Pervasive Technologies

Technologies Required for Low Sonic-Boom Aircraft

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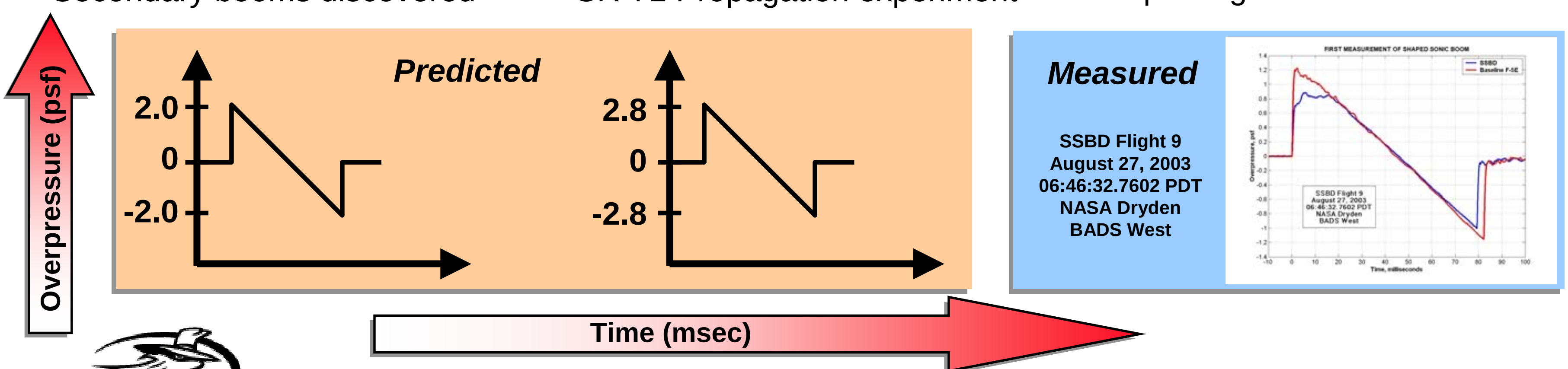
Low Sonic-Boom Design Capabilities Have Progressed Since The Concorde Era

Courtesy of Northrop Grumman

Concorde (1979 – 2003)
- Max. Overpressure ~2.0 psf
- Max. Takeoff weight ~400 klbs
- Designed through trade studies
- Not designed for low sonic-boom
- Land restricted supersonic flight
- Secondary booms discovered

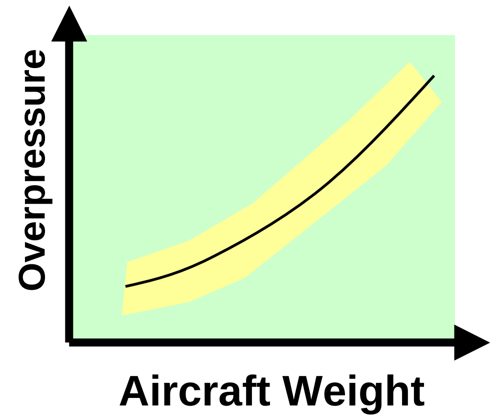
HSCT/HSR program (1990's)
- Max. Overpressure ~ 2.8 psf
- Max. Takeoff Weight ~ 700 klbs
- MDO Demonstration
- Applied CFD shape optimization
- Boom prediction improved
- SR-71 Propagation experiment

