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JAMSAIL: A 3U CUBESAT FOR GNSS INTERFERENCE MAPPING, IONOSPHERIC SCINTILLATION ANALYSIS, AND ADCS RESEARCH

Abstract

Global Navigation Satellite Systems (GNSS) play a crucial role in both civilian and military applications, with increasing demand for their utilization in space. However, GNSS receivers are highly susceptible to interference from jamming, spoofing, ionospheric scintillation and multipath signals, which can significantly degrade both positioning and timing accuracy and reliability. The challenge of characterizing and mapping interference from space is further compounded by substantial free-space path loss, resulting in weak GNSS signals. JamSail, a student-led 3U CubeSat developed at the University of Nottingham, aims to address these challenges through an In-Orbit Demonstration (IOD) of a novel CubeSat-hosted GNSS interference mapping payload. Supported by the Nottingham Geospatial Institute (NGI), the mission serves as a research and training platform for students ranging from undergraduate to PhD levels. The ability to monitor GNSS interference using cost-effective CubeSats presents a promising opportunity for the development of future constellations dedicated to GNSS signal monitoring, ultimately enhancing the resilience and reliability of global GNSS infrastructure. The JamSail payload suite includes a CubeSat-based GNSS interference mapping system, outward-facing cameras for outreach and pointing validation, and an in-house-developed magnetorquer-based attitude control system. The CubeSat leverages commercial off-the-shelf (COTS) subsystems, including an onboard computer (OBC), an electrical power system (EPS), and UHF/S-band radio transceivers. Structural components, such as the machined rails, will be partially manufactured in-house, while additive manufacturing technologies will be utilized for other components in collaboration with specialized companies across Europe. Beyond its scientific goals, JamSail provides hands-on student training, fosters interdisciplinary collaboration, and supports the UK space sector by addressing gaps in high-fidelity training and workforce development. Preliminary experimental validation of the GNSS payload has been conducted using Fast Fourier Transform (FFT) spectrum monitoring and Doppler shift measurements. The ADCS is composed of a 3-axis actuator, 3-axis sensors (accelerometer, gyroscope, magnetometer, Sun sensors) and an in-house developed control algorithm. Additionally, the GNSS payload will be used as an additional sensor during Nadir pointing procedures to further enhance the determination accuracy during the ADCS' most critical stage. Finally, the satellite may also employ a communication risk mapping method to account for ionospheric scintillation effects, thereby enhancing the reliability of the mission's communications. This paper presents the system architecture and mission budget of the JamSail, along with the design and preliminary results

of the payloads. It also provides an overview of the subsystems, structures, challenges encountered, and future work required for the advancement of these technologies.