

IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Small Launchers: Concepts and Operations (7)

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INVESTIGATION OF MICROSATELLITE AIR-LAUNCH METHODS

Abstract

One way of achieving the goal of affordable and responsive microsatellite launch is by using air launch. It avoids the energy waste associated with launching from the ground because of the dense atmosphere at lower altitudes, and enables significantly lighter launcher. There are many methods for air launching a satellite which differ by the type of carrier platform, type of mounting, release method and launcher characteristics. Current air launch systems do not comply with the responsiveness requirements, and similarly to ground launchers they need weeks of preparation. One method of dealing with this requirement is by using a high-performance combat aircraft as a carrier and attaching the launcher on standard payload stations. In such way the launcher and its satellite can be installed and launched within hours. In this work three launcher configurations were investigated for air-launch from F15 combat aircraft into a 250 km circular orbit, or a more elliptic one. The three concepts were: 1. GTLV (Gravity Turn Launch Vehicle) – consisting of three solid rocket motors. 2. DRLV (Ducted Rocket Launch Vehicle) – consisting of first ducted rocket (ramjet) stage and two solid rocket motors. 3. TRIPOD – a three body configuration, employing five solid rocket motors in three stages. These configurations represent three methods of coping with the limitations imposed by the carrier aircraft. This research results revealed feasibility for air-launch of 48-114 kg microsatellites. For minimizing structural mass of the launcher, a Gravity Turn Trajectory (GTT) was chosen. Launching at a relatively high initial flight path angle into a gravity turn trajectory, a flight path without lift force (zero angle of attack) throughout the launch is achieved. This enables minimization of structural reinforcements. The launch sequence and all the parameters were modeled in MATLAB, conducting a thorough parametric investigation. A spherical rotating earth model was used in the equations of motion that were written for a flight above the equator. Sensitivity analyses were done on all parameters (initial flight path angle, coast time between the stages, initial altitude and the initial velocity of the F15). A 250 km circular reference orbit was chosen. The use of an F15 as a platform for launching a microsatellite via three conceptual launchers has been demonstrated. The concepts proved to be viable, and using commercial-off-the-shelf (COTS) motors decreases the cost, development complexity, and carrier aircraft adaptability regarding structural modification and flight envelope.