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FUTURE EUROPEAN REUSABLE BOOSTER STAGES: EVALUATION OF VTHL AND VTVL RETURN METHODS

Abstract

Reusability of launch systems will strongly impact the launch service market if certain boundary conditions, such as sufficient reliability and low refurbishment costs, can be achieved. The German Aerospace Center (DLR) is performing a systematic investigation of return methods for a reusable booster stage of a future European launch vehicle. This launcher shall be able to transport 7.0 t to a GTO, launching from the European spaceport in Kourou. The final goal is the determination of the impact of the different return methods on a technical, operational and economical level and the identification of their potential for a future European launch system. Compared to previous work presented on the IAC 2017, this paper includes winged vertical take-off and horizontal landing (VTHL) as well as winged and non-winged vertical take-off and vertical landing (VTVL) configurations. Additionally, the design parameters have been refined for a better accuracy. The main focus of this paper lies on the comparison of the different return options and their impact on the various subsystems and the entire launcher design and performance.

The preliminary results of a first design phase employing structural indexes derived from existing stages were used to narrow down the field of potential designs, especially with regard to the rocket staging. The selected launchers were modelled in more detail, including the preliminary design of major subsystems such as propulsion, aerodynamics, structure, propellant management and thermal protection. Key system drivers and subsystems, for which the reusability capability has a large impact, were investigated in more detail. These comprehensive designs allow an in-depth analysis and comparison of the different propellant options, especially for those for which no historical rocket designs exist (i.e. LCH4 or LC3H8). The comparison of different potential propellants is made across the different return options in order to assess the suitability of the various possible combinations. The fuels investigated in combination with liquid oxygen are kerosene, liquid hydrogen, methane and propane as well as a selection of subcooled variations. Reusable engines and their impact on the booster stage are also evaluated. Finally, the impact of the selected target payload mass and orbit is explored by determining and comparing the launcher performances for different possible target orbits.