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HYBRID ROCKET ENGINES AS AN OPTION TO FUTURE APPLICATION FOR THE BRAZILIAN  
SPACE SECTOR

**Abstract**

The contemporary space transportation industry is based on complex and expensive rocket engines derived from the last century successful space programs of the United States, Russia, and the European Union. The development and operational costs of such technologies have been supported mostly by government agencies, to acquire and ensure the strategic capability to send commercial and military satellites into space. More recently, the opening of the market to private companies and the advances of electronic and power systems are gradually reducing the size and weight, and thus the launch costs, of satellites. The investments brought by non-governmental funding in some sectors of the space industry have been causing a new flow of progressive reduction of costs and the improvement of technologies and processes. This new context induced a revision of the classical approach in the space sector leading not only to the development of innovative technologies but also bringing back old ideas and solutions which were previously overlooked. In the sphere of rocket propulsion, the well-known hybrid rocket engines (HREs) recently have received substantial renewed interest for some specific applications, such as spacecraft orbit transfer (Haag, 2001), decelerator engine for re-entry capsules (Andrianov, et al., 2015), upper stages of launcher vehicles (Casalino and Pastrone, 2010), and small satellite launchers (Costa and Vieira, 2010), (Schmierer, 2019). Brazil has a long history of study in the field of HREs, mainly related to base science research of combustion behaviour, combustion instabilities phenomena, development of propellants and sounding rocket prototypes, as well as an established international net of collaborations. Based on the status of hybrid rocket propulsion in Brazil and the advancement of the HREs in the last decades, this technology can be considered as a future option for the Brazilian space program. This paper describes the past and actual status of hybrid rocket propulsion in Brazil, and the conceptual design of a HRE upper stage able to place small payloads ( 500 kg) at an equatorial Low Earth Orbit using Alcântara Launch Centre (CLA) as the launch site.