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Lost in Translation: Why 5G -NTN must focus on Interoperability

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We are currently witnessing the previously unconnected communications landscape striding towards ubiquitous coverage for users via the convergence of terrestrial and satellite communications networks. 5G NTN (Non-Terrestrial Networks) brings terrestrial and satellite networks into a shared communications ecosystem, combining their strengths to deliver more resilient, high-performance connectivity for users. However, these two industries operate in significantly different ways.

Mobile Network Operators (MNOs) have spent decades navigating challenges surrounding interoperability to deliver services to customers. An MNO user can access networks around the world using the same handset. To get to this point, all networks and manufacturers have worked to a standards-based approach to guarantee interoperability. This is markedly different from the structure of satellite operations. Satellite Network Operators (SNOs) utilise proprietary infrastructure, allowing these organisations to maximise spectral efficiency through their physical infrastructure, resulting in operational and cost efficiency whilst maintaining full control over their assets. These vastly different approaches bring a new challenge to both industries: how should networks be structured to encompass both types of operator?

The need for convergence

It is important to consider why MNOs and SNOs are looking towards a future in which their services are linked. MNOs deliver low-cost connectivity to a high number of users using terrestrial infrastructures. This provides reliable, mobile, low-latency services to users, with a well-established ecosystem ensuring that regular devices can connect easily when in range of a mast. However, coverage is limited by infrastructure; remote areas are often underserved or even unserved, whilst geographical topography can impinge on signal availability. On the other hand, SNOs deliver wide-reaching coverage with high-bandwidth, this has traditionally been delivered at a higher price whilst requiring specialist equipment to access the network. It is clear to see why SNOs and MNOs will benefit from working alongside one another; each delivers what the other is limited by. But this leads us on to the question: how?

In 2022, the 3GPP initiative delivered Release 17, the first to cover 5G NTN. 3GPP specifications cover cellular telecommunications technologies, including radio access, core network , and service capabilities. The telecommunications industry has been built upon 3GPP standards to ensure seamless interoperability amongst networks and devices. From a terrestrial perspective, 5G NTN has introduced changes to assumptions that cellular networks have relied upon for decades, including fixed cells, short propagation delays, continuous coverage, modest Doppler , and largely national operating domains.

Release 17 introduced normative requirements for NTN networks in 3GPP specifications. This formally introduced requirements for satellites to become a part of the 5G network, laying out how technologies must be orchestrated to ensure interoperability, including satellite access, service continuity between terrestrial and satellite networks, roaming/network selection for satellite-capable UEs, UE location support, and NR operation over NTN. Release 18 has continued to build on this, driving the integration of NTN more deeply into 5G-Advanced, including satellite IoT/MTC support, additional spectrum, work, and satellite backhaul considerations.

As two communications industries expand to encompass one another, are MNOs and SNOs facing the same challenge to achieve interoperability?

MNOs: simply adapting already agile networks?

Having developed in isolation from one another, MNO and SNO networks are built on incredibly different infrastructures. Adapting to deliver 5G NTN to deliver interoperability between the two industries is set to pose different challenges for each. Modern MNO networks are already built upon modularity and interoperability, and are therefore in a strong position to adapt to the new demands of 5G NTN. The handset, RAN, core, transport, OSS/BSS, and service platforms are separated by standardised interfaces, with independent conformance testing and certification keeping the ecosystem working efficiently. Due to the nature of the industry, MNOs are used to multi-vendor procurement, software upgrades, cloud-native cores, virtualised network functions, orchestration platforms, and continuous lifecycle management.

Although it will not require a complete reinvention of the MNO network, NTN adds new physics into a system designed around terrestrial assumptions. Networks must cope with long and variable delays, high Doppler, moving beams, intermittent coverage, weaker link budgets, and more complex spectrum coexistence. This impacts mobility management, timing, random access, scheduling, RF performance, device testing, orchestration, and service assurance. The move to NTN is going to require a shift in working for MNOs, especially surrounding RF, mobility, spectrum, interference, and assurance which is a challenge the magnitude of which we don't yet fully realise. However, these changes are being added to operating systems which are already agile, reducing the scale of the challenge for the industry. Flexibility is a key attribute within the telco industry, and MNOs are comfortable in adapting to the demand of industry standards to access global networks. 5G NTN is an extension of this demand, albeit a significant and emerging one.