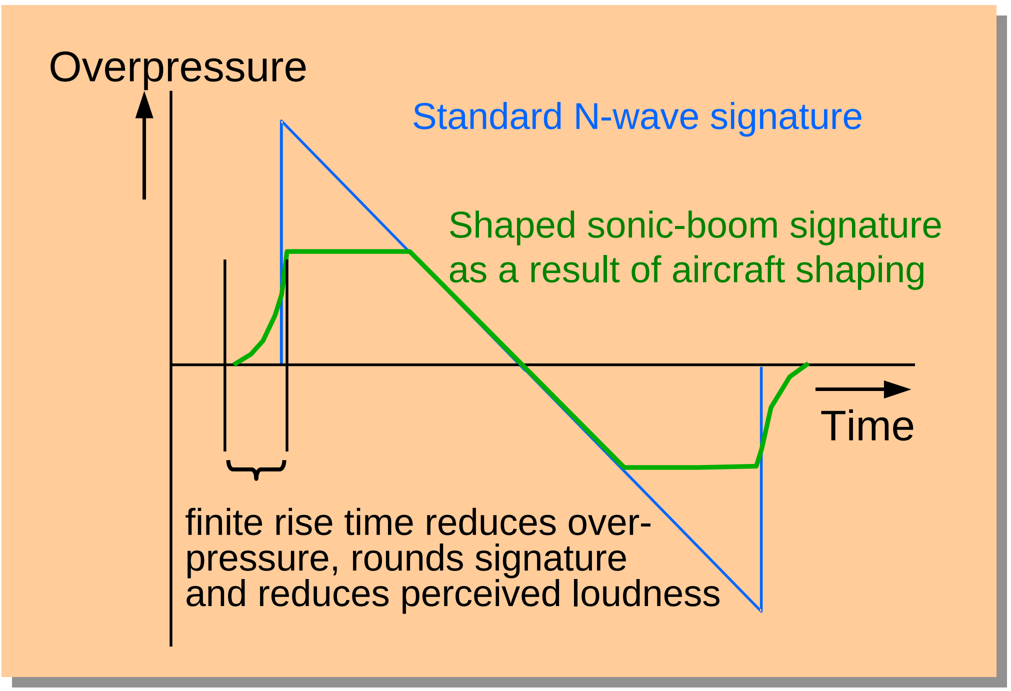
QSP program (2001-2003)
- Max. initial overpressure ~ 0.3 psf
- Max. Takeoff Weight ~100 klbs
- Boom reduction technologies
- CFD shape optimization for boom
- SSBD program demonstrates shaped signature



Weight Reduction & Sonic-Boom Signature Shaping Provide Greatest Boom Reduction

- Overpressure is related to aircraft weight
- Overpressure cannot be eliminated, but the goal is to soften the perceived loudness to acceptable levels





- Aircraft shaping provides for reduced overpressure and reduced perceived loudness
- Aircraft shaping as a means to reduce boom was first introduced by Seebass and George in 1960s
- Best technology for aircraft shaping is Multi-Disciplinary Optimization (MDO)
- Acceptability requirements needed to design aircraft

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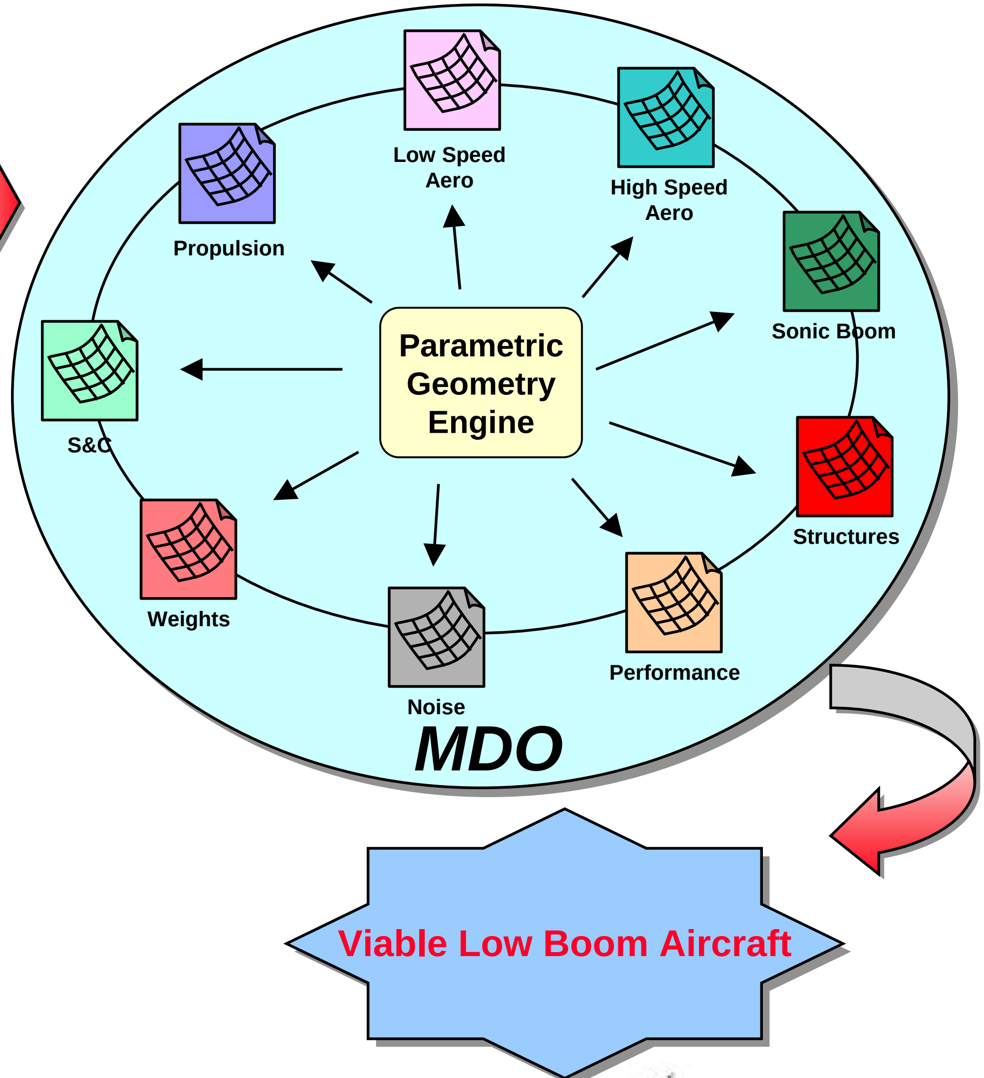
High-Fidelity MDO is the Best Design Approach to the Multi-Dimensional Sonic-Boom Design Paradigm

