Noise

Air traffic in 2025 may be double that of today. Accommodating such an increase will require passenger and cargo air vehicles to fly cleaner and quieter, consume less fuel, and take off and land on short runways. Increased performance requires expansion of the allowable flight envelope, increased structural reliability with reduced structural weight, and increased energy efficiency and operability for advanced airframe and engine systems and subsystems.

Although some specific system-level goals for noise, emissions, and performance have been identified, technologies will be evaluated using trade studies for typical engines and aircraft. The 10-year strategy includes provisions for novel test methods and validated prediction tools that can be used to improve system tradeoffs for advanced concepts capable of meeting longer-term noise, emissions, and performance targets.

Subsonic Fixed Wing Aircraft Goals		Supersonic Aircraft Goals	
Aircraft Generation	**Noise Goal**	**Aircraft Generation**	**Noise Goal**
N+1 (2015 Entry into Service) – Conventional tube and wing, B737/CFM56 baseline	-32 dB (cum below stage 4)	N+1, (2015 Entry into Service) – Supersonic business jet aircraft	65-70 PLdB sonic boom; Airport Noise: Meet current regulation with margin (stage 4)
N+2 (2020-25 Entry into Service) – Unconventional configuration like Blended Wing Body, B777/GE90 baseline	-42 dB (cum below stage 4)	N+2, (2020 Entry into Service) – Small supersonic airliner	65-70 PLdB sonic boom; Airport Noise: -10 dB (cum below stage 4)
N+3 (2030-35 Entry into Service) – Advanced concept aircraft, relative to user-defined baseline	55 LDN (dB) at average airport boundary	N+3, (2030-35 Entry into Service) – Efficient Multi-Mach aircraft	65-70 PLdB low boom flight; Airport Noise: -10 dB (cum below stage 4)

Objectives

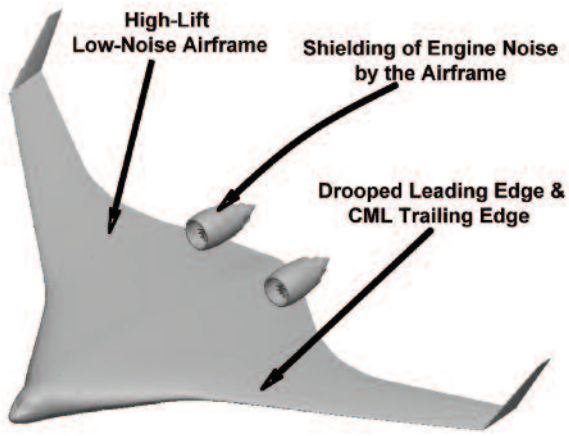
- Development of prediction and analysis tools for reduced uncertainty in the design process.
- Development of concepts/technologies for enabling dramatic improvements in the noise, emissions, and performance characteristics of subsonic/transonic aircraft.

Relevance

- Direct impact on the future designs of a wide range of subsonic aircraft relevant to industry, the Department of Defense, and other government agencies.
- Direct impact on JPDO & NextGen operational and environmental goals and objectives.

The geared turbofan UHB engine with an advanced fan for noise reduction is being developed by NASA in partnership with industry.

An over-the-rotor metal foam liner reduces fan noise.



Advanced aircraft configurations, such as Blended Wing Body, offer the potential for significant noise reduction.

Approach

- Enable major changes in engine cycle/airframe configurations.
- Reduce uncertainty in multi-disciplinary design and analysis tools and processes.
- Develop/test/analyze advanced multi-discipline-based concepts and technologies.
- Conduct discipline-based foundational research.

New computational tools for aircraft noise prediction will allow a more accurate accounting of the aircraft noise source characteristics and locations along with the effects of engine installation, airframe-engine interaction, atmospheric gradients, and wind.

Noise Reduction in Subsonic Fixed Wing Aircraft

Research efforts within the program are focused on reducing both airframe and engine noise. Airframe noise-reduction research includes continuous mold-line wing structures; drooped leading edge; active flow control; adaptive and flexible wing structures; smart chevrons; and toboggan fairing for landing gear noise reduction.

Technologies for engine noise reduction include Ultra-High-Bypass (UHB) engines, such as the geared turbofan engine; soft vane, over-the-rotor foam metal liners; distortion-tolerant fans with active noise control; and variable-area fan nozzles. Multifunctional materials and structures containing metallic and polyimide foams and aerogel materials are being developed for application in long ducts and fan-containment systems to simultaneously carry load and reduce noise.

