

Supersonics

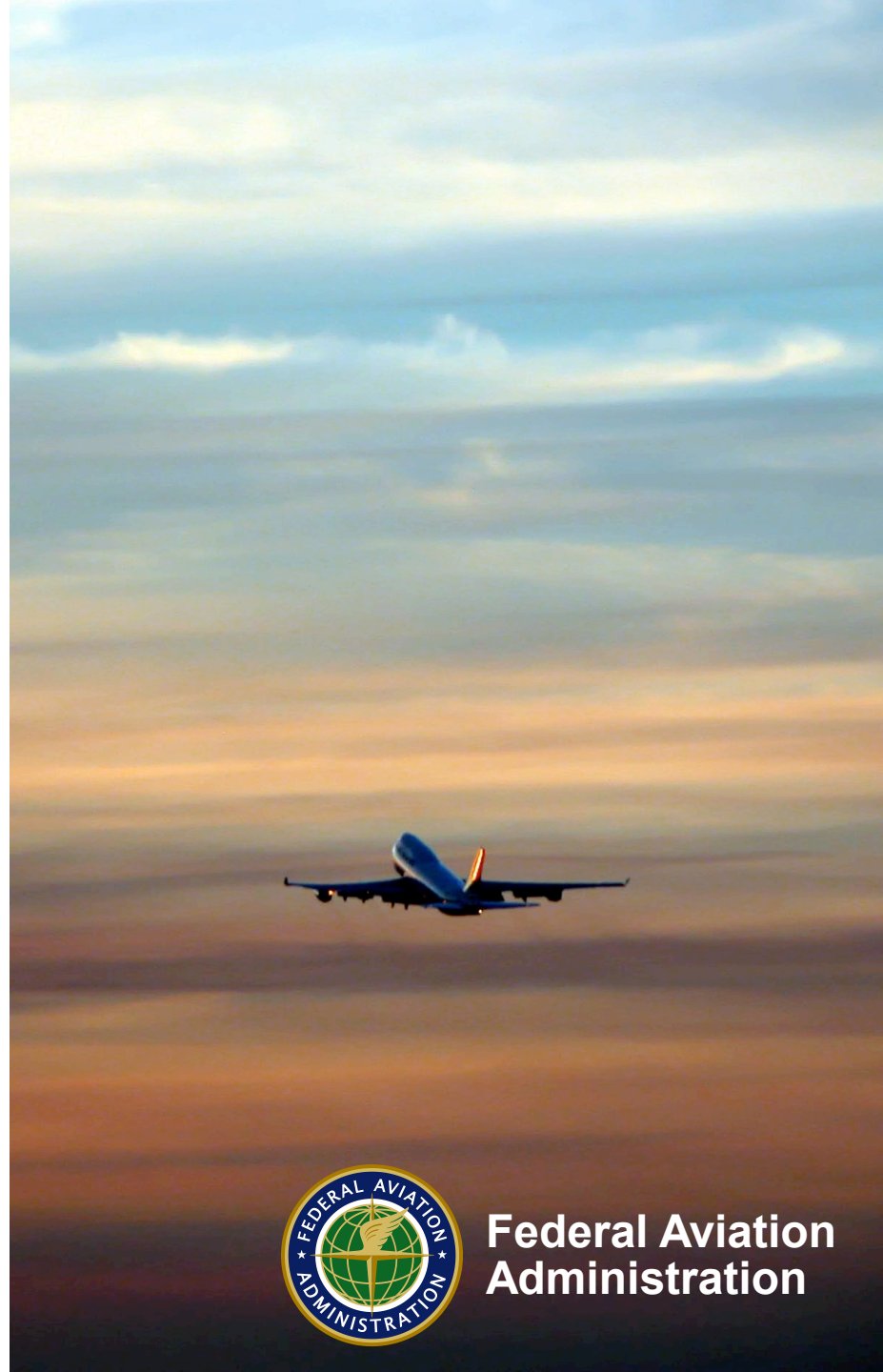
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**Federal Aviation
Administration**



Supersonics

- **FAA Supersonic Noise Regulations**
- **ICAO Standards Development Schedule**
- **Supersonics Interest within the U.S.**
- **Research Activities**
- **2025 Research Goals for Supersonic**



FAA Supersonic Noise Regulations

- **14 CFR part 36, Noise Standards: Aircraft Type and Airworthiness Certification does not apply to supersonic aircraft other than the Concorde**
 - FAA Assistant Chief Counsel for Regulations Interpretation, February 21, 2018
- **14 CFR Part 91.817 prohibits flight in excess of Mach 1 over land**
 - Appendix B allows supersonic operation under certain conditions granted on an individual basis
- **FAA has a statutory mandate to "protect the public health and welfare from aircraft noise and sonic boom" in 49 USC 44715.**



FAA Supersonic Noise Regulations (continued)

- **Two supersonic rulemaking activities on “Spring 2018 Unified Agenda of Regulatory and Deregulatory Actions”**
 - Domestic Noise Certification of Supersonic Aircraft (RIN: 2120-AL29)
 - Special Flight Authorizations for Supersonic Aircraft (RIN: 2120-AL30)
 - The two supersonic rulemaking activities would not rescind the 14 CFR Part 91.817 prohibition of flight in excess of Mach 1 over land.
 - Part of the Department of Transportation’s priority on innovation in transportation.

