IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

Author: Mr. Tommaso Mauriello
Sirius Space Services, Italy

Mr. Jascha Wilken
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Space Systems, Germany
Mr. Leonid Bussler
DLR (German Aerospace Center), Germany
Mr. Steffen Callsen
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Space Systems, Germany
Dr. Martin Sippel
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany

MULTIDISCIPLINARY DESIGN ASSESSMENT OF PROMISING AERODYNAMIC SHAPES FOR HYPERSONIC PASSENGER TRANSPORT

Abstract

Hypersonic vehicles for point-to-point transport of passengers on Earth need to be able to minimize the acoustic impact on overflown populations. Populated areas can either be overflown outside of the atmosphere or circumnavigated, the best option depending upon the geographical features of the route under question. In order to enable as many route options as possible, an aerodynamic shape is needed that can both perform high angle of attack re-entries after a ballistic arch as well as deliver high L/D ratios in quasi-stationary flight over unpopulated areas [1]. An MDAO methodology was developed with the objective of optimizing the SpaceLiner passenger stage aerodynamic shape to perform both the types of re-entry trajectories. The tasks of the MDAO methodology were (1) the computation of vehicle performance from a wing shape parametrization using fast estimation methods, (2) the exploration of the design space by means of parametric studies and (3) the optimization of the vehicle aerodynamic shape. Upon completion of a multi-objective evolutionary wing-shape optimization, a promising configuration was identified, and selected as a first candidate aerodynamic shape for the SpaceLiner 8 passenger stage. The expected improvement in re-entry performance was validated by direct comparison with the previous design configuration along point-to-point (P2P) routes of interest. After an overview of the MDAO methology, this article focuses on providing a comprehensive analysis of this new configuration and its performance assessment at subsystems' level, as within the MDAO methodology simplifying assumptions had to be made for some disciplines, and their validity were analyzed *a posteriori*. Subsonic aerodynamics at landing were cross-checked with computational fluid dynamics (CFD) simulations, validating the predicted lift generation at subsonic speeds, and obtaining an improvement in trim performance with respect to the results obtained with fast estimation methods. The thermal protection subsystem was recomputed, assessing the difference in mass and center of gravity position with respect to the estimated values. The effects of an uncertainty on the center of gravity position were also evaluated in terms of trim performance. Re-entry performance (heat flux and population disturbance) was assessed on additional P2P routes of interest, and the obtained re-entry profiles treated in detail. Overall, the cross-checks at subsystems' level provided promising results and consolidated the choice of the selected aerodynamic shape as the baseline configuration for the SpaceLiner 8 passenger stage.

[1] Sippel, Martin et al.: Towards the next step: SpaceLiner 8 pre-definition. International Astronautical Congress 2023, Oktober 2023, Baku, Azerbaijan.