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AERODYNAMIC AND AEROTHERMODYNAMIC DESIGN OF THE USV3 RE-ENTRY VEHICLE *

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Abstract

This paper deals with the aerodynamic and aerothermodynamic design analysis of a conceptual aeroshape, designed to fit the constraints of VEGA launcher fairing and with the capability to perform an end-to-end mission from launch, orbit keeping, re-entry and landing on conventional runway. Aerodynamic and aerothermodynamic performances of the aeroshape under investigation were evaluated for the whole flight scenario by means of several numerical tools as low-order methods and computational fluid dynamics code. Results are provided in the paper and considered applicable to drive the choice of a more suitable aeroshape for a whole re-entry system development.

1. INTRODUCTION

Since 10 years, CIRA is involved in research activities related to the development of a flying test bed (FTB) for demonstration of key technologies for atmospheric re-entry from Low Earth Orbit (LEO) [1–6]. Recently, a FTB, called Polluce, carried by stratospheric balloon has experienced a flight from Mach 1.2 to splashdown using in the last phase of descent a subsonic parachute [7,8]. The FTB now under investigation at CIRA, namely USV3, is an Unmanned Space Vehicle (USV) concept that has to follow a set of technical guidelines on which relies the Italian Aerospace Research Programme (PRORA) [8–10]. Among others, the objective to perform an autonomous re-entry flight, with enhanced manoeuvrability and conventional landing by using ordinary gear on a runway is considered as mandatory [9]. In this framework, several design analyses are currently on going with the aim to address the development of an autonomous flying test bed able to perform an end-to-end mission from launch, orbit keeping, re-entry and landing on conventional runway. The reference aeroshape is based on a winged body concept with low wing aspect ratio in order to cope with VEGA launcher fairing constraint [2,3]. The advantages of using a winged body that relies on improved low speed flight, landing performance and hypersonic manoeuvrability must be weighted against the complexity of the design by aerodynamics and aerothermodynamics point of view.

Generally speaking, the choice for winged or lifting entry relies on a trade-off of many requirements such as: deceleration limits, atmospheric uncertainties, landing site or targeting and recovery, mass limitations etc. These mission requirements will translate into aerothermodynamic requirements during the vehicle design process where at each position in time during flight limits imposed on g-force, dynamic pressure, heat flux, heat load, wall temperature etc. are not to be exceeded. These limits depend of course on the state of the art in space technology. The flight aerothermodynamic loads depend on the atmospheric characteristics such as density and temperature, the vehicle aerodynamic parameters such as geometry, mass, and aerodynamic coefficients, and on flight conditions such as incidence and speed.

The most important vehicle parameters during reen-

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