Paper ID: 16119
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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Launch Services, Missions, Operations and Facilities (2)

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SCALE MODEL STUDIES ON LAUNCH VEHICLES FOR CHARACTERIZING THE LIFTOFF ACOUSTICS AND SUPPRESSION

Abstract

Investigation on the supersonic jet noise during the lift-off of an advanced launch vehicle is complicated by the simultaneous flow of multiple jets, and their deflection by jet deflectors. Further, the presence of the launch pedestal service structure and the moving vehicle itself act as reflecting surfaces, which contribute to the acoustic environment. The primary source of noise is the two jets emerging from the base of the launch vehicle at high Mach number. The present work involves the suppression of noise as measured at different parts of the launch vehicle in a small-scale replica of a full launch pad for different locations on the vehicle along its vertical lift-off trajectory. Jet noise is suppressed by water injection at different locations in the launch pad such as the upstream and downstream edges of the jet deflector cover-plate, bottom and top surfaces of the launch pedestal and at two different locations on the service structure. Series of model studies were conducted with different scales and driving fluids for characterizing the aeroacoustic ambience simulating lift-off environment. An acoustic suppression system based on water injection on the supersonic jet exhaust from the rocket nozzle has been derived through these experimental model studies. The adequacy of scaling factor for models and substitute cold and hot driving fluids for the rocket exhaust was meticulously chosen for achieving reasonably accurate sound reduction level prediction for the full scale with various water injection schemes. The suppression system with optimum water injection parameters for the launch pad was derived after conducting a series of experiments by varying independently each water injection parameters like injection location with respect to the nozzle exit plane, injection angle, injection pressure and mass flow rate etc. Smaller scale model with surrogate gas allows conducting a large number of tests with relative ease for the optimization of each injection parameter. Finally, the

derived injection parameters were verified through scale model testing with actual solid rocket motors firing. From the tests, it is found that sustained suppression of noise is obtained only with injection of water in successive stages closer to the nozzle exit, in liftoff.From the spectral characteristics, it is observed that water injection near the nozzle exit affects all the noise sources, i.e., both the high-frequency and low-frequency sources simultaneously.Based on these experimental results, an acoustic suppression system using water injection is being realized at launch pad.