ment of these slots would be chosen, in conjunction with those of other components, to optimize performance.

The upper end of the injection tube would be covered with a cap that would contain a number of outer slots equal to the number of injection slots. The cap would translate axially (up and down in the figure). Two retaining pins (of which one can be seen in the figure) in holes in the cap would protrude into grooves in the injection tube to prevent the cap from coming off the injection tube while allowing the cap to slide freely only within limits. The pins would also keep the outer slots in the cap aligned with the injection slots in the tube.

A coil spring would lie in an annular recess in the injection tube and would be compressed between the bottom of the recess and an inner flange at the bottom of the cap. Small tangential holes could be included, in addition to the outer slots, to allow initial flow at the lowest power level. The cap and the exposed portion of the injector tube would protrude into a manifold containing the fluid to be injected, and outer flanges on the cap would contribute drag between the cap and the fluid to damp any oscillatory motion of the cap, thereby helping to suppress instability. Labyrinth-type seal grooves would prevent gross leakage, so that most of the flow must enter the injection tube either through the tangential slots or the small tangential holes.

In operation, the pressure drop between the manifold and the inside of the cap (which pressure drop would be part of the total pressure drop from the manifold to the combustion chamber) would create a force that would push the cap downward against the spring. This downward motion would cause the outer slots in the cap to partially expose the tangential slots in the injection tube, thereby limiting the pressure drop by increasing the cross-sectional area for flow into the tube. The number and dimensions of the tangential slots would be chosen in conjunction with the stiffness and preload of the spring to obtain the optimum pressure drop as a function of the rate of flow (and, hence, as a function of the combustion power level).

This work was done by Huu Trinh and William Myers of Marshall Space Flight Center.

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32518-1.

✿ 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.

Dryden Flight Research Center, Edwards, California

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 Bruce Cogan and Seung Yoo of Dryden Flight Research Center. Further information is contained in a TSP (see page 1). DRC-009-040