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CONCEPTUAL DESIGN OF "SILVER EAGLE" - COMBINED ELECTROMAGNETIC AND HYBRID ROCKET SYSTEM FOR SUBORBITAL INVESTIGATIONS

Abstract

This paper reports on the conceptual design of a combined semi-reusable electromagnetic and hybrid rocket system for suborbital applications, which is developed by the German Aerospace Center (DLR). SILVER EAGLE uses a ground based Lorentz rail accelerator (LRA) to reach supersonic initial velocity (approx. M = 1.6). During the motion inside LRA tube the rocket vehicle is exposed to acceleration of 3300 g's. Later during the vehicle ascent, an advanced hybrid rocket engine is used as a second stage accelerator. Flying along a suborbital trajectory the propelled vehicle, carrying up to 5 kg payload, achieves the apogee point at an altitude of 100 km. SILVER EAGLE is a new and flexible multipurpose suborbital vehicle, particularly advantageous for upper atmosphere investigations and microgravity experiments. It can be further used as technology demonstrator and platform for testing of superior technologies in aerospace engineering. By replacement of the payload container the vehicle can be transformed into an Unmanned Aerial Morphing Vehicle for early warning, monitoring the appearance of natural disaster (Tsunami, Earth-quakes i.e.) and for hazardous chemical and radiation catastrophe monitoring.

The first part of the paper deals with the design of a LRA with an acceleration length of 16 m. According to the mission parameters, a generic layout considering operational parameters such as size, shape, energy and power, is discussed. Various design options such as rail segmentation, magnetic field augmentation and the applied armature technology are analyzed. Special attention is paid to technical solutions increasing the launch efficiency of the LRA on one side and on inter-stage coupling on the other side.

In the second part of the paper solutions for the propelled vehicle are presented: the lightweight structure, thermal protection, advanced hybrid rocket engine (HRE), aerodynamic design/stabilisation and payload packages. The applied coupled aerodynamic and flight mechanic calculations based on 3DOF enable the estimation of the trajectory for different applications. The advanced HRE, based on non-cryogenic High Test Peroxide (HTP)/ Hydroxyl -Terminated Polybutadiene (HTPB) high-energy propellants is described in detail. The influence of reaction rates, fuel/oxidizer mixing ratio and selection of regulating system for process control on combustion efficiency, engines specific impulse and characteristic velocity are discussed. A special feature of this propulsion system is a catalytic HTP ignition for highly reliable operation.