ICAO Standards Development Schedule

- **Collaboration through the International Civil Aviation Organization (ICAO)'s Committee on Aviation Environmental Protection (CAEP)**
- **Landing and take-off cycle noise: by 2022 for CAEP adoption (CAEP/12)**
- **En route sonic boom: by 2025 for CAEP adoption (CAEP/13)**
- **The schedule is challenging and data is needed.**



ICAO CAEP WG1

- **Progress has been made on:**
 - Identifying certification measurement locations for assessing sonic boom noise on the ground;
 - Decision on a certification metric (EPNL) for LTO noise
 - Selecting an appropriate noise metric for use in a Standard that assesses sonic boom noise and shows favorable correlation between outdoor measurement and indoor human response; and
 - Evaluating the benefits of using sonic boom predictions in supersonic noise certification in addition to physical measurements.



Supersonics Interest within the U.S.

- **Companies are working to develop civil supersonic aircraft**
 - Some companies have announced orders and/or timing for an aircraft type certificate application
 - Multiple aircraft designs accounting for different missions being discussed (e.g. Mach 1.4 business jet, Mach 2.2 airliner)
- **FAA collaborating both nationally and internationally regarding developing necessary certification standards and processes**



Supersonics Interest within the U.S. (continued)

- **Supersonic overflight design approaches**
 - No specific technology to mitigate sonic boom
 - Mach cut-off
 - Operationally manage flight such that sonic boom does not reach the surface due to atmospheric refraction.
 - Low boom technology
 - Conceptually an ideal supersonic aircraft designed intentionally for low sonic boom.



Research Activities

- **Exploring establishing research team to support standard setting process for CAEP/12 & 13**
- **ASCENT Projects 10, 41, 42, and 47**
- **CLEEN III Market Survey**
- **NASA Research**
- **International Research and Collaboration**
 - RUMBLE
 - JAXA



- **Title: Aircraft Technology Modeling & Assessment**
- **Objectives:**
 - Assess potential environmental impact of potential future supersonic air travel (domestic & global).
 - Develop demand and forecast through 2050.
 - Analyze existing and future supersonic technologies (e.g. traditional, low sonic boom shape profiles, etc.).
 - Provide scenarios with potential changes in fuel burn, CO₂, H₂O, NO_x and noise area exposure.

- **Status:**
 - Preliminary supersonic demand and fleet assumptions
 - Characterized supersonic routes and potential new fleet allocations
 - AEDT supersonic vehicle (Concorde) modeling testing
 - Preliminary estimates of vehicle environmental performance parameters
 - Preliminary fleet level impact assessment
- **FY19+ Goals:**
 - Refine demand and fleet modeling assumptions
 - AEDT and EDS development of future supersonic vehicles
 - Trades between vehicle capabilities and environmental impacts
 - Detailed vehicle and fleet-level impacts assessment
 - Different classes and technology levels of supersonic vehicles
 - Modeling capability of cruise emissions/noise

- **Title: Identification of Noise Acceptance Onset for Noise Certification Standards of Supersonic Airplanes**
 - Investigating certification standards, evaluating factors of noise impact, and methods to enhance community tests of human response to low boom signatures.
- **Objectives:**
 - 41A: Removing turbulence from measured sonic booms.
 - Develop methods to de-turb (remove turbulence from) sonic booms collected during a certification field test.
 - 41B: Community impact and acoustic acceptability
 - Develop Low Cost Noise Monitors to optimize measurement requirements and minimize costs in future acoustical measurement field testing.
 - Conduct environmental masking urban/rural literature review to investigate the role background noise plays on noise impact and perception.

ASCENT Project 41 – continued



- **Status**

- Methods for deturbing signatures of various shapes evaluated. (41A).
- Designed and tested a low cost noise monitor. (41B)
- Identified literature on environmental noise and perception. (41B)

- **FY-19**

- Explore approaches to model secondary sonic boom effects.
- Offer “deturbing” signatures method recommendation.
- Analyze protocols and methods (Reference Day, standard atmosphere, acoustical mic array configurations, etc) in support of noise certification standard for supersonic aircraft.
- Continue ICAO Impact Sciences Group leadership and studies in support of CAEP.



- **Title: Acoustical Model of Mach Cut-off Flight**
- **Objectives:**
 - Predicting Boomless Mach Cut-off: Applying Enhanced Ray-tracing
 - Model Mach Cut-off by enhanced methods and explore conditions where the sonic boom does and does not reach the ground.
 - Perceptual Study: Metric Analysis & Annoyance Lab Study
 - Experimental human response lab studies of acoustical emissions that relates perceptual characterization of noise and informs about metrics for use in predicting reactions to Mach-cutoff flyovers.

