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DIAGNOSIS AND EVA SERVICING OF UNPREPARED ON-ORBIT ROBOTIC HARDWARE

Abstract

Over the last 14 years the Mobile Servicing System (MSS) has proven critical to the continued successful operation of the International Space Station (ISS). In addition to performing both scheduled and unscheduled maintenance activities, the MSS has taken on the critical role of the capture and docking of free-flying resupply spacecraft. At the heart of the MSS is the Space Station Remote Manipulator System (SSRMS), a seven-degree of freedom robotic arm that is central to robotic operations on the ISS. A Latching End Effector (LEE) is installed at each end of the SSRMS and serves as the primary robotic interface between the arm and payloads. The LEE captures payloads through a series of snaring, rigidization and latching operations in order to secure the payload and to provide power/data connections.

On GMT 2014/140 during a capture operation LEE-A exceeded current limits during operation of the latch resulting in a stall of the mechanism. Available telemetry was indicative of degraded latch drivetrain performance. Shortly after the latch stall event, LEE-A also experienced high currents in the rigidize mechanism resulting in a stall.

A comprehensive root cause investigation was undertaken involving fault tree generation, reviews of historical ground and on-orbit test data, materials evaluations, additional ground and on-orbit testing as well as the development of revised control parameters and capture procedures to allow for continued MSS operations during the investigation process. Based on data from all of these sources the most probable causes of the degraded latch drivetrain performance were determined to be degradation of the dry film lubricant on the latch ballscrews and linear bearings. Telemetry from the rigidize stall event indicated

similar degraded performance in that drivetrain, with the probable cause also being degraded dry film lubricant on the rigidize ballscrew.

Experience with this type of degradation indicated that application of wet lubricant to these locations would likely restore LEE-A performance, extending the life of the system. None of these mechanisms were designed for access while on-orbit, however. In collaboration with the NASA EVA group the authors developed tools and techniques using existing on-orbit resources to allow an EVA crewmember to apply wet lubricant to the affected mechanisms. Rapid prototyping technologies were used to quickly iterate EVA tool and procedure design during this process.

On GMT 2015/056 the EVA crew successfully lubricated all of the required mechanisms. Initial characterization testing of LEE-A has demonstrated significantly improved drivetrain performance.