SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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AEROTHERMODYNAMIC AND TPS DESIGN ANALYSIS OF THE USV3 RE-ENTRY VEHICLE

Abstract

In the last ten years, CIRA is being strongly involved in many research activities related to re-entry systems technologies in the frame of national and international programs. Two of main topics covered are Aerothermodynamics and Thermal Protection System with both numerical and experimental approaches thanks to in house developed CFD code and PWT facility. Actually in the frame of CIRA USV program, the USV3 project is ongoing to design and to develop an autonomous, unmanned space vehicle able to perform an end-to-end mission from launch, on-orbit operations, re-entry and landing on conventional runway. The present paper reports on design analysis accomplished to assess the aerothermal environment the vehicle experiences during descent. CFD analyses have been carried out to address aerothermodynamic flowfield past the concept and surface distributions of heat flux, pressure, and shear stress to design the vehicle Thermal Protection System. Indeed, a summary review of the USV3 aerothermodynamic characteristics has been provided at several points of nominal descent trajectory as the peak heating conditions, according to the Trajectory-Based design approach. The code H3NS, developed at CIRA, was used to perform the CFD analysis in turbulent and chemical equilibrium and non-equilibrium flow conditions. The CFD assessment of the thermal load on the vehicle, has been used as input for the design of the TPS of the most critical parts of the vehicle. The TPS design is based on technologies with high Technology Readiness Level as project requirements. The external surface of the most thermally loaded regions shall be protected with Ceramic Matrix Composites.. The parts of the external surface that are heated below the 400C and that require a structural consistency shall be realized in metallic alloys. The external part of the vehicle that are not heavily loaded shall be protected with flexible external insulators . The cold structure shall be protected from excessive heating, using different layers of ceramic nonstructural insulating materials. The main aim of this phase of the design is to define the thickness needed for each layer of insulating material able to effectively protect the cold structure. For this tasks many different mono and bi-dimensional FEM models have been created, representative of the different parts of the vehicle. The different models account also for the use of different materials for the internal

cold structure. The optimization of the TPS stratification have been accomplished with the Design of Experiment numerical technique.