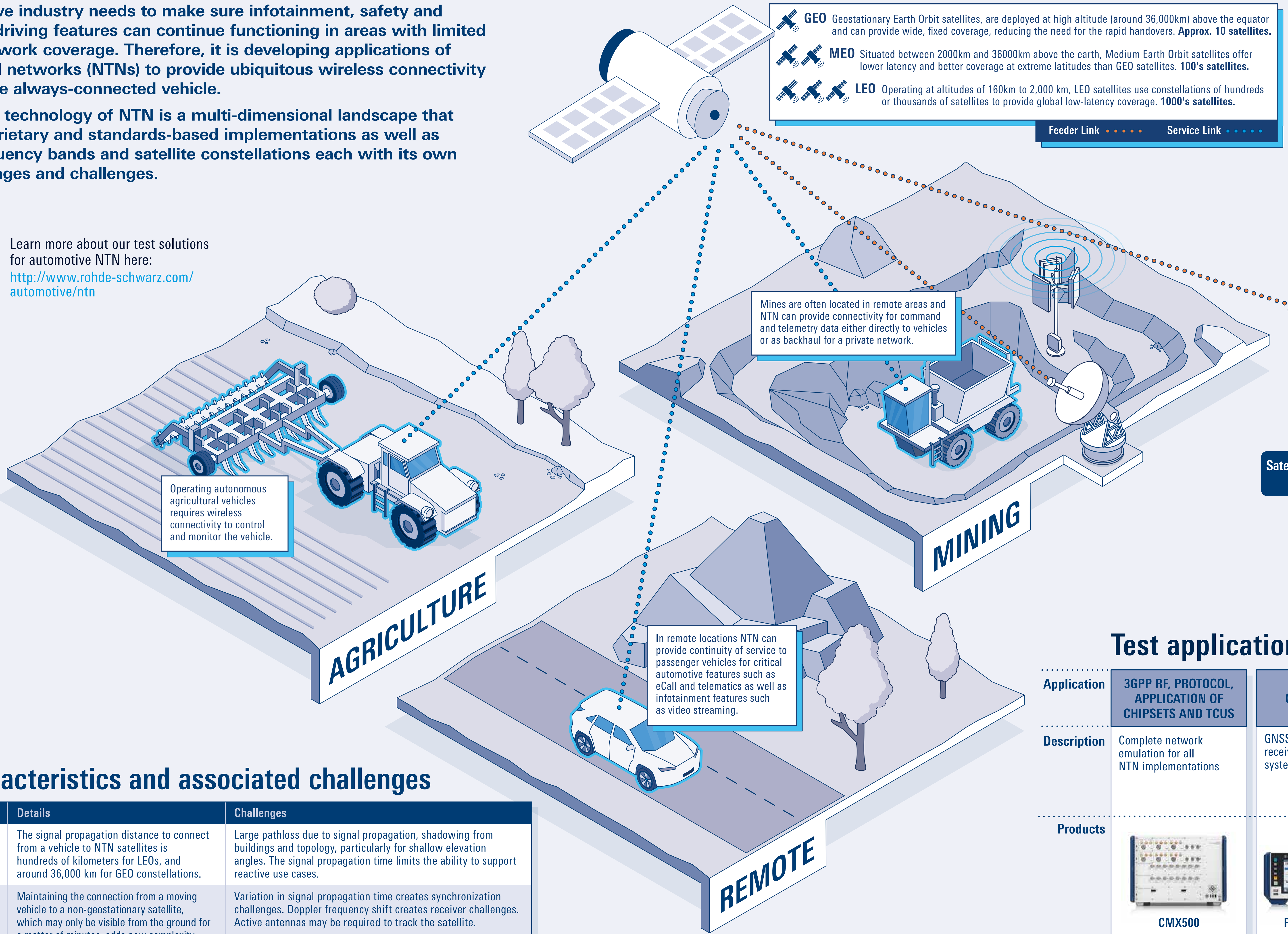
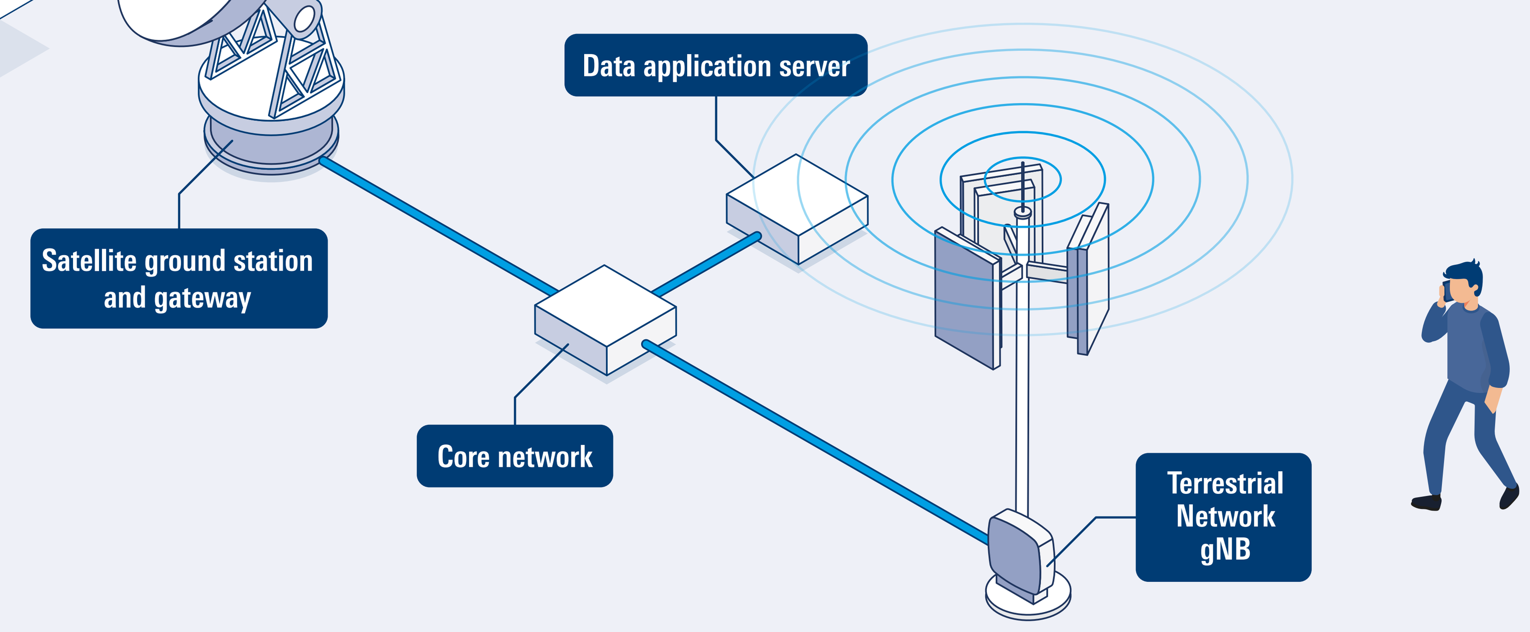
AUTOMOTIVE APPLICATIONS OF NON-TERRESTRIAL NETWORKS

