Advanced Hybrid Rockets for Future Space Launch

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Under a contract from AFRL, Space Propulsion Group Inc.(SPG) has been developing paraffin-based hybrid rocket technology as a cost-effective and safe alternative to solid and liquid rockets. The fast burning paraffin-based fuels allow for a single circular port design, eliminating the significant disadvantages of multiport systems, such as the low fuel utilization. The major tasks of the technology development program are 1) fuel formulation, 2) fuel structural modeling and testing, 3) motor internal ballistic design, 4) fuel processing. Each of these tasks includes modeling and testing (laboratory, component or motor testing) efforts which are used jointly to enhance the understanding of the physical/chemical processes that take place in the propulsion system so that scalable design tools for hybrid rockets can be developed.

Liquid oxygen (LOX) has been selected as the primary oxidizer in this program due to its high performance, low cost, availability and relative safety. Despite its advantages, the use of cryogenic liquid oxygen presents significant difficulties in the development of stable and efficient motors. In the previous programs these difficulties have been addressed by the injection of hot combustion gases into the pre-combustion chamber (Lockheed Martin approach) or by the injection of pyrohoric liquids into the incoming LOX flow (AMROC approach). Both of these approaches, which concentrate on vaporizing the incoming oxidizer by an external heat source, result in significant systems complications leading to significant decrement in the competitiveness of the end product. SPG has managed to achieve stable and efficient combustion motor operation without resorting to any heat or pyrophoric mass addition. The stable behavior, which is achieved by a proprietary internal motor configuration, has been demonstrated using the 11 inch diameter (7,000 lbf thrust class) paraffin-based/LOX motor. Combustion efficiencies in the 95- 98% range have also been achieved in the same motor configuration.

SPG has successfully converted the 11 inch heavy weight motor to a carbon composite based flight weight system that can be used in applications requiring a total impulse of 466 kN-sec.

SPG has also started a scaled up testing effort of its paraffin-based/LOX motor technology. Development of a 22 inch flight weight paraffin-based motor has been started (including 8 test firings) This motor is capable of producing thrust levels up to 155 kN.

In this paper the results of a number systems studies shall be discussed. The following systems have been considered in the study:

1) Replacement of the GEM 60 solid rocket motor with the advanced hybrid rocket
2) Replacement of the Castor 30 solid rocket motor with the advanced hybrid rocket

3) Development of a three stage hybrid rocket based ground lunch system for injecting small satellites into low Earth orbit.

A ROM cost analysis for each system will also be included in the final version of the paper.

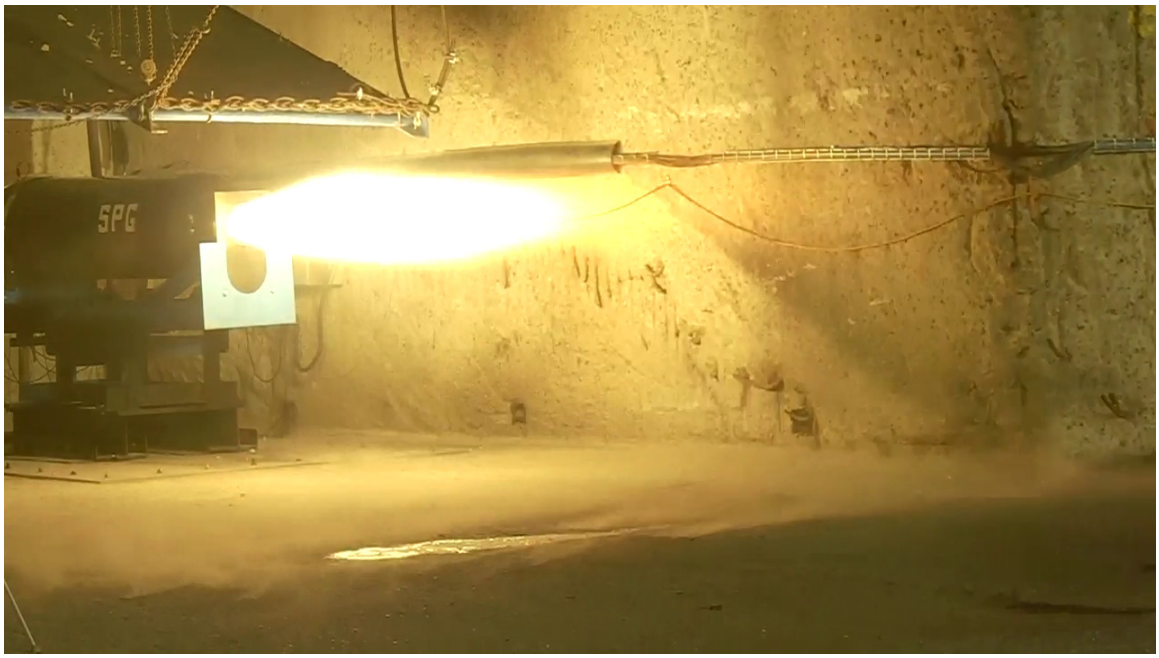

Figure 1: SPG's 22 inch motor firing.

