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A SUMMARY OF THE ANALYTICAL TECHNIQUES INVOLVED IN ROBOTIC LIFE EXTENSION ON THE INTERNATIONAL SPACE STATION

Abstract

The MDA-built Mobile Servicing System (MSS), consisting of Canadarm2, the Mobile Remote Servicer Base Station (MBS), and Dextre, has been providing robotic capability on the International Space Station (ISS) since 2001. All three were certified to ten years of on-orbit life. Launched in 2001, Canadarm2 reached its ten year on-orbit life limit in 2011; whereas the MBS, launched in 2002, reached it in 2012. As Dextre was launched in 2008, it will reach its ten year on-orbit life limit in 2018. A life extension assessment effort was initiated by the Canadian Space Agency (CSA) to extend the utilization of the MSS to correspond with the mission of the ISS to 2024. Recognizing the conservative design margins built into the hardware, the main focus of the assessment was to determine whether the hardware could meet its operational and performance requirements during its extended usage and to predict the sufficiency of spares to maintain MSS functionality to 2024. When assessing hardware life, MDA and CSA identified four primary areas of concern: materials life, concerned with the degradation of material properties with exposure to space environment; electronics life, concerned with the functional performance of electrical, electronic electromechanical (EEE) components; mechanisms life, concerned with the functional performance of moving components; and structural life, concerned with the loading and fatigue life of the fracture critical elements. Analysis for age related failures need to consider all four areas, as any one of the four may become the life limiting factor of an Orbital Replaceable Unit (ORU) based on its predicted usage. A component may also experience random failure due to the cumulative operating time approaching the mean-time-between-failure (MTBF), which is taken into account by reliability analysis. The overall 'life' of a component, therefore, will be the shortest limit imposed by either a random failure or component 'age'. Through further ground testing of components, improved forecasting of spares requirements, periodic on-orbit inspections of at-risk hardware, and data/performance trending to forecast anomalies, the life extension project continues to demonstrate that the MSS can be operated beyond its original life until at least 2024 with the manufacture of additional spares. This paper will summarize the various analytical techniques involved in extending the MSS's life on the ISS that can be applied to ensure the long term operability of future space robotic capabilities.