National Aeronautics and
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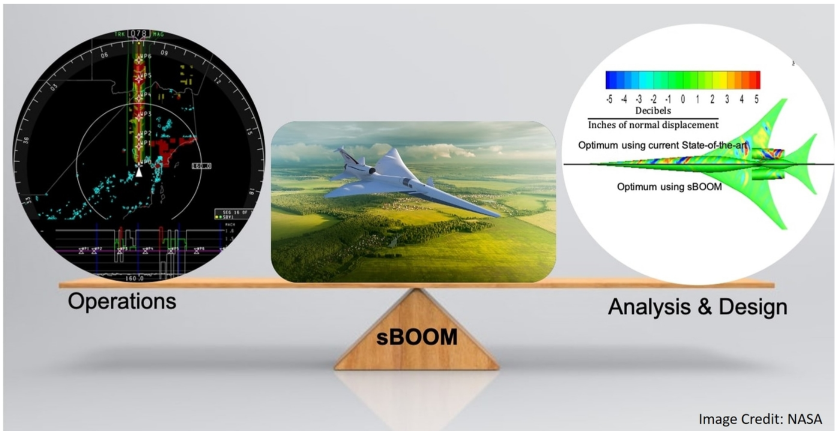

TECHNOLOGY SOLUTION

Aerospace

High-Fidelity Sonic Boom Propagation Tool

Predict and mitigate ground noise generated during supersonic flight

Innovators at the NASA Langley Research Center have developed a system for predicting sonic boom propagation of supersonic aircraft, the sBOOMTraj tool. This software system enables efficient computation and mitigation of sonic boom loudness across the entire duration of a flight mission. The primary challenge with supersonic flight remains the mitigation of the sonic boom to levels that will be acceptable to humans on the ground. As industry progresses towards realizing a commercial supersonic aircraft, the push from regulators to reduce noise levels has intensified. To meet this need, sBOOMTraj was developed to predict and mitigate sonic boom levels without resorting to less accurate shock theory or other numerical post-processing techniques. The software incorporates atmospheric and terrestrial effects, as well as functionality to handle aircraft trajectories and maneuvers. SBOOMTraj has potential applications in the design and development of next generation supersonic aircraft, and may also enable pilots and operators of such aircraft to plan flight paths to reduce their noise footprints.

BENEFITS

- Changed the supersonic aircraft design paradigm: provides immediate and realizable benefits in aircraft design with subtle and non-intuitive solutions through its unique adjoint-based optimization approaches
- Incorporates atmospheric effects: includes mean-flow atmospheric effects in computations to account for propagation in a moving medium
- Computes sonic boom loudness and pressure:offers computation of loudness or noise metrics along with sonic boom ground pressure profile
- Easily used with other advanced computational methods or standalone tools: sBOOMTraj can be distributed as an API library, enabling integration with advanced aircraft design frameworks (e.g., Cart3D, FUN3D) to allow realization of cross-discipline benefits using multi-disciplinary design optimization
- Predicts sonic boom levels across the entire supersonic mission: enables efficient predictions of ground signatures across the entire supersonic mission
- Potential to tie-in with other real-time technologies: using sBOOMTraj in conjunction with such technologies could enable integrated/holistic avionics suites in the cockpit

THE TECHNOLOGY

The sBOOMTraj tool offers an updated approach to accurately predict sonic boom ground signatures for supersonic aircraft. The tool is based on the numeric solution of the augmented Burgers equation where the regular Burgers equation is augmented with absorption, molecular relaxation, atmospheric stratification, and ray tube spreading terms in addition to the non-linear term from the regular equation. The primary idea behind such augmenting is that atmospheric losses are captured, which results in more realistic sonic boom predictions compared to linear theory methods. While previous iterations of the software (sBOOM) were limited to single point analysis (i.e., a point in supersonic climb or cruise), sBOOMTraj extends the prediction of sonic boom to multiple points along the supersonic mission. This includes updated functionality to handle aircraft trajectories and maneuvers as well as inclusion of all relevant noise metrics. The improvements allow efficient computation of sonic boom loudness across the entire supersonic mission of the aircraft.

The sBOOMTraj tool can predict ground signatures in the presence of atmospheric wind profiles, and can even handle non-standard atmospheres where users provide temperature, wind, and relative or specific humidity distributions. Furthermore, sBOOMTraj can predict off-track signatures, ground intersection location with respect to the aircraft location, the time taken for the pressure disturbance to reach the ground, lateral cut-off locations, and focus boom locations. The software has the ability to easily interface with other stand-alone tools to predict the magnitude of focus, post-focus, and evanescent booms, and also has the ability to handle different kinds of input waveforms used in design exercises.

The sBoomTraj tool could be extremely useful in supersonic aircraft operations as it can predict where sonic booms hit the ground in addition to providing the magnitude of sonic boom loudness levels using physics-based simulations. Using this tool, pilots may be able to steer supersonic aircraft away from populated areas while also allowing real-time adjustments to their flight trajectories, allowing trade-offs associated with sonic boom, performance and acceptability. The predicted sonic boom loudness contours during supersonic flight may also be used in supersonic aircraft design and development, including certification of aircraft under future regulations that may be imposed.

sBOOMTraj offers a revolutionary approach to mitigating sonic boom through its unique sonic boom adjoint equations. This potentially has immediate and realizable benefits in supersonic aircraft design when integrated with other disciplines. The NASA technology can potentially aid in supersonic aircraft operations with its integration in a cockpit interactive application that can provide feedback to the pilot on sonic boom impingement areas on the ground with real-time atmospheric and terrain updates. sBOOMTraj has the potential to support both aircraft design and operations, which is extremely rare.

APPLICATIONS

The technology has several potential applications:

- Aerospace and Aviation: design and development of supersonic aircraft
- Transportation: certification and operation of next generation supersonic aircraft for commercial aviation
- Military: real-time adjustments to flight trajectories and maneuvers to reduce sonic-boom propagation of military supersonic aircraft

PUBLICATIONS

Patent No: 11,492,134

"Advanced Sonic Boom Prediction Using the Augmented Burgers Equation," Rallabhandi, Sriram K., July 2011, https://arc.aiaa.org/doi/10.2514/1.C031248

"Sonic-Boom Mitigation Through Aircraft Design and Adjoint Methodology," Rallabhandi, Sriram K. et al., March 2014, https://arc.aiaa.org/doi/abs/10.2514/1.C032189

More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Langley Research Center

Mail Stop 020
Hampton, VA 23681
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

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