SPACE SYSTEMS SYMPOSIUM (D1)
Space Systems Architectures (4)

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DEFINITION AND TESTING OF AN ARCHITECTURAL TRADESPACE FOR ON-ORBIT ASSEMBLERS AND SERVICERS

Abstract

Purpose: While there have been several on-orbit servicing and assembly missions, such as the Orbital Express servicing demonstration, Hubble Space Telescope servicing mission, and proposed James Webb Space Telescope assembly, there has yet to be an analysis of the full tradespace of servicing and assembly architectures. This paper proposes a set of eight architectures that fully span the design tradespace of on-orbit assembler and servicer satellites. In addition, the paper discusses current and future hardware-in-the-loop testing of various architectures in a sequence of iterative and incremental tests in ground and microgravity environments.

Methodology: In this paper, a framework is presented that defines the tradespace for servicing and assembly architectures across the three axes of distributed vs. centralized functionality, proximity operation vs. fully captured operations, and integrated vs. external servicing/assembly satellites. These tradespace dimensions create eight possible architectural modes, but very little analysis and testing has been performed to show relative operational feasibility between them. A qualitative analysis of the full architectural tradespace is presented, detailing the advantages and disadvantages of each of the core architectures. The paper also delves into the recent and ongoing ground and on-orbit testing that is being conducted as part of the Massachusetts Institute of Technology Space Systems Laboratory's Synchronized Position Hold Engage and Reorient Experimental Satellites (SPHERES) facility for the verification of these architectures. The SPHERES testbed, consisting of three nano-satellites, has operated aboard the International Space Station (ISS) since 2006. The satellites have been upgraded with vision systems and will shortly be outfitted with docking ports that have operated successfully with the ground testbed. With this hardware, it is possible to conduct incremental, iterative dynamics and controls experimentation and demonstrate the operational capabilities of the eight architecture modes for on-orbit servicing and assembly.

Results and Conclusions: The Visual Estimation for Relative Tracking and Inspection of Generic Objects (VERTIGO) program is already in orbit aboard the ISS and provides stereovision capabilities to the SPHERES satellites. The SPHERES Docking Port (SDP) in conjunction with the Halo (an array of six electromechanical expansion ports) provides ready reconfiguration to the facility. Ground and ISS testing has occurred which has demonstrated the capabilities of many of these architectures; the paper describes how these results and the planned test sequences for the remaining architectures reduce risk for

on-orbit assembly and servicing missions.