Paper ID: 70594
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IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

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AERODYNAMIC INTERFERENCE AND SEPARATION ANALYSES OF A TWO-STAGE SPACEPLANE FOR SMALL SATELLITE LAUNCH

Abstract

Two-Stage-To-Orbit (TSTO) spaceplane is a promising next-generation space transportation system because of its reusability, high frequency operation, and mission flexibility. The booster and orbiter stages of TSTO spaceplane are separated at supersonic or hypersonic speed under high dynamic pressure. Since complicated aerodynamic interference between the booster and orbiter exists, the separation operation and attitude control are important research issues.

This paper presents 1) the computational fluid dynamics (CFD) analysis for various relative positions and angles and 2) the flight simulation of longitudinal separation motion for a TSTO spaceplane of winged booster that has non-winged expendable orbiter piggyback.

The CFD analysis is performed at Mach number of 5.8 and angle-of-attack between -5.0 and 10.0 degrees in terms of relative axial positions, vertical distances and pitch-angles between the booster and orbiter. The interference pitching moments around the center of mass for both the booster and orbiter are evaluated by the equivalent elevator and gimbal deflections respectively. The results show that the booster must deflect the elevator nose down and the orbiter must deflect the gimbal angle nose up in order to avoid the collisions, when the relative vertical distance and pitch-angle between the booster and or orbiter are small.

The longitudinal three-degree-of-freedom flight simulation is performed for the cases of with and without thrust of orbiter to evaluate the passive separation motion from the angle-of-attack of 1.0 to 10.0 degrees. Aerodynamic forces and moments acting on the booster and orbiter are calculated by interpolating the data tables obtained by CFD analysis. It is found that the booster and orbiter separate without collision in all the simulation cases.