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# MBSE APPROACH FOR FUTURE 6G TN-NTN DISTRIBUTED NETWORKS

**Abstract**

Satellite communications (SATCOM) are experiencing a significant transformation due to the recent goal of integrating them with the terrestrial networks (TN) for the sixth generation (6G) of wireless technology. Alongside traditional SATCOM applications like media broadcasting or backhauling, there is rising demand for new use cases such as media streaming and latency-sensitive services. The need to extend network coverage to typically unserved areas (eg., aeronautical and maritime regions, rural areas, and developing countries) is encouraging the research for innovative satellite architectures. Additionally, the New Space economy, bringing advancements in digitalization, miniaturization and re-usability, has attracted substantial private investment, that is supporting the rapid changes in the sector.

Within the 6G context, Non-Terrestrial Networks (NTNs) face new challenges. Future NTNs demand flexibility and scalability to provide reliable global coverage while remaining cost-effective. Consequently, there is a structural paradigm shift, from large standalone payloads to a coordinated dynamic network of multi-orbit space-borne nodes. These federated nodes vary in size, performance and autonomy but interconnect to actively collaborate in resource sharing, thereby enhancing performance and efficiency. To achieve 6G goals, comprehensive co-development of terrestrial, feeder link, space and user segments at all layers is imperative.

The inherent complexity of the system necessitates diligent management of information, design choices and coordination. To handle such critical labour for the NTN – TN integration, Model-Based System Engineering (MBSE) is proposed. MBSE serves as a common reference source and facilitates design information exchanges for stakeholders, tracing technological decisions and documentation. Moreover, this modelling approach enables the assessment and comparison related to the feasibility and complexity of various technological solutions.

This paper aims to present the application of MBSE in developing fractionated and federated systems within the 6G TN-NTN integration, emphasizing space and ground segment co-design. The proposed model, built using ARChitecture Analysis  Design Integrated Approach (ARCADIA) as a methodology and Capella as a tool, addresses this matter from a decision-making perspective. Starting from the mission requirements of 6G SATCOM, a set of functionalities is derived and associated with various possible technological solutions. Ultimately, the model facilitates a trade-off analysis for the Measure of Effectiveness (MoE) in alignment with stakeholders' expectations.