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Author: Mr. Sven Stappert
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany

Mr. Jascha Wilken
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Space Systems, Germany
Mr. Leonid Bussler
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany
Dr. Martin Sippel
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany
Dr. Josef Klevanski
DLR (German Aerospace Center), Germany
Mr. Christian Hantz
DLR (German Aerospace Center), Germany
Dr. Sebastian Karl
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany
Ms. Lâle Evrim Briese
DLR, German Aerospace Center, Germany
Dr. Klaus Schnepper
DLR (German Aerospace Center), Germany

EUROPEAN NEXT REUSABLE ARIANE (ENTRAIN): A MULTIDISCIPLINARY STUDY ON A VTVL AND A VTHL BOOSTER STAGE

Abstract

The recent success of the emerging private space companies SpaceX and Blue Origin in landing, recovering and relaunching reusable first stages have demonstrated the possibility of building reliable and low-cost reusable first stages. Thus, the importance for assessing whether such a reusable launch vehicle (RLV) could be designed and built in Europe has increased. Due to this renewed interest in RLVs, the German Aerospace Center (DLR) has initiated a study on reusable first stages named ENTRAIN (European Next Reusable Ariane). Within this study two different return methods, respectively vertical take-off, vertical landing (VTVL) and vertical take-off, horizontal landing (VTHL) with winged stages, are investigated. The goal is to assess the impact of the return method on the launcher design and to conduct a preliminary design for a possible future European RLV.

The ENTRAIN study is divided into two parts. The first part of the study featured a broad RLV system study considering different propellant combinations, staging velocities, engine cycles and return modes for the investigated RLVs [1]. By the end of the first part of this study, one promising VTVL and one promising VTHL concept were selected to be subjected to a detailed multidisciplinary investigation of the respective launchers. A VTVL launch concept with a LOX/LCH4 lower stage and a LOX/LH2 upper stage was selected. The selected VTHL launcher is composed of two LOX/LH2 stages and is supposed to be captured in air and towed to the landing site by a another aircraft.

The selected configurations are investigated in depth considering numerous aspects crucial for the design of an RLV stage. First, the launchers are investigated with regard to the aerodynamics and aerothermodynamics of the ascent and descent phase using sophisticated tools and CFD analyses to de-

termine re-entry loads and aerodynamic properties. Furthermore, the structural design of such a launch system is evaluated considering required re-entry hardware. Within this paper the latest status of the two RLV systems preliminary design process is presented. Furthermore, the critical aspects of each launcher shall be identified and possible solutions are discussed. Finally, the two launchers are evaluated with respect to performance into various target orbits considering different possible market scenarios.

[1] Wilken, J., Stappert, S., Bussler, L., Sippel, M., Dumont, E., "Future European Reusable Booster Stages: Evaluation of VTHL and VTVL Return Methods", IAC-18-D2.4.1, 69th International Astronautical Congress, Bremen, Germany, 01.-05. October 2018, https://elib.dlr.de/122188/