



F-5 Shaped Sonic Boom Demonstration (SSBD)



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F-5 SSBD Origin

- Northrop Grumman will perform the F-5E shaped sonic boom demonstration in a cooperative¹ industry and government effort under DARPA's Quiet Supersonic Platform (QSP) program² awarded in July 2001.³
- The contract, valued at \$3.4 million, is for the first flight demonstration of a sonic boom mitigated by aircraft shaping.³
- The test will involve all government and industry QSP participants because it is considered a key overall program enabler and risk-reducer.⁴
- The [SSBD] program intends to demonstrate for the first time that an appropriately shaped aircraft will produce a mitigated sonic boom⁵ validating NASA's [long pursuit and Jones-Seebass-George-Darden's] 30-year-old theory.⁶

1. www.aerotechnews.com/starc/2001/081001/sonic_boom.html.

2. www.flug-revue.rotor.com/FRNews1/FRNews01/FR010812.htm

3. www.capitol.northgrum.com/contracts/darpa_phase2.html

4. www.ainonline/issues/06_02/06_02_ssbjquestionpg1.html

5. www.darpa.mil/body/pdf/QSPph2.pdf

6. *Aerospace America*, June 2002, p. 32.



F-15B Close In-Flight Sonic Boom Measurements

- NASA's Dryden's F-15B Research Testbed aircraft recently flew in the supersonic shock wave of a U.S. Navy F-5E. Four flights were flown in order to measure the F-5E's (close up) sonic boom signature at Mach 1.4, during which more than 50 shockwave patterns were measured at distances as close as 100 feet below the F-5E.⁷
- The F-15B's specially-instrumented noseboom recorded static pressure measurements while flying behind and below the F-5E. This provided a baseline measurement of the F-5E's sonic boom characteristics. Differential Global Positioning System (GPS) receivers on both aircraft yielded relative aircraft position.⁷
- Sonic boom ground data was gathered by two Dryden-developed Boom Amplitude and Direction Sensors (BADs). Twenty-five sonic booms from the F-5E and F-15B were recorded.⁷

7. www.dfrn.nasa.gov/PAO/PressReleases/2002/02-17.html



F-15B Close In-Flight



Sonic Boom Measurements (cont)

- “The flight data show fine details unseen in the preflight predictions. Based on these details, the Computational Fluid Dynamic (CFD) grid density was increased. Preliminary flight data agree well with the CFD predictions over most of the region, with an adjustment needed to the predictions in the region of the engine inlet. These flight data allow the QSP team to validate prediction tools to design aircraft with lower sonic booms,” said Ed Haering, Dryden’s principal investigator for sonic boom studies.⁷
- Dryden’s F-15B will again fly in the Shaped Sonic Boom Demonstrator’s shock waves to record changes produced by the F-5E modifications.⁷

7. www.dfrc.nasa.gov/PAO/PressReleases/2002/02-17.html



F-5 SSBD Modification

- Northrop Grumman is attempting to quiet the sonic boom with a modified F-5E whose specially-shaped-nose may keep shock waves from forming into the abrupt wave, (reducing overpressure) that reaches ground level in the form of a sonic boom.⁸
- For the tests, Northrop Grumman will modify the nose of a surplus Air Force F-5E with a specially designed nose glove⁴ by lengthening it four feet, with the forward half of the fuselage reshaped.⁸
- Northrop Grumman will test the company's CFD-based design concepts with a modified F-5E Tiger fighter plane that has a longer nose and re-contoured body.⁹

8. www.projectblack.net/boom.html

4. www.ainonline/issues/06_02/06_02_ssbjquestionpg1.html

9. www.popsci.com/popsci/aviation/article/0,12543,194456-5,00.html



F-5 SSBD

Wind Tunnel Tests

- The demonstration will include a wind tunnel test to validate computed sonic boom signature predictions and safety-of-flight wind tunnel tests to verify handling qualities of a modified F-5E.⁴

4. www.ainonline/issues/06_02/06_02_ssbjquestionpg1.html



F-5 SSBD Expected Ground Signature



- The modified aircraft is expected to produce a specially “shaped” sonic boom with significantly less intensity than the conventional sonic boom produced by an unmodified F-5E.¹⁰
- The flight test will use a Northrop Grumman F-5E aircraft with a modified forward fuselage to produce a shaped sonic boom that is expected to be noticeably quieter than a conventional sonic boom.³
- We [Northrop Grumman] have come up with a shape and extension on the F-5 nose that would produce a flat-top pressure wave on the ground, 30,000 ft. below the airplane.⁶

10. www.spacedaily.com/news/plane-sonic-02b.html

3. www.capitol.northgrum.com/contracts/darpa_phase2.html

6. *Aerospace America*, June 2002, p. 32.



F-5 SSBD CDR Complete



- Northrop Grumman has successfully completed a Critical Design Review (CDR) with DARPA, an important milestone in preparation for the first-ever flight demonstration of a sonic boom mitigated by airframe shaping.¹¹

11. www.spacedaily.com/news/plane-sonic-02b.html



F-5 SSB Demonstration

- A series of flight tests to validate the predicted persistence of shaped sonic booms.⁴
- The sonic boom flight demonstration...will occur at the NASA Dryden Flight Research Center at Edwards Air Force Base.¹¹
- An important milestone...Northrop Grumman plans to flight test an F5E aircraft modified to produce a shaped signature below the aircraft when flown at Mach 1.4 and 30,000 ft. Experiments using this vehicle will help determine the extent to which analytical tools used to predict the propagation of N-wave signatures can be used for shaped signatures.¹²
- Work on both contracts is expected to conclude at the end of December 2002.³

4. www.ainonline/issues/06_02/06_02_ssbquestionpg1.html

11. www.spacedaily.com/news/plane-sonic-02b.html

12. www.nap.edu/openbook/0309082773/html/18.html

3. www.capitol.northgrum.com/contracts/darpa_phase2.html



F-5 SSBDemonstration (cont)

- Northrop Grumman plans to fly nine sorties and 18 tests, at speeds up to Mach 1.5,¹³ over a specific course lined with ground instruments to measure the intensity of the sonic booms. Another unmodified F-5E will be used as a baseline aircraft for sonic boom data comparisons.⁸ The unmodified F-5E will fly on the same path immediately before or after the test aircraft.¹³
- The goal of Northrop Grumman's F5 shaped sonic boom demonstration is to show that the boom signature from the modified airplane matches the CFD prediction.¹⁴
- What the engineers want to find out is whether the far-field effects—the measured boom on the ground—match the predictions. If they do, then Boccadoro's [Northrop Grumman] team and others will be well on their way to designing the low-boom supersonic jet of the future.⁹

13. www.awgnet.com/shownews/01nbaa2/airfrm20.htm

8. www.projectblack.net/boom.html

14. www.pilotmag.com/September/article3_sep.html

9. www.popsci.com/popsci/aviation/article/0,12543,194456-5,00.html



F-5 SSBDemonstration (cont)

- Most of the data on the response of people and buildings to sonic booms are for N-wave signatures and boom overpressures greater than 1.0 lb/ft². There is no database on the response of people and buildings to shaped signatures of less than 1.0. Human response data are also needed...both to guide the development of new technology and to support necessary changes in federal regulations that prohibit sonic booms over land. A significant finding from past sonic boom studies is that **startle, rattle, and building vibrations** are key elements in determining the response of people to sonic booms.¹²