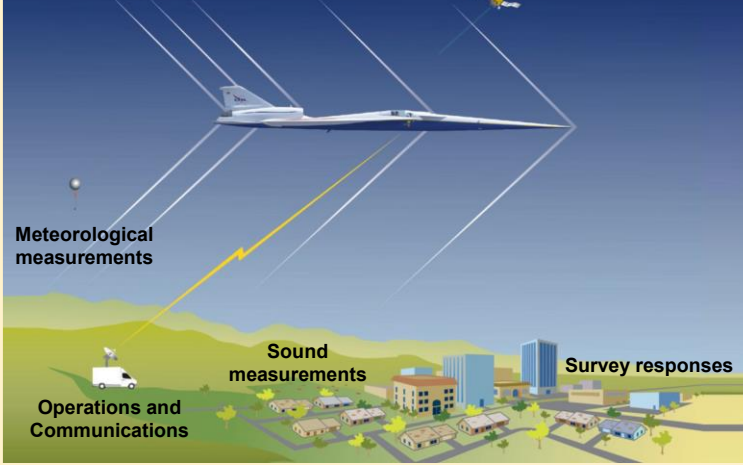
Data System Development



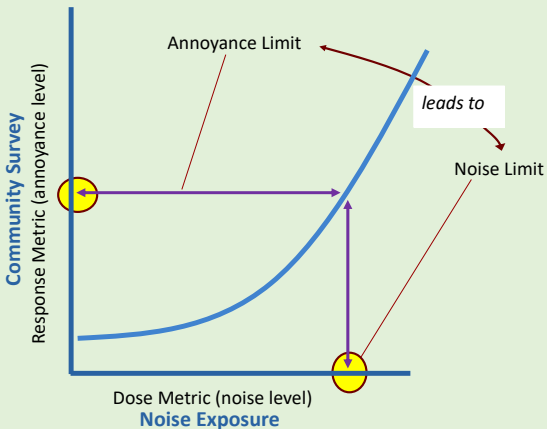
Public Survey Response



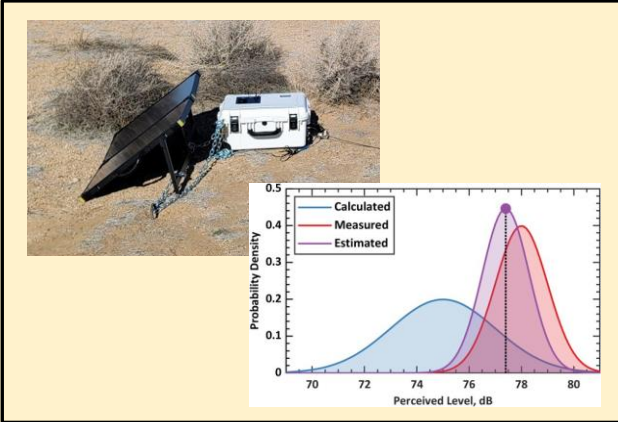
X-59 Community Overflights



Dose-Response Relationship



Acoustic Levels

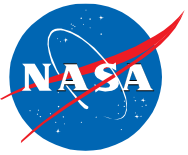


- Airfield is Edwards AFB
- Defined geographic boundaries and nominal flight path
- Carpet and flight path variation being evaluated
 - Historical weather influences
 - Airspace coordination and planning

