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NEXT-GENERATION TRACKING SYSTEMS FOR ENHANCED SPACE DOMAIN AWARENESS AND OPTIMIZED SPACE TRAFFIC MANAGEMENT

Abstract

The exponential increase in satellite deployments, human space flight and rocket launches by both commercial and governmental entities has significantly intensified the complexity of space operations, particularly within the densely populated orbital regimes such as Low-Earth Orbit (LEO). This rapid expansion of on-orbit infrastructure, coupled with the growing presence of space debris, has outpaced advancements in Resident Space Objects (RSO) sensing, tracking and communication capabilities, underscoring the urgent need for advanced and cohesive support systems. Traditional ground stations, primarily designed for essential communication and data relay, are unable to keep pace with the growing data needs let alone the complex demands of modern Space Traffic Management (STM). Our investigation examines the technological requirements for next-generation Space Domain Awareness (SDA) architectures and emphasizes the importance of developing ground stations that seamlessly integrate cutting-edge Space Situational Awareness (SSA) equipment with existing ground infrastructure. These systems can assist in automating and reducing the turn-around time for acting on actionable intelligence alongside providing real-time tracking, accurate prediction, and characterization of RSO. The proposed ground stations network offers enhanced capabilities for detecting, identifying, and tracking a wide range of space objects, facilitating more precise orbit determination, maneuver prediction, and conjunction analysis to mitigate the risk of cascading collisions (i.e., Kessler Syndrome). Moreover, the integration of autonomous systems for efficient processing of vast amounts of tracking data is crucial for enabling prompt responses to emerging threats in space. This is essential for safeguarding the space environment, ensuring the continued functionality of vital space-based critical infrastructure, and supporting the sustainable use of space amidst increasingly congested orbital zones.