Air Launch: Examining Performance Potential of Various Configurations and Growth Options

Abstract

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The Advanced Concepts Office at NASA's George C. Marshall Space Flight Center conducted a high-level analysis of various air launch vehicle configurations, objectively determining maximum launch vehicle payload while considering carrier aircraft capabilities and given dimensional constraints. With the renewed interest in aerial launch of low-earth orbit payloads, referenced by programs such as Stratolaunch and Spaceship2, there existed a need to qualify the boundaries of the trade space, identify performance envelopes, and understand advantages and limiting factors of designing for maximum payload capability. Using the NASA/DARPA Horizontal Launch Study (HLS) Point Design 2 (PD-2) as a point-of-departure configuration, two independent design actions were undertaken. Both configurations utilized a Boeing 747-400F as the carrier aircraft, LOX/RP-1 first stage and LOX/LH2 second stage. Each design was sized to meet dimensional and mass constraints while optimizing propellant loads and stage delta V (ΔV) splits. All concepts, when fully loaded, exceeded the allowable Gross Takeoff Weight (GTOW) of the aircraft platform. This excess mass was evaluated as propellant/fuel offload available for a potential in-flight refueling scenario. Results indicate many advantages such as large, relative payload delivery of approximately 47,000 lbm and significant mission flexibility, such as variable launch site inclination and launch window; however, in-flight cryogenic fluid transfer and carrier aircraft platform integration are substantial technical hurdles to the realization of such a system configuration.