Analysis of the Effects of Streamwise Lift Distribution on Sonic Boom Signature

The objective is to find ways to reduce sonic booms.

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Investigation of sonic boom has been one of the major areas of study in aeronautics due to the benefits a low-boom aircraft has in both civilian and military applications. Current Federal Aviation Administration regulations prohibit supersonic flight over land due to potential effects the sonic boom may have on structures and humans.

This work conducts a numerical analysis of the effects of streamwise lift distribution on the shock coalescence characteristics. A simple wing-canard-stabilator body model is used in the numerical simulation. The streamwise lift distribution is varied by fixing the canard at a deflection angle while trimming the aircraft with the wing and the stabilator at the desired lift coefficient. The lift and the pitching moment coefficients are computed using the Missile DATCOM v. 707. The flow field around the wing-canard-stabilator body model is resolved using the OVERFLOW-2 flow solver. Over-set/chimera grid topology is used to simplify the grid generation of various configurations representing different streamwise lift distributions. The numerical simulations are performed without viscosity unless it is required for numerical stability. All configurations are simulated at Mach 1.4, angle-of-attack of 1.50, lift coefficient of 0.05, and pitching moment coefficient of approximately 0. Four streamwise lift distribution configurations were tested.

The pressure signatures are measured at 1.6 body lengths below the aircraft on the symmetry plane of the aircraft. The results to note are the relative location and the strength of the shocks for different configurations. Correlating between the amount of positive lift generated by a lifting surface and the shock location, it is clear to see that shock of the lifting surface that generates more positive lift “arrives” at the measurement point in front of the shocks of lifting surface that generate less positive lift. This observation is valid for all three lifting surfaces. This is clearly evident when comparing the shocks of the wing and canard for different configurations. The observation is not as clear in the stabilator; however, it is still valid when examining a magnified view of the plot. This shows that lift can directly influence the local Mach angle of shocks. In addition, an observation can be made that the shock of the wing that generates more positive lift is stronger compared to shocks generated from wing with less positive lift.

From the above observation of relationships among the lift, shock strength, local Mach angle, and shock location, it can be reasoned that the shock coalescence can be mitigated if all shocks generated on the aircraft are of equal strength. The shocks of such configurations would propagate at a same angle, which would prevent shock coalescence. Therefore, instead of producing two strong sonic booms, it would produce multiple, weaker sonic booms.

This work was done by Juan H. Agui of Glenn Research Center, and R. Vijayakumar of Aerofil. Further information is contained in a TSP (see page I).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18837-1.

Rad-Tolerant, Thermally Stable, High-Speed Fiber-Optic Network for Harsh Environments

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Future NASA destinations will be challenging to get to, have extreme environmental conditions, and may present difficulty in retrieving a spacecraft or its data. Space Photonics is developing a radiation-tolerant (rad-tolerant), high-speed, multi-channel fiber-optic transceiver, associated reconfigurable intelligent node communications architecture, and supporting hardware for intravehicular and ground-based optical networking applications. Data rates approaching 3.2 Gbps per channel will be achieved.

The high-speed 3.2-Gbps components, coupled with their Intelligent Node architecture, or universally with other architectures, will allow for orders of magnitude increases in the levels of automated onboard science data processing. Pure hardware processing capabilities have been achieved with the flexibility of reprogrammability utilizing FPGA control chips in the Intelligent Node architecture. Rad-tolerant versions of the current FPGA being evaluated are available through Xilinx. Due to the high-speed designs and partnerships
A new fluorescence cell has been developed for the laser induced fluorescence (LIF) detection of formaldehyde. The cell is used to sample a flow of air that contains trace concentrations of formaldehyde. The cell provides a hermetically sealed volume in which a flow of air containing formaldehyde can be illuminated by a laser. The cell includes the optics for transmitting the laser beam that is used to excite the formaldehyde and for collecting the resulting fluorescence. The novel cell is used to sample a flow of air containing formaldehyde can be illuminated by a laser. The cell includes the optics for transmitting the laser beam that is used to excite the formaldehyde and for collecting the resulting fluorescence. The novel cell is half the size of a White-merriott cell. In these implementations, two or three mirrors are used to obtain multiple reflections of the laser (30+ passes) within the cell, resulting in increased laser fluence in the detection region and thus, higher detection sensitivity.

A smaller, simpler, and more robust LIF detection cell was designed for a new instrument prototype. The primary consideration in the detection cell is the sensitivity it provides to detecting a species with LIF. The new design forgoes the multipass approach that increases laser fluence. Instead, the focus is on the increased fluorescence collection efficiency and decreased stray light factors. The new fluorescence detection cell uses a single laser pass that is carefully baffled to reduce stray light. The key features in the reduction of stray light are the placement of precision, laser-machined apertures; the use of high-grade black absorptive paint; and wedged or angled anti-reflection-coated laser windows.

The small detection volume illuminated by the single laser pass allows higher numerical aperture optics to collect the fluorescence. An aspheric lens with NA = 0.66 is used to image the fluorescence on a large-area PMT. The use of the high NA aspheric lens and the placement of the PMT close to the illuminated volume are the key features for the high collection efficiency.

The overall performance of the cell is comparable to the performance of a White-type multipass cell that has 32 passes. The size of the new cell is half the size of a White cell with comparable sensitivity. All components are either off-the-shelf or standard products. No custom optics were used in this design. Most importantly, the cell is extremely simple to adjust or align, and once aligned, it is insensitive to thermal and mechanical distortions.

This work was done by Thomas Hanisco and Maria Cazorla of Goddard Space Flight Center, and Andrew Swanson of the University of Maryland, Baltimore County. Further information is contained in a TSP (see page 1). GSC-16433-1