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BROADBAND SATELLITE SYSTEMS AND THEIR EVOLUTION TOWARD INTEGRATED TERRESTRIAL–SATELLITE NETWORK ARCHITECTURES

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ABSTRACT

Although satellite systems were traditionally limited to broadcast services, trunk connectivity, and coverage of remote and underserved regions, their evolution toward broadband satellite systems has significantly increased capacity and enabled a wide range of applications. High Throughput Satellite (HTS) architectures have been driven by growing demands for global connectivity, high data rates, and emerging services such as mobile broadband and the Internet of Things (IoT). More recently, the emergence of Low Earth Orbit (LEO) mega-constellations has further advanced satellite communications by enabling lower latency, greater flexibility, and improved support for delay-sensitive applications. In parallel, increasing demand for ubiquitous global connectivity has driven the convergence of terrestrial and satellite networks, requiring unified and interoperable network architectures. The 3rd Generation Partnership Project (3GPP) plays a central role in standardizing Non-Terrestrial Networks (NTN) by extending 5G and future 6G architectures to include satellite and high-altitude platforms as integral components of mobile systems. Through its ongoing activities, 3GPP defines architectural adaptations, radio interface enhancements, and interoperability mechanisms that enable satellite integration into 5G New Radio (NR) networks and support seamless operation across terrestrial and non-terrestrial segments.

This paper reviews the technological advancements that have enabled HTS systems and analyzes their impact on modern satellite communication capabilities. It also examines terrestrial–satellite network convergence, key

architectural concepts, and application scenarios enabled by this integration, with particular focus on 3GPP NTN standardization activities that form the basis for satellite integration into 5G/6G ecosystems.