Notional Design Objectives
- Low Sonic Boom ~0.3psf
- Long Range ~5,000nmi
- Low noise – Stage 4 compliant
- Weight ~100,000 lbs
- Good Low Speed Aero ~7,000 TOFL
- High Cruise Performance
- Low Fuel Burn Rate



- Lower weight supersonic business jets have the best chance to meet potential stringent over-land sonic boom requirements
- Multiple, often conflicting, design requirements make it difficult to design viable supersonic aircraft the “Old Fashioned,” parametric, “Trial-and-Error” way
- High-fidelity MDO technology can provide a path to success

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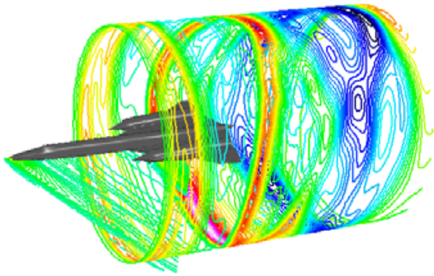
Pervasive Technologies That May Enable A Viable Supersonic Over-Land Aircraft



SR-71 Propagation Experiment

Low-Boom Shaping Technologies

- High-Fidelity MDO with Computational Fluid Dynamics (CFD)
- Equivalent area distribution (SEEB criteria)
- SR71(1995) and Shaped Sonic Boom Demo (2003)
- Synthetic vision to remove cockpit design constraints

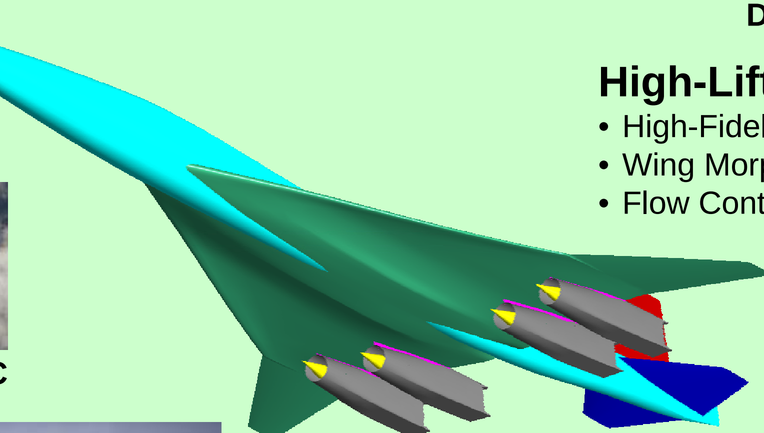
(Picture Courtesy Northrop Grumman)

Shaped Sonic-Boom Demonstration

Off-Body Energy Deposition

- Plasma
- Thermal Keel

F-16XL SLFC



High-Lift

- High-Fidelity MDO with CFD
- Wing Morphing
- Flow Control

Cruise Performance

- High-Fidelity MDO with CFD
- High Speed Research program (1990's)
- Supersonic Laminar Flow Control
- Light weight materials
- Probabilistic Design

NASA F-15B Utilized For Laminar Flow Experiments

Advanced Engine Technologies

- Inlet Shaping for Boom & Performance
- Improved TSFC
- Light-weight high-temperature materials
- Improved noise characteristics

