Paper ID: 54437
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IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems Verification and In-Flight Experimentation (6)

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FLIGHT TESTING OF AN AERIAL LIQUID OXYGEN TRANSFER SYSTEM

Abstract

Rocketplane Global, Inc.(RGL) is continuing its preliminary engineering and development effort for its Mach 12 spaceplane design, based on a 20 year legacy of systems engineering for a variety of high Mach suborbital spaceplanes. The first stage reusable launch system is capable of delivering up to 2,000 kg to a 800 km polar orbit and can deliver over 2,500 kg to the ISS orbit. A key enabling technology for this system is the use of a KDC-10 tanker aircraft to transfer the majority of the propellant load to the spaceplane once the vehicle is in the air and flying at normal subsonic jet speed. The tanker carries the 64,000 kg of LOX plus the kerosene fuel. By taking off "light" with only a small fraction of the fuel and oxidizer required to pre-chill and condition the tanks and lines, and then transferring this propellant load in flight, the vehicle dry mass fraction challenges are greatly reduced. This in turn enables the disruptive reduction in launch price to less than $20 million for a 2 ton LEO satellite or deployment of multiple 150 kg microsats from a dispenser.

While the transfer of large volumes of kerosene from a tanker to a receiver aircraft has been a routine TRL9 level operation for decades, the midair transfer of large volumes of cryogenic fluid at high flow rates between two aircraft has not been done before. However, such transfers using long flexible vacuum jacketed hoses are a routine part of ground operations for launch vehicles. RGL has proposed a Space Act Agreement with the Kennedy Space Center Cryo Lab to develop and test its aerial LOX transfer system on the KSC cryo test facilities and demonstrate the transfer process using LN, and described this ground testing program in the IAC-18-D2.5 session. The next phase of testing will involve a subscale flight test demonstration of about 500 kg of cryogenic fluid (first LN and then LOX) using external pod stores on a Gulfstream G3 as the tanker and the wing tank fitted with a transfer probe on a F-104 Starfighter. The tanker pod will deploy a subscale 3cm vacuum jacketed hose with a drogue basket out to a 40 meter safe distance, and the F-104 pilot will contact the drogue receptacle and initiate the cryo fluid transfers. This paper will describe the aerial cryogenic fluid transfer flight test program, test objectives and safety protocols.