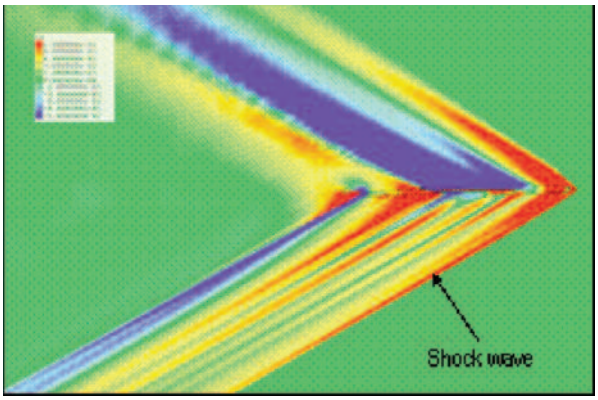
Novel Hybrid Wing Body (HWB) configurations are now in development and testing that integrate airframe and propulsion systems. The HWB dramatically reduces noise and will help to achieve N+2 goals for the 2020 timeframe. One example is the Blended Wing Body (BWB) configuration that can achieve significant noise reduction through airframe shielding of engine noise.

Computational tools with improved noise prediction capability are being developed to identify promising noise-reduction technologies. Advanced flow and noise-diagnostic techniques are helping researchers to better understand the sources of airframe, fan, and jet noise, with a focus on detailed spatial and temporal characteri-

zation of noise-generation mechanisms. Prediction capabilities are focused on rotor-stator interaction noise; slat and landing gear noise for airframes; flow interaction and acoustic scattering for integrated propulsion-airframe systems; and the integration of various tools into the Aircraft Noise Prediction Program (ANOPP).

Noise Reduction for Supersonic Aircraft

Sonic booms that accompany travel beyond the speed of sound are a major environmental challenge to civil supersonic transportation. Others include airport noise, as supersonic air vehicles fly at subsonic speeds, and high-altitude emissions, where the exhaust from supersonic engines can have a negative impact on the atmosphere.

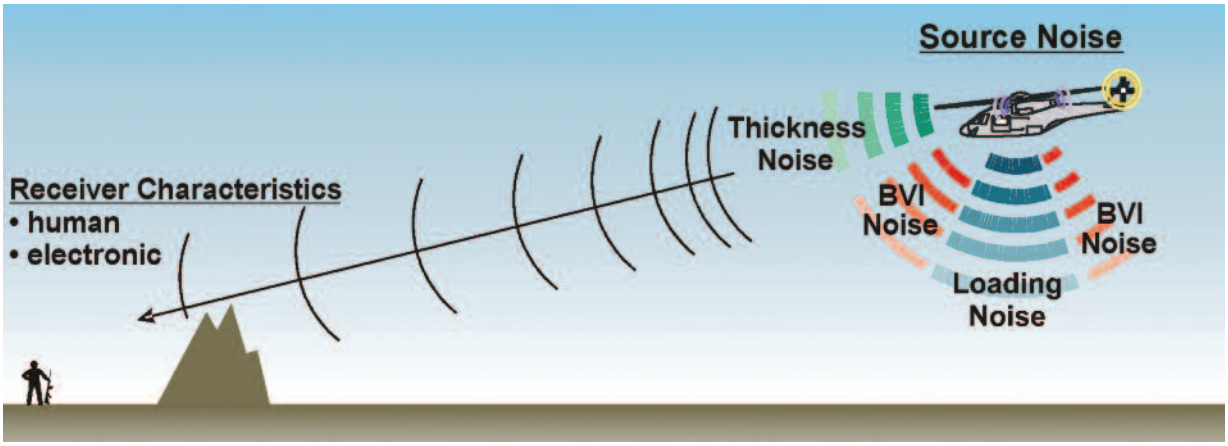


Advanced CFD-based computational tools will improve the accuracy of sonic boom prediction.

To be economically viable, future supersonic civil aircraft must be capable of supersonic flight over land. In order to achieve this result, questions associated with sonic boom noise must be addressed. Existing knowledge is based primarily on experiments conducted during the 1960s as part of the United States Supersonic Transport (SST) program and the Concorde development program. It was concluded that high-amplitude sonic booms were clearly unacceptable to a large segment of the population, and overland flight was prohibited. As a result, there has been little effort devoted to the study of sonic boom impact—except for the military context of prediction of booms within training areas.

