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KEYNOTE: ADVANCING IN-ORBIT ROBOTIC ASSEMBLY AND DISASSEMBLY OF HIGH-VALUE INFRASTRUCTURES USING END-OVER-END WALKING MANIPULATORS

Abstract

Despite the ongoing efforts to achieve a carbon-neutral economy by 2050, the global dependency on conventional fossil fuels is growing. Further innovations in clean energy technologies, including hydro, solar, wind, fission, biofuel, and emerging fusion technology, will help address the energy transition. However, variable wind and solar renewables will dominate and need sources of storage or dispatchable energy generation that do not currently exist at scale. Space-based power generation and transmission are economically and technically feasible, offering weather-independent energy to enhance reliability and decrease costs in our future energy systems.

There is a growing interest in testing and commercializing continent-scale Space-Based Solar Power (SBSP) generation and transmission. However, setting up complex orbital infrastructure and associated logistics of the orbital power station is still immature technology. Advancements in Robotics, Automation, and AI are key to making the SBSP station a worldwide endeavor to address growing energy demands on Earth and mitigate the risks of climate change. Likewise, robotics innovation is key to allowing in-orbit assembly of the modular Large Aperture Space Telescope (LAST), significantly larger than the Hubble Space Telescope and the James Webb Telescope, for astronomical observations.

This paper focuses on orbital green energy, sustainability, and space exploration through robotic intervention. It presents the next generation of innovative dexterous walking robotic manipulators - the End-Over-End Walking Manipulator (E-Walker) - suitable for various orbital infrastructure assembly and disassembly missions. The Mission Concept of Operations (ConOps) demonstrates the assembly of a 25m SBSP satellite and a 25m aperture primary mirror of a LAST using multiple E-Walkers. The E-Walker technology showcases the potential of collaborative robotic systems for in-space construction, utilizing innovative assembly algorithms within a microgravity simulation environment using ROS2/Isaac Sim. Furthermore, the disassembly algorithms showcase an innovative methodology to efficiently replace defective modules onboard the SBSP satellite and LAST.

The mission ConOps presented can be further extended for future maintenance and decommissioning of orbital infrastructures, minimizing the need for several extravehicular activities. This pioneering research advances space assembly technologies and paves the way for sustainable maintenance practices in future in-orbit robotic missions supporting a range of in-space servicing, manufacturing, and decommissioning operations. The E-Walker technology is also applicable for constructing space-based polar shields to slow

the melt rate of the polar ice caps, thereby offering mitigation effects to save wildlife and help safeguard coastal cities, communities, and low-lying islands.