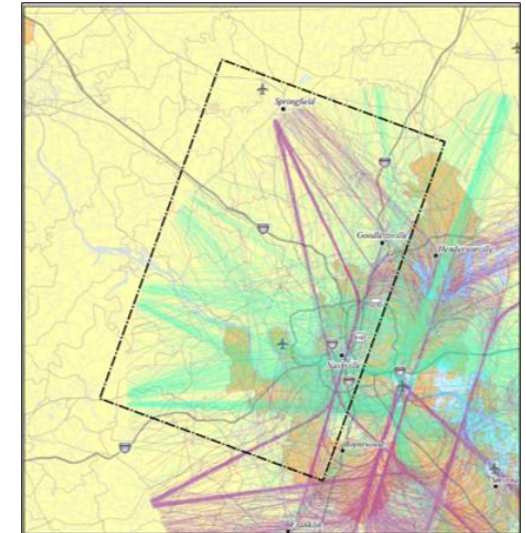
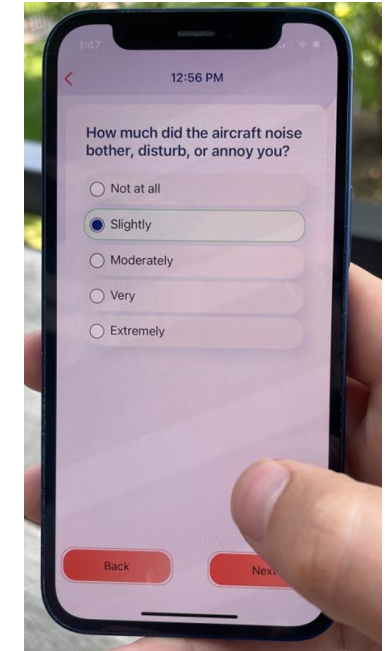
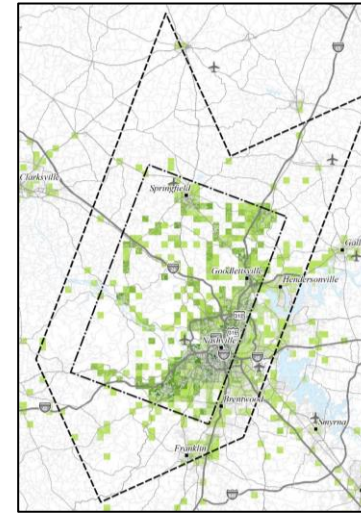


- [illegible]

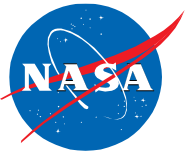
Survey System Checkout Test Completed



- **Conducted in Nashville, Tennessee**
 - Enrollment August-October 2023
 - Survey study November 2023
 - ~ 600 survey participants
 - Multiple surveys during the day
- **Survey execution and data system operation**
 - Survey instrument
 - Participant recruitment and retention (paid incentive)
 - Communications/tech support
 - User interface for viewing survey results
 - No NASA-directed overflights (survey questions were on general aircraft sound)
- **Results/Lessons learned**
 - Successful execution of full process
 - Participation and response rates above expectations
 - Addressing improvements to internal processes
 - Progressing with integrating survey system with overall data system for community testing



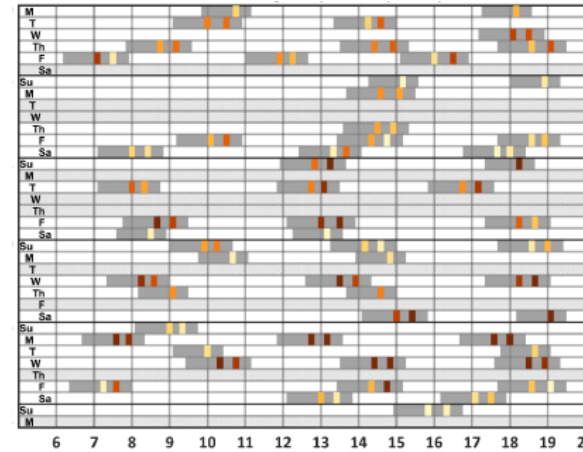
Survey Design and Analysis



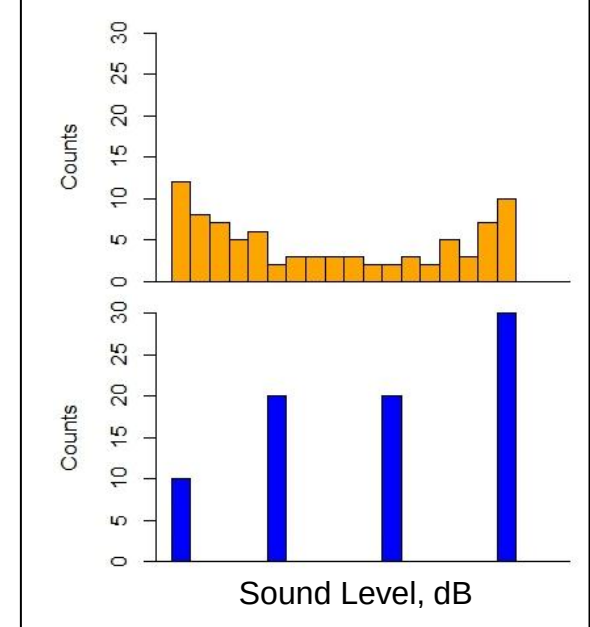
- **Exposure scheduling**

- Distribution of dose level across loudness range
 - Range may vary for each community test
 - Resolution/fineness
 - Weighting
- Randomization over month-long test
 - Weekday/weekend
 - Time-of-day (waking hours only)
 - Adjustable to interruptions or flight ops considerations
 - Maintenance, Weather
 - Fatigue rules