NASA's F-15B #836 is shown in flight with the Gulfstream QuietSpike™ telescopic nose deployed. Photo by Jim Ross.

The ability to model sonic boom propagation from the aircraft to the ground will be a necessity, with all relevant physical phenomena included in such models. This will enable the accurate prediction of sonic boom levels on the ground for candidate new designs under realistic atmospheric conditions and for all flight conditions. In addition, in order to fully understand human reaction to sonic booms, it is necessary to be able to predict the transmission of booms into buildings. Both interior noise levels and structural vibration are of interest since both are important characteristics of the indoor environment.



Fundamental studies and modeling to understand generation and propagation of noise will enable development of noise reduction technologies.

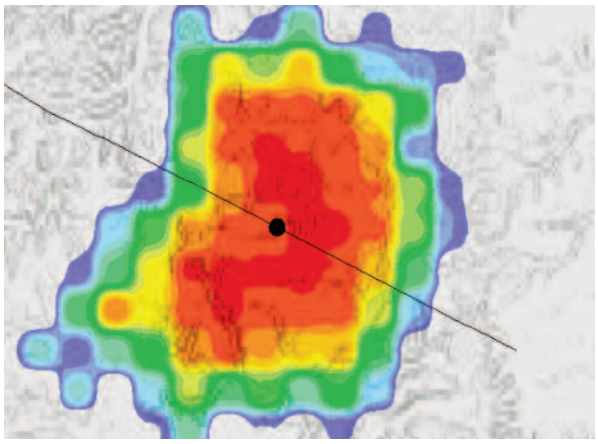
The goal of research on supersonic jet noise reduction is to enable vehicles in the vicinity of airports that are no louder than the existing fleet. Current research activities include development of novel noise-reduction technologies and creation of design and analysis tools to evaluate and optimize noise along with other aircraft performance measures. Several jet-noise reduction technologies are being developed: shock modification for reduced broadband shock noise; offset stream nozzles to reduce high-speed noise; unsteady actuators for time-dependent jet control; reshaping of the exhaust plume; and noise suppression using plasma actuators.

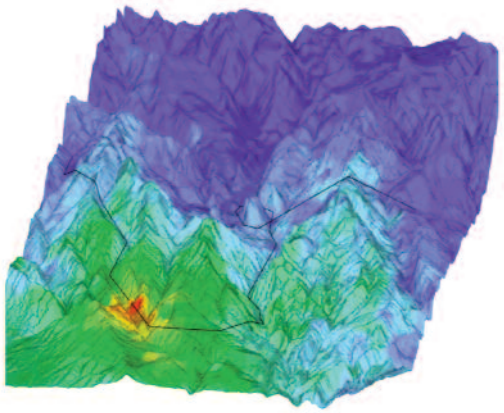
Noise Reduction for Rotary Wing Aircraft

Rotorcraft acoustics research focuses on the study and control of source noise, interior noise, gear noise, propagation, and concepts for low-noise operations in the future.

Interdependent task areas in the acoustics discipline concentrate on the development of validated prediction tools and capabilities for the rotorcraft vehicle system as well as for its components (i.e., rotor, engine, and interior noise, propagation, and acoustic scattering). System capabilities combine the components so that rotorcraft source noise and its propagation can be investigated for noise impact due to rotor design and/or rotorcraft operations and procedures.

Tools will cover a range of fidelity, in that they will include first-principle computational fluid dynamics (CFD) and computational structural dynamics (CSD) capabilities and validated analysis tools that are also appropriate for integration into multidisciplinary predictive capabilities for development and assessment of noise technologies and noise-mitigation procedures.





NASA joined with the Department of Defense, the University of Mississippi DARPA, and Boeing Helicopter on rotorcraft acoustics testing at Florida's Eglin Air Force Base. Noise from the aircraft was measured for various flight conditions. Computer models then took into account this measured noise from the helicopter, plus weather and terrain in forward flight, and predicted the noise heard on the ground. In the models, red denotes the hottest noise signatures. The image on the right shows an aircraft flying through mountainous terrain, with noise concentrated in the canyons and blocked by mountains. One outcome of this research is the development of flight paths that minimize the disturbance to those on the ground.

Computational tools and technologies for noise reduction developed in the Fundamental Aeronautics Program are contributing to the achievement of NextGen goals.