SNO networks: a deep dive into new waters?

SNO networks are vastly different from those of MNOs. Built for maximum efficiency, SNO systems are proprietary. As with mobile networks, there is an exceptionally high cost associated with owning and managing satellite constellations, and maintaining full control over assets has long been the industry's approach to maintaining control over profits. Link budgets are at the core of constellation and terminal design. Decisions are driven by spectral efficiency, with operators striving for optimal OpEx and CapEx. Often, the entire network supply chain is owned and

controlled by the operator, providing them with control over operational performance at a very granular level.

This creates a significant challenge surrounding interoperability. In recent years, the satellite industry has started shifting parts of their systems to introduce improved interoperability, with software-defined components and virtualisation at the ground segment helping to deliver more flexible networks. However, as the industry looks to slot into the wider 5G NTN landscape, infrastructure must be carefully planned to ensure that investment is placed into future-proof networks. As SNOs look to create new networks capable of running to 3GPP standards, there are a large number of operational decisions to make to ensure that systems are live in time to tap into the first wave of NTN opportunities, whilst being agile and flexible enough to adapt to the inevitable evolution of the 5G NTN.

Architectural flexibility is key for SNOs wishing to deliver 5G NTN capabilities to their networks. Satellite assets are long-lived whilst 5G NTN standards are evolving, and SNOs must establish infrastructures which enable continuous network management. Without this flexibility, SNOs could face expensive and slow pivots to stay aligned with future updates to 3GPP standards. This flexibility will also allow network updates to accommodate future demands of 5G NTN, such as the need for multi-orbit and hybrid orchestration. In the future, services may need to move between terrestrial, LEO, MEO, and GEO depending on demand, such as coverage, latency, capacity, regulation, and economics. By building a dynamic network now, SNOs can stay on the front foot and expand capabilities as and when 5G NTN demands them.

A large challenge for SNOs is balancing proprietary optimisation against 3GPP interoperability. The historic satcom model of tightly integrated waveform, modem, terminal, and payload design does not map cleanly onto a mass-market standards ecosystem. This serves as a big challenge for SNOs, demanding a significant shift in how satellite networks are designed and integrated within the wider NTN. SNOs need a clear terminal and RF strategy, as weak handset RF performance directly increases satellite complexity, link-budget pressure, and constellation cost. With the coexistence of NTN, terrestrial networks, and satellite systems increasing, spectrum and interference management must be planned for as a dynamic operational challenge to ensure operational and budget efficiency.

5G NTN is demanding a fundamental shift in how SNOs operate, and it is introducing new processes to well-established networks. Pivoting to a more agile infrastructure is a necessity for SNOs. 3GPP will continue to evolve, meaning flexibility is fundamental when establishing these new capabilities.

Delivering a unified communications network

MNOs have long built their networks upon agility and interoperability due to the nature of the industry, and this flexibility is proving advantageous as it pivots towards 5G NTN delivery. Mobile networks are largely localised, with a large customer base and effective low ARPU (average revenue per user). Although it must adapt to align with the latest 3GPP releases, the largely software-defined industry is in a good position to deliver NTN capabilities. On the other hand, in an industry based on proprietary, vertically optimised systems, SNOs have a larger task ahead of them. There are important steps to take for SNOs that want to deliver 5G-NTN services; establishing networks that are future-proof and adaptable will be the key to their success.

However, creating these networks requires a significant shift in how SNOs deliver their services. It is not the case of expanding existing proprietary structures or systems; it requires a complete rethink. 5G NTN is a significant opportunity for SNOs, however it rewrites the traditional satcom business case, where revenue has previously been made per bit from a small number of high-value global customers. Acknowledging the challenges discussed above and creating systems to mitigate potentially limiting factors will determine whether an SNO will be effective in 5G NTN delivery. As we move towards the delivery of a unified communications network, operators are facing lucrative opportunities. Success will be directly related to the establishment of agile, forward-thinking 5G NTN infrastructures, which can adapt to market demand, evolve with 3GPP updates, and ultimately, deliver seamless interoperability throughout the communications ecosystem. Investing in intelligent infrastructure will be the key to operator success in 5G NTN.