Example of month-long exposure schedule

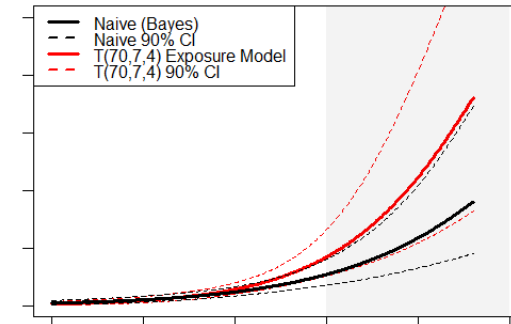


Examples of dose distribution approaches



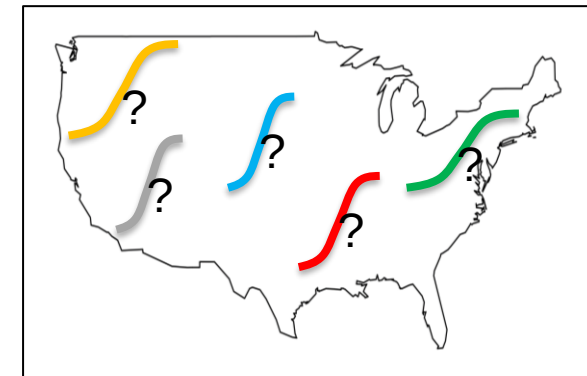
- **Influence of dose error**

- Uncertainty in exposure level impacts dose-response analysis
- Addressing strategies to mitigate



- **Interpretation/combining of results from multiple sites**

- Limited number of community tests
- Potential for inconsistency in dose-response relationships

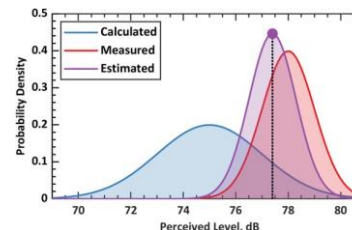


Exposure Estimation



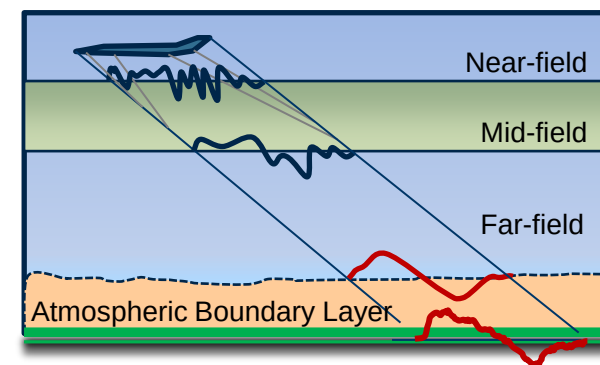
- **Overall exposure estimation = GRS measurements + predicted/calculated levels**

- Addresses uncertainties in measurement and calculations
- Incorporates variability of atmospheric turbulence



- **Sonic boom propagation modeling and metrics improved**

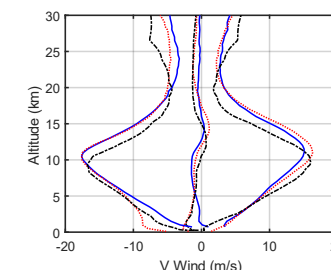
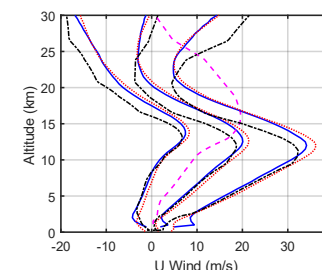
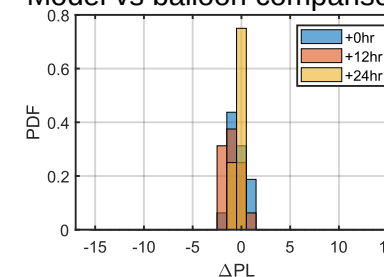
- PCBoom updates for Phase 3 atmospheric turbulence modeling needs
- Narrowband Octave-band Metrics (NOM) source code updated and released
- Available for use by international sonic boom research communities



