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Advance Higher Throughput Communications and Networks for GEO and LEO satellites (3)

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HYBRID GEO-LEO SATELLITE NETWORK FOR MULTI-SERVICE 5G/6G NTN CONNECTIVITY IN AUSTRALIA

Abstract

The integration of Low Earth Orbit (LEO) constellations with Geostationary Earth Orbit (GEO) satellites presents a transformative opportunity for Non-Terrestrial Networks (NTN), particularly in vast regions like Australia, where remote and underserved areas require robust, high-capacity connectivity. This study develops and evaluates a hybrid GEO-LEO satellite network architecture tailored to support diverse NTN services, including Fixed Satellite Services (FSS), Mobile Satellite Services (MSS), and Broadcasting Satellite Services (BSS), in alignment with 5G and emerging 6G network requirements.

Utilizing a multi-layered satellite architecture, this research examines the dynamic connectivity between a backend GEO satellite, multiple LEO satellites at different altitudes, three ground stations (GS), and various user terminals (UTs) across Australia. The methodology incorporates dynamic link budget analysis, visibility assessments, Doppler compensation techniques, and modulation/coding (MOD/COD) scheme optimization across L, S, C, Ku, Ka, Q, and V bands to ensure seamless and adaptive connectivity.

Simulation results indicate that a hybrid GEO-LEO architecture can significantly enhance network resilience, spectral efficiency, and service availability, enabling low-latency broadband for remote communities, high-reliability TTC for LEO operations, and efficient BSS for digital inclusion initiatives. The findings provide a framework for NTN deployments, guiding the integration of next-generation satellite communications with terrestrial networks for scalable, high-performance connectivity solutions.

This study aligns with ITU, 3GPP, and DVB-S2X standards, offering practical insights into the design and operational feasibility of 5G/6G NTN systems. The proposed methodology serves as a benchmark for future NTN implementations, advancing the global vision of ubiquitous connectivity through space-based networks.