SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems Verification and In-Flight Experimentation (6)

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SHEFEX I+II POST-FLIGHT ANALYSIS: STARTING POINT FOR A VIRTUAL FLIGHT TEST ENVIRONMENT

Abstract

In order to advance hypersonic space transportation such that it becomes an affordable and reliable routine operation as the air transportation of today, essential improvements, far beyond current technologies are required to fulfill mission and safety constraints and to ensure economic viability. Due to the significant technical progress in computer technology and computational fluid mechanics more and more strategies for the direct interdisciplinary coupling between fluid mechanics and structure mechanics or aerodynamics and flight mechanics are developed. Within the design process of hypersonic aircraft a direct coupling between fluid mechanics and flight mechanics, structure and control enables an immediate analysis of a projected vehicle. For hypersonic vehicles this is of special interest, as the ground test options are limited and demonstration of full vehicles in flight is risky, expensive and time consuming.

Therefore, a coupling of the DLR Navier-Stokes Code TAU with commercial FEM solvers like ANSYS or Nastran, the trajectory code REENT and Simulink for the definition of control algorithms is currently under way. The mid-term goal is to establish a numerical environment, which enables the numerical flight test of autonomously flying, fully controlled and structurally flexible future space transportation configurations.

While high fidelity CFD results are today based on the solution of the Navier-Stokes equations, they still require validated models e.g. to account for laminar / turbulent transition, turbulence as well as high temperature and combustion effects. Therefore, the environment requires systematic ground tests and efficient, more demanding, flight experiments for validation. At DLR the post flight analysis of the Shefex I and Shefex II flights is still extensively under way. The results deliver valuable knowledge for the aforementioned approach and its proof.

The present paper introduces the numerical environment and highlights selected results of the post-flight analysis which enables to predict the heating process of the sharp edged TPS in extensive detail and allows the 6DOF rebuilding with focus to aerodynamic and flight mechanic aspects. The comparison of flight experiment and numerical analysis enables deep understanding of phenomena and points to potential lack of knowledge for the successful design of future flight experiments. Finally, an outlook is given how the target of a "numerical flight test" can be reached and shortcomings to be overcome are addressed.