- **Forecast Atmospheric Profile Tool developed**

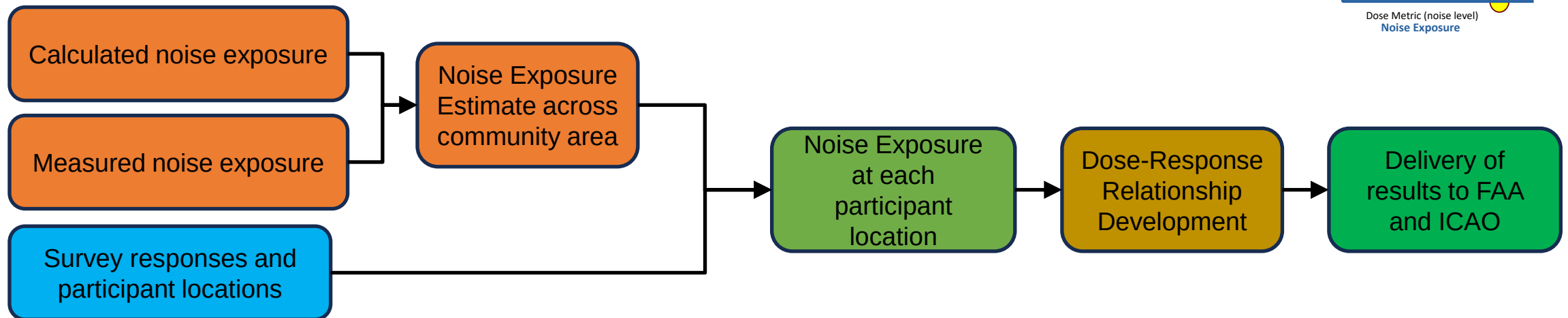
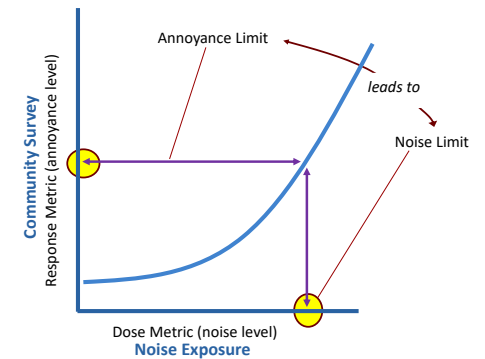
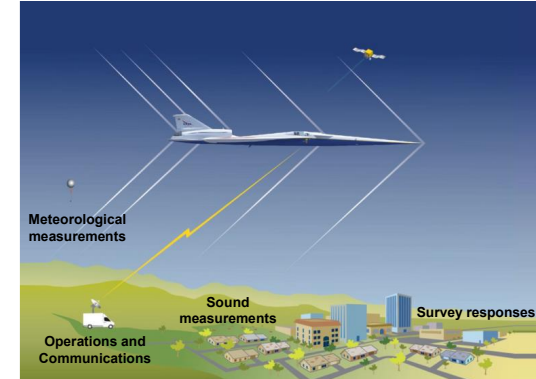
- Input to propagation modeling and flight planning tools to achieve target sound level
 - X-59 configuration
 - Flight track
- Validation cases for multiple parameters and locations
- Wind, temperature, humidity, etc.

Model vs balloon comparison



Data Collection, Processing, and Delivery

- Calculated noise exposure via propagation analysis for as-flown conditions
- Measured noise exposure – Acoustic waveforms and metrics via GRS
- Single-event and cumulative survey responses and participant locations
- Measured and calculated levels combined for best estimate of exposure
- Resulting exposure levels matched to participant response and location
- Dose-response analyses
 - Individual Community Tests
 - Combining across multiple tests
- Delivery of technical methods and overall results to FAA and ICAO



Questions?



Photo Credit: Lockheed Martin