MASTERING THE ORBIT: END-TO-END NTN TESTING WITH THE CMX500 RADIO COMMUNICATION TESTER

A comprehensive single-platform solution for validating non-terrestrial network (NTN) performance and reliability in two principal test configurations: full satellite access network (SAN) and gNB/core emulation

Your task

The transition to NTN, particularly in the context of future 6G systems, presents a series of unique and complex challenges that extend significantly beyond the scope of conventional terrestrial network validation. A key challenge is the emulation of the satellite radio channel's dynamic and harsh conditions. Low earth orbit (LEO) satellites operate at extreme velocities, which causes a multitude of impairments that are very difficult to replicate in a laboratory setting. Examples of these include substantial Doppler frequency shifts, long and highly variable propagation delays that compromise the performance of real-time applications, significant path loss and unpredictable atmospheric fading phenomena, such as those induced by precipitation.

Another key task is the management of complex mobility protocols. The limited geographical footprint of LEO satellites necessitates frequent and seamless handovers between adjacent beams and from one satellite to another. The success of this process relies on the availability of accurate real-time ephemeris data to prevent service interruptions. Furthermore, seamless interoperability between NTN and terrestrial network segments is a major architectural challenge. Finally, the highly dynamic nature of the operational environment is a challenge for reliable key performance indicator (KPI) measurement and subsequent root cause analysis, since performance degradation may stem from a multitude of interdependent and shifting factors.

Rohde&Schwarz solution

The CMX500 radio communication tester is a unified platform solution that addresses the full range of NTN testing challenges within a single integrated instrument. It provides a complete end-to-end test environment for realistic simulation and in-depth analysis of NTN devices and infrastructure. Its versatility enables deployment in two principal testing configurations:

- **Full SAN emulation:** In this configuration, tailored for device manufacturers, the CMX500 emulates the complete network architecture. This encompasses the satellite payload, associated links, the gateway and the terrestrial core network functions, thereby enabling comprehensive device testing against a realistic fully simulated NTN environment.
- **gNB and core network emulation:** For satellite network operators (SNO), the CMX500 can also be used to test live or emulated satellite components by emulating the terrestrial gNB and 5G core network. This allows operators to validate their proprietary infrastructures and their interactions with standards-compliant cellular components.

Application Card | Version 01.01

The CMX500 creates a high-fidelity digital twin of the live-sky environment, emulating all satellite orbits and frequency bands with dynamic Doppler and delay compensation, as well as realistic fading profiles (R&S®CMX-KE611 NR NTN fading profiles), to ensure repeatable testing conditions. For full-stack conformance, the tester provides integrated base station and core network emulation, supporting both transparent and regenerative payloads. This enables comprehensive, standards based preconformance testing for early validation. In addition, the CMX500 addresses the burgeoning direct-to-cell (DTC) market by providing comprehensive test support for relevant technologies such as the R&S®CMX-KS550B LTE-DTC extension, along with predefined test procedures such as the R&S®CMX-KF655X XLAPI LTE-DTC Starlink test cases.

Key features include extensive RF measurements and advanced application testing over external IP networks to verify the real-world quality of service (QoS) and quality of experience (QoE). The R&S®CMX-KS627B option offers an intuitive visual workspace, while the R&S®CMX-KS627M option enhances testing with auto-deployment and auto-handover features for robust, long-term operation.

The entire testing process can be fully automated through the powerful XLAPI Python interface, while the optional AI-powered ScriptAssist tool improves the speed and effectiveness of creating dependable automation scripts. For NR-NTN preconformance testing, we provide test plans under the R&S®CMX-KC665B license. Additionally, the R&S®CMX-KF651X license is available for XLAPI Python and CMSequencer support.

Application

Bringing NTN testing to life

The CMX500 enables test scenarios under real-world conditions. A typical workflow uses the R&S®CMX-KS627M NR signal extension medium to define a user equipment's (UE) location, load a constellation via TLE data and simulate network deployment. This provides a holistic view for analyzing satellite visibility, trajectories and coverage gaps.

The auto-deployment and auto-handover functionalities are essential to identify anomalies during long stability tests. Simulating hours of travel with automatic satellite connections and handovers is crucial for verifying battery life, detecting software defects and finding subtle handover logic anomalies.

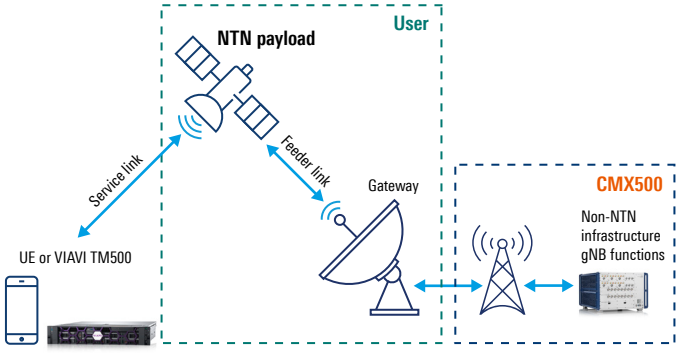
After scenario deployment, comprehensive application-level testing using the R&S®CMX-KA100 application test feature set is performed by connecting the CMX500 to an external network. Routing live traffic assesses the performance of any IP based application over the simulated NTN link.

CMX500: The all-in-one signaling tester for NTN

In a single instrument, the CMX500 empowers engineering teams to accelerate development, ensure quality and confidently deploy reliable NTN services.

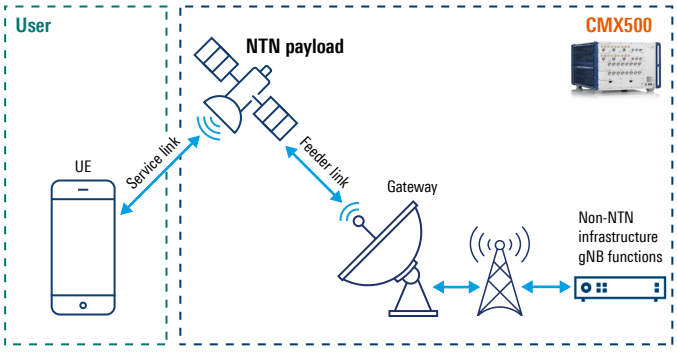
Use case: gNB and 5G core network emulation

Typical customers are satellite operators who provide their own satellite network (satellite gateway and satellite payload). In this setup, the CMX500 is only providing the 5G NTN backend services (gNB, 5G core network and the corresponding signaling message) to connect the UE with the customer's satellite network.



Use case: Emulation side – SAN

Typical customers develop chipsets, mobile phones or user terminals. The CMX500 emulates the entire satellite access node, which includes the gNB, 5G core network and the corresponding signaling message, satellite gateway and satellite payload.



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Mastering the orbit: End-to-end NTN testing with
the CMX500 radio communication tester
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