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ORBITAL DOCKING AND INTEGRATION NEXUS (ODIN): A SCALABLE AND SUSTAINABLE IN-ORBIT PLATFORM FOR SPACE RESEARCH

Abstract

In this paper, we present the Orbital Docking and Integration Nexus (ODIN), a scalable, autonomous, and reusable in-orbit platform designed to host and support payloads for scientific research, Earth observation, and space technology demonstrations, up to 3U in size. With the impending decommissioning of the International Space Station (ISS), there is a growing need for alternative platforms that can sustain space-based research while ensuring accessibility, cost-effectiveness, and sustainability. Unlike standalone CubeSats, which must independently manage power, thermal regulation, and communication, ODIN provides these essential services, thereby simplifying mission design, extending operational lifetimes, and reducing overall mission costs. By allowing payloads to dock, conduct experiments, and later be safely released for atmospheric reentry, ODIN minimizes the need for deploying multiple dedicated small satellites, reducing space debris and ensuring responsible disposal practices. Its reusable design directly contributes to the United Nations Sustainable Development Goals (SDGs), particularly Goal 12: Responsible Consumption and Production, by promoting sustainable practices in satellite operations.

We outline the system architecture, autonomous navigation and docking mechanisms, and operational framework of ODIN, which is currently designed as a 27U system optimized for Low Earth Orbit (LEO) with the potential to be scaled for deep-space applications. The platform supports multiple mission types, including scientific research, Earth observation, and global security initiatives. To demonstrate ODIN's versatility, we present two case studies featuring in-house developed payloads at the University of Nottingham. The first involves a biological payload investigating freeze-dried cellulose stacks for in-situ protein synthesis in spaceflight, using fluorescent spectroscopy and imaging for real-time molecular analysis. This research has direct implications for space-based biomanufacturing and long-duration human spaceflight, supporting Goal 9: Industry, Innovation, and Infrastructure by driving advancements in space biotechnology. The second case study focuses on a GNSS interference mapping payload, designed to detect and characterize disruptions in navigation signals, a capability critical for transportation resilience, infrastructure security, and Earth observation applications. This supports Goal 11: Sustainable Cities and Communities, ensuring reliable navigation and telecommunications networks. Through its autonomous hosting capabilities, multi-mission functionality, and responsible deorbiting mechanisms, ODIN represents a sustainable, scalable, and commercially viable solution for the future of in-orbit research.