Design of Space Systems to Enable In-space Assembly and Servicing

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For several decades, NASA has employed in-space systems to enhance the performance and extend the useful life of operational orbital assets. In at least one case, an operational mission was not only enhanced, but enabled – the International Space Station was made possible by crewed and robotic in-space assembly, and continues to support installation and operation of new science and technology payloads. In several cases (Hubble Space Telescope, Intelsat 401, Westar and Palapa), major operational assets were rescued or repaired soon after launch when otherwise mission-ending anomalies occurred or were detected. In addition to the original rescue, Hubble was upgraded four times, enabling high-demand, world class science over four decades. More recently, two Northrop Grumman Mission Extension Vehicles have captured two Intelsat spacecraft near the end of their life and fuel capacity, to take over maneuvering duties.

In spite of these recent operational achievements, and with the exception of large human exploration vehicles and large space telescopes, space architects rarely consider in-orbit servicing and assembly capabilities in their future planning. Technologies such as multi-launch mission architectures (and rendezvous and proximity operations systems), docking systems, external robotics, advanced tools, modular systems and structures, and fluid transfer systems are available today to support these missions. In-space manufacturing will soon be operational to enable resilient missions that recover from on-orbit failures, and expand the utilization of space. We envision a future that includes these capabilities, and discuss the cultural, engineering, and technological challenges to achieving this vision. We discuss the vision, the proverbial chicken and the egg (which came first, the serviceable spacecraft or the servicer?), the cost, risk, and perceptions thereof of in-space operations, a “spectrum” of cooperative servicing design considerations, and the current status of the space industry’s slow but steady march to widespread operational use of on-orbit servicing, assembly, and manufacturing.