Handling Qualities Prediction of an F-16XL-Based Reduced Sonic Boom Aircraft

This technique helps determine how much an aircraft could be modified without affecting its baseline handling qualities.

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A major goal of the Supersonics Project under NASA’s Fundamental Aeronautics Program is sonic boom reduction of supersonic aircraft. An important part of this effort is development and validation of sonic boom prediction tools used in aircraft design. NASA Dryden’s F-16XL was selected as a potential testbed aircraft to provide flight validation.

Part of this task was predicting the handling qualities of the modified aircraft. Due to the high cost of modifying the existing F-16XL control laws, it was desirable to find modifications that reduced the aircraft sonic boom but did not degrade baseline aircraft handling qualities allowing for the potential of flight test without changing the current control laws. This was not a requirement for the initial modification design work, but an important consideration for proceeding to the flight test option.

The primary objective of this work was to determine an aerodynamic and mass properties envelope of the F-16XL aircraft. The designers could use this envelope to determine the effect of proposed modifications on aircraft handling qualities.

The approach to this objective had two parts. First was validation of the existing NASA DFRC F-16XL simulation that would be providing data for this effort, as well as the handling qualities tools that would analyze the data. The second part was modifying the simulation to represent the modified aircraft and determining the modification envelope, which showed how much of the aircraft could be modified without affecting baseline aircraft handling qualities.

Validation of the F-16XL simulation was important as the simulation had not been used for research in over 10 years. Updates and modifications had been made to the simulation for use as a demonstration device. Check case data included with the simulation were compared with data generated from the current simulation and matched almost exactly. Pilot input from flight test data was fed into the simulation, and aircraft response was compared to simulation response.

Validation of the handling qualities tools was also important as these tools had been updated and modified since being used for F-16XL analysis. Flight test and simulation data were input into the handling qualities tools and compared to past results.

With the simulation and handling qualities tools validated, the simulation was modified to represent potential aerodynamic and mass properties changes due to the aircraft modifications. The values of these parameters represent a best guess of how proposed modifications would affect aircraft aerodynamic and mass properties. The parameters selected were those thought to be most affected by the modifications.

The simulator was set up at one of a list of various flight conditions with one of the parameters modified. Pitch and roll frequency sweeps were input into the simulation and simulation response was recorded. These data were then input into the handling qualities tools, and the handling qualities of the modified aircraft were predicted. The final step was to have pilots perform a task in the simulator and make handling qualities ratings and comments. A tracking task was set up in the simulator and performance criteria were defined. This would allow final validation of the handling qualities tools.

This work was done by Huu Trinh and William Myers of Marshall Space Flight Center. Further information is contained in a TSP (see page 1). DRC-009-040