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Author: Dr. Cameron Ower
MDA, Canada

Mr. Andrew Keenan
Canadian Space Agency, Canada
Ms. Jill McGuire
National Aeronautics and Space Administration (NASA), United States
Mr. Frank Cepollina
National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, United States
Mr. Robert Lucas
MDA Space Missions, Canada

SPDM GROUND TESTING OF THE ROBOTIC REFUELING MISSION (RRM) OPERATIONS

Abstract

The Robotic Refueling Mission (RRM) is an external International Space Station (ISS) experiment that in 2012 will demonstrate robotic servicing tasks and technologies of an emulated unprepared satellite client in a zero-g environment. Working with the Canadian Space Agency's (CSA) Special Purpose Dexterous Manipulator (also known as "Dextre"), the RRM uses representative satellite, fueling, and diagnostic interfaces and specially designed dexterous tools to demonstrate and test the robotics tasks, tools, and procedures needed to service in-operation spacecraft which was not designed to be serviced once on orbit. The RRM payload developed by NASA's Goddard Space Flight Center (GSFC) consists of four robotic tools, representative satellite and fueling interfaces, interactive servicing task boards, tool and equipment stowage areas, and avionics. The RRM will perform its tasks using Dextre, the two-armed robot developed by MDA for the CSA to perform delicate assembly and maintenance tasks in the ISS external environment. Dextre uses the robotic tools to manipulate Multi-Layer Insulation (MLI), grasp and remove sealing caps and valves, cut wires, connect and seal to fuel valves, and transfer fuel across the tool-to-valve interface. Other task boards are also included that allow Dextre to perform additional robotic servicing tasks as well as evaluate machine vision algorithms.

The RRM operations will require extreme precision and delicate force control and will be among the most advanced and complicated ever performed by Dextre on the ISS, requiring it to operate at or near the limits of it capability. With the goal of testing and refining flight operating procedures for the upcoming mission and further exploiting Dextre capabilities such as ground control and automatic functions like force-moment accommodation, NASA GSFC and MDA conducted high fidelity ground testing with the SPDM Ground Test-bed (GT) at MDA's Brampton facility. The flight-like SPDM GT manipulator used flight-spare RRM hardware and attempted all RRM mission tasks on flight-representative task boards. Feedback from GT operations was used to update flight operating procedures for the 2012 mission as well as to tune SPDM control parameters for optimal performance.

This paper summarizes the results of the SPDM-GT RRM testing and discusses the challenges experienced and the benefits of such pre-flight testing. These results will be compared with those obtained from the actual on-orbit servicing operations using RRM. The paper concludes with a discussion on the viability of robotic servicing of unprepared satellites using current technologies and proposed enhancements that would benefit such activities.