Viable Supersonic Over-Land Aircraft

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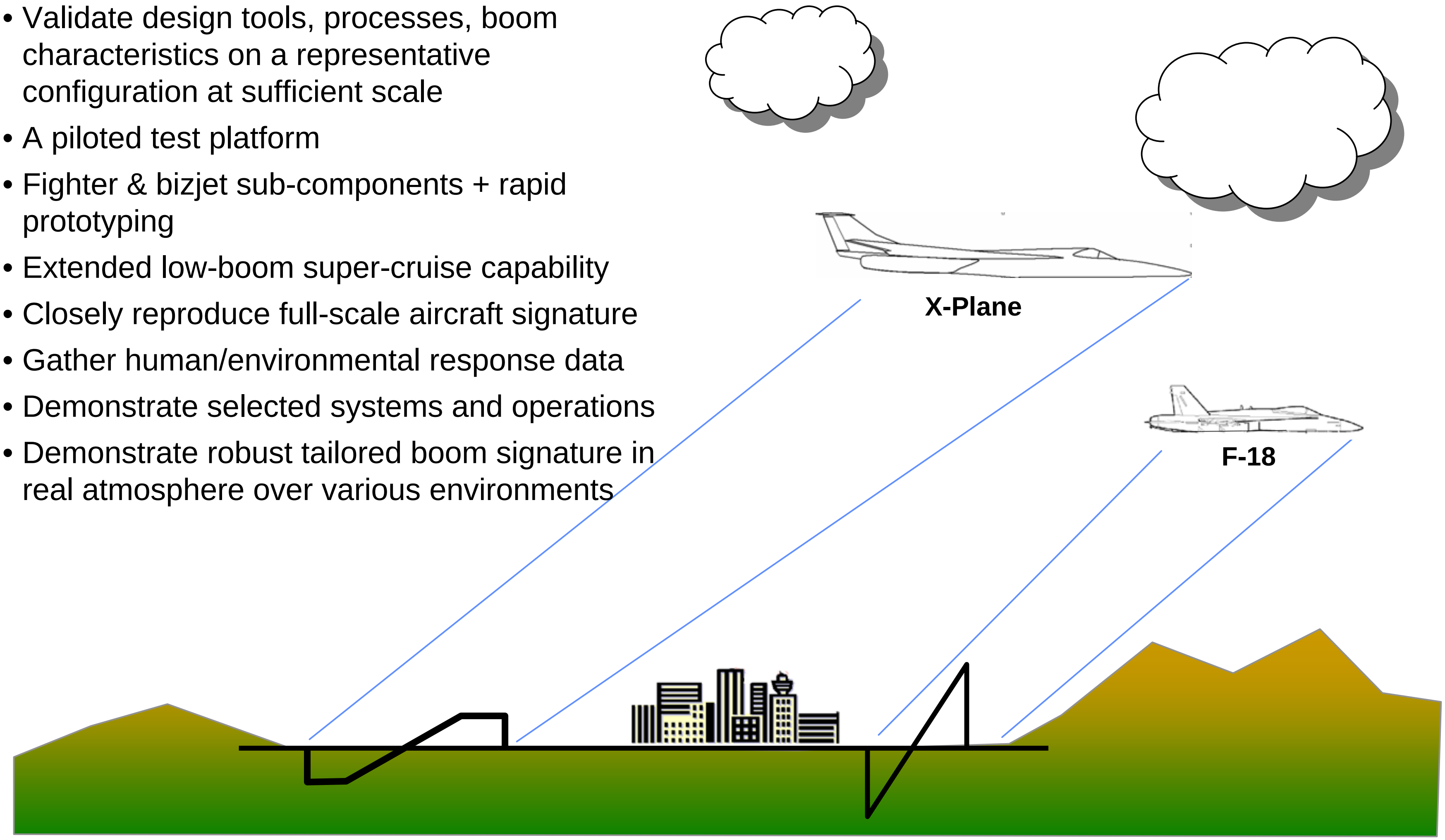
A Low-Boom Technology Demonstrator (X-Plane) Is Required

- Validate design tools, processes, boom characteristics on a representative configuration at sufficient scale
- A piloted test platform
- Fighter & bizjet sub-components + rapid prototyping
- Extended low-boom super-cruise capability
- Closely reproduce full-scale aircraft signature
- Gather human/environmental response data
- Demonstrate selected systems and operations
- Demonstrate robust tailored boom signature in real atmosphere over various environments



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Many Challenges and Issues Remain

Challenges

- A robust low-boom aircraft
- An economically viable low-boom aircraft
- Full configuration high-fidelity MDO coupled with propulsion
- Balancing multi-variable design objectives
- Defining over-land boom requirements

Issues

- Focused boom due to acceleration and maneuver
- Uncertainty in atmospheric turbulence effects
- Uncertainty in wind and temperature effects
- Low sonic-boom acceptance criteria