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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems Technologies (5)

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MULTIDISCIPLINARY DESIGN OPTIMIZATION OF GROUND AND AIR-LAUNCHED HYBRID ROCKETS

Abstract

Access to space is now more important than ever. For the last few years, smaller and smaller satellites are acquiring the capacity to do what was previously only possible with large platforms. Currently, most small countries can build a small satellite, but most cannot afford to launch one by themselves.

Air launching rocket vehicles has been touted as a possible solution to reduce the cost of both the launch vehicle and its operation, especially for the launch of small payloads. Most research in the field looks into solid rockets, here, however, hybrids are investigated. Hybrid rocket vehicles work by burning solid fuel with liquid oxidizer. Unlike solid rockets, hybrids can be re-ignited, are safer, and have a potentially higher orbital injection accuracy and specific impulse.

To study the feasibility and performance of such a solution, a Multidisciplinary Design Optimization tool was used. The tool is an improvement upon a previous software package that only supported solid rocket technology. It addresses trajectory computation, estimation of vehicle dimensions and propulsion performance and launch simulation. The tool was developed in C^{++}, and is now capable of handling multi-stage solid-only rockets, hybrid-only rockets and mixed configurations. It consists of performance and dimension estimators for individual rocket stages, these are integrated into a launch vehicle whose launch is simulated and analysed.

The tool has been used to optimize the configuration of a rocket vehicle designed to attain a circular orbit (eccentricity < 0.01) at 780 km altitude. By iterating on the design using an optimization process known as Particle Swarm Optimization, it attempts to reduce the take-off weight of its solutions. The tests allow one to compare hybrid propellant rockets to solid ones in both air and ground launched scenarios. Based on the assumptions made, it was found that air-launch reduces GTOW by about 70 % when compared to an equivalent ground launch. It is also found that, in general, hybrid rockets have a GTOW similar to, or higher than, their solid counterparts. The research also tackles whether mixed configurations (with both solid and hybrid stages) allow one technology to strengthen the other. Results are also shown on the launch performance of existing engines, to both validate the models and offer insight to manufacturers into how their vehicles will perform once launched.