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CRYOGENIC REFUELING DEMONSTRATION ON THE ROBOTIC REFUELING MISSION – 3 (RRM3)

Abstract

On Dec. 5, 2018 NASA launched the Robotic Refueling Mission – 3 (RRM3) payload aboard SpaceX Commercial Resupply Service (CRS) 16 to the International Space Station (ISS). RRM3 was berthed on the ISS Express Logistics Carrier (ELC) on Dec. 15. RRM3 is a mission to demonstrate techniques for robotic refueling of liquid methane, a cryogenic fuel. RRM3 builds on the previous success of RRM1 and RRM2, which demonstrated the ability to access, uncap, and reseal fueling valves on a simulated uncooperative spacecraft interface. On RRM3, liquid methane flows through each of three transfer lines from a Source Dewar to a Receiver Dewar. The hard transfer line was plumbed in during the build of the payload and does not require robotic operation. The CryoCoupler Assembly (CCA) transfer line requires robotic mating of a Cooperative Service Valve (CSV) prior to the transfer to mimic refueling of a cooperative payload. The most challenging transfer is through the Cryo Transfer Hose (CTH) flexline, which simulates refueling of an uncooperative payload. The flexline is robotically positioned and inserted through an open port and snakes through plumbing before seating at the tank inlet. Passage of the flexline through a restriction is observed by the Visual Inspection Poseable Invertebrate Robot 2 (VIPIR2), a borescope camera that is maneuvered into position through a tortuous path, then retracted to allow the inspection port to be sealed prior to the flow of methane. All robotic operations are monitored through two cameras mounted on RRM3, one stationary and one capable of panning and tilting.

This paper describes the results of the two robotic transfers and compares them to the non-robotic transfer. Differences between the transfer parameters are discussed, particularly those that relate to differences in the tools and transfer lines associated with the cooperative and uncooperative interfaces.