ASCENT Project 42 – continued



- **Status**

- New ray tracing method tool enhanced to account for vertical winds.
- Completed Mach Cut-off sensitivity of wind components.
- Applied data from 3 atmospheric databases to understand weather variability and needed spatial density.
- Perceptual study trends show that thunderous and swooshing aspects are correlated with annoyance, while rumble is not.

- **FY-19**

- Continue to compile best available atmospheric conditions to understand stability of Mach Cut-off flight and risk of sonic boom release.
- Experiment to look at annoyance is underway.
- Identification of applicable metrics for Mach Cut-off to follow.



- **Title: Clean Sheet Supersonic Engine Design and Performance**
 - Not yet started
- **Objectives:**
 - Identify mission profiles and operating requirements for supersonic propulsion systems.
 - Build engine cycle decks to explore the design space.
 - Assess technologies, fuel and environmental performance.
 - Analyze fuel burn, noise, and emission profiles.
 - Reduced-order performance modeling.
 - Simplify detailed models and pass to ASCENT Project 10 for aircraft design and subsequent fleet assessments.

CLEEN Phase III Market Survey

- **Considering whether to include supersonic aircraft within CLEEN Phase III.**
- **Market Survey closed on August 31.**
- **Input requested on Supersonic Aircraft**
 - Innovative technologies and/or operational concepts.
 - Whether CLEEN should support the development of technologies related to civil supersonic aircraft?
 - How could CLEEN or a program like CLEEN fit into company's strategy for technology development to enable the reintroduction of civil supersonic aircraft?
 - CLEEN Phase III Goals.

NASA Research

- **Heavy reliance on NASA Research for identification of community response to sonic boom.**
- **Quiet Supersonic Flight Testing**
 - Galveston, Texas area; November 2018.
 - Study techniques for obtaining accurate community response data, using surveys, to the reduced sounds of supersonic flight over a community that is relatively unfamiliar with these sounds.
- **Low Boom Flight Demonstrator (X59 QueSST)**
 - Contract awarded.
 - First flight 2021.
- **Supersonic Transport Concept Aeroplane (STCA) studies.**



International Research and Collaboration RUMBLE

- **Regulation and norm for low sonic Boom Levels**
- **Consortium of European and Russian Organizations**
- **“...production of the scientific evidence requested by national, European and international regulation authorities to determine the acceptable level of overland sonic booms and the appropriate ways to comply with it.”**
<https://www.futuresky.eu/projects/noise>
- **Interface to ICAO SSTG**



International Research and Collaboration

JAXA

- **Japan Aerospace Exploration Agency**
- **Drop test for Simplified Evaluation of Non-symmetrically Distributed sonic boom (D-SEND)**
 - <http://global.jaxa.jp/projects/aero/sf/>
- **D-SEND#1**
 - Two different axisymmetric bodies are dropped and their sonic booms are measured and compared.
- **D-SEND#2 test - July 2015**
 - Demonstrated the whole-aircraft sonic boom design technology.



2025 Research Goals for Supersonic (1 of 3)

- **LTO Noise and Emissions**
 - Revised Emissions Certification Scheme
 - Development of performance data, noise data (NPDs), and emissions indices for AEDT modeling
 - Complete a comparison of rank ordering of certification versus day-to-day operations noise
- **Engine Emissions Certification Support**
 - nvPM sampling probe compatibility
 - Climb/Cruise NO_x relationships
 - Engine stability at LTO thrust levels
 - Representativeness



2025 Research Goals for Supersonic (2 of 3)

- **Aircraft Design/Operations**
 - Develop an understanding of the trade space of LTO noise, emissions, and sonic boom noise
 - Develop an understanding of the relationship between en route operations and sonic boom concentrations
 - Understand the potential of a clean sheet engine to reduce environmental impact
- **Review of Ban of Over Land Flight**
 - Consideration of potential impacts (annoyance, sleep CVD, damages)
 - Consideration of different scenarios such as limits of operations or limits on time of day



2025 Research Goals for Supersonic (3 of 3)

- **Sonic Boom Certification**
 - Procedures (what to measure, how to measure, reference day...)
 - Consideration of Mach Cut-off viability including repeatability and allowance of accidental sonic boom
- **Emissions Source Characterization & Impacts**
 - Engine measurement campaigns
 - Evaluate the climate and ozone impacts of SST
- **Other Considerations**
 - Modeling sonic boom (methodology, data collection)
 - Identification of significance criteria for NEPA
 - Policy for when to conduct NEPA
 - Noise measurement system guidance for measuring sonic booms



Summary

- **FAA regulatory activity ongoing**
 - Would not rescind the 14 CFR Part 91.817 prohibition of flight in excess of Mach 1 over land
- **ICAO SARP development ongoing**
- **Research activities ongoing to support various aspects of supersonic aircraft design and certification**