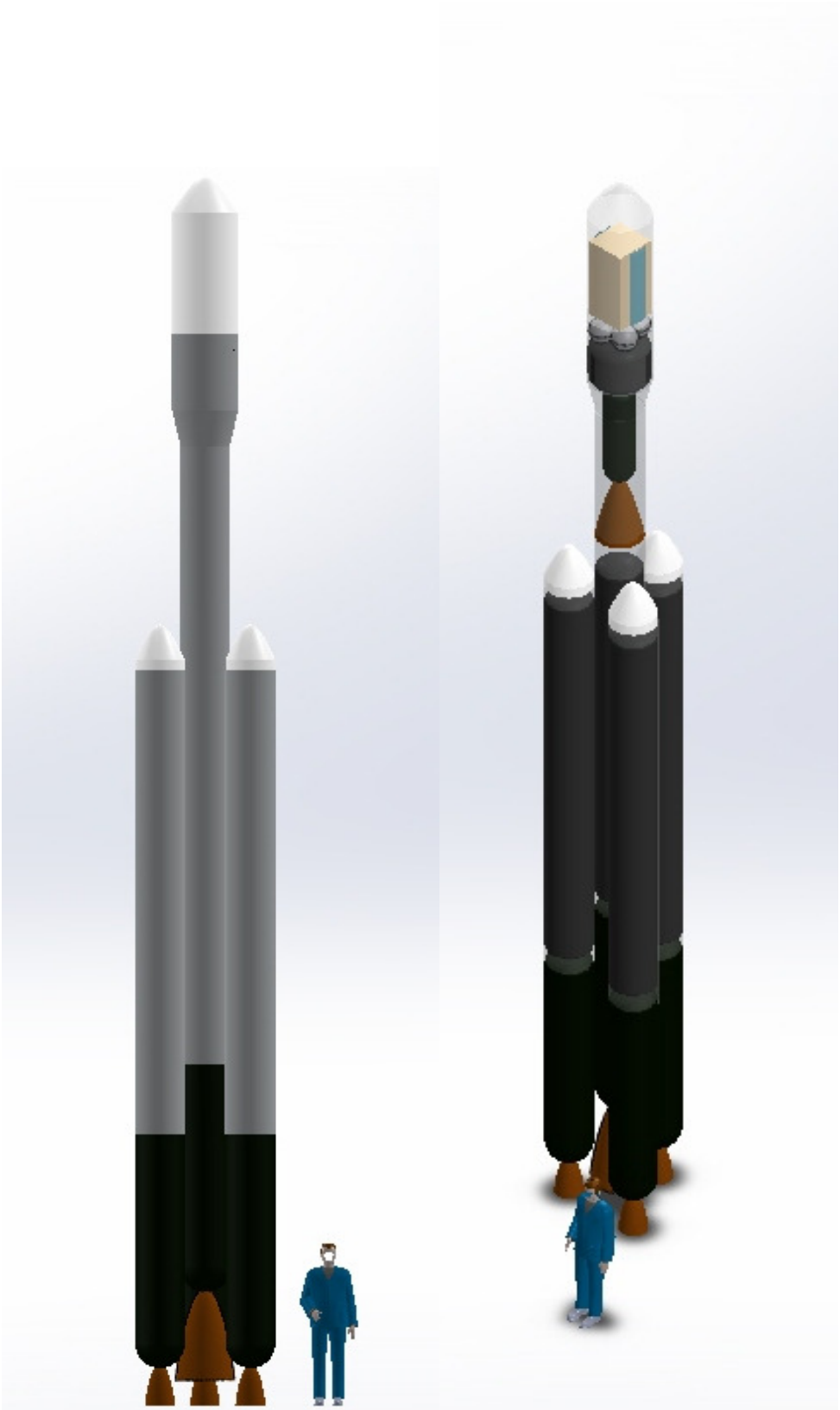

Figure 2: Three stage hybrid rocket launch vehicle