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MISSION ANALYSIS AND SIMULATION OF NOMINAL AND OUT-OF-NOMINAL MISSION SCENARIOS FOR SUBORBITAL VEHICLES: AN ITALIAN CASE-STUDY

Abstract

On June 2023, the first commercial suborbital launch with horizontal take-off and landing of Virgin Galactic's WhiteKnight Two (WK2) / SpaceShipTwo (SS2) "Unity" system was successfully completed at Spaceport America in New Mexico (USA). The launch set a milestone on the path of development and consolidation of the Commercial Space Transportation in the context of the New Space Economy. This paper aims at preliminary investigating potential future suborbital vehicles operations on the Italian territory. To achieve this goal, it is of uttermost importance to simulate nominal and out-of-nominal situations within a proper mission analysis, characterizing the aerodynamic and propulsive performance of a representative suborbital vehicle system. In this paper, a multi-fidelity approach is pursued to enable the fast and agile assessments of these characteristics, followed by more accurate analyses. Following this rationale, a first aerodynamic database is built, before getting access to a 3D CAD model of the vehicles, by making use of analytical semi-empirical models. These models, already available in literature and specifically addressing high-speed vehicles, are compared and duly customized in order to better capture the peculiarities of the specific case study. In particular, 4 different aerodynamic databases are generated in order to capture all the configurations of a vehicles system representative of the WK2/SS2 one: (i) the coupled configuration, where mother aircraft and suborbital spaceship are mechanically joined, (ii) the mother aircraft standalone, (iii) the suborbital spaceship feathered (to increase drag during the re-entry phase) and (iv) the suborbital spaceship un-feathered. Complementary, the propulsive database is generated by modelling the propulsive systems modes of operations through thermodynamic 0D simulations. The defined aerodynamics and propulsive databases capture the variation of aero-propulsive characteristics of the reference vehicles at different speeds, angles of attack and altitude conditions. These databases are the used to run multiple mission studies using the commercial software ASTOS. In particular, this

paper aims at identifying few feasible mission options from/to the representative environment of Grottaglie Airport, in southern Italy, during nominal conditions as well as following contingency or emergency scenarios.