The automotive industry needs to make sure infotainment, safety and autonomous driving features can continue functioning in areas with limited terrestrial network coverage. Therefore, it is developing applications of non-terrestrial networks (NTNs) to provide ubiquitous wireless connectivity and ensure the always-connected vehicle.

The emerging technology of NTN is a multi-dimensional landscape that includes proprietary and standards-based implementations as well as different frequency bands and satellite constellations each with its own set of advantages and challenges.

Learn more about our test solutions for automotive NTN here:
http://www.rohde-schwarz.com/automotive/ntn





NTN technologies comparison

Technologies	Advantages	Challenges	Potential supported automotive use cases
NB-NTN	Constellations already operational	Low data-rate Limited use cases	Basic telematics; Emergency call; Stolen vehicle recovery; Basic voice transmission
NR-NTN	Supports higher data-rate services	Requires large and power-hungry active antenna if using higher frequency bands RF transceiver design more complex if using higher frequency bands	OTA firmware updates; Infotainment services; Teleoperated driving support; Enhanced traffic info; Emergency call; Voice calls; Video calls; Telematics
DTC	Able to provide connectivity with only minor modification to vehicle	Regulatory approval sometimes required Currently only LTE Services supported on a best effort basis	Telematics; Messaging; Voice calls; Emergency call
Proprietary	Operational, broadband connectivity	Only works with specific technology. No compatibility and interoperability with 3GPP compliant networks and devices Challenging to integrate large terminals into vehicles	Messaging; Internet browsing; Video streaming; Voice calls

Test applications and solutions

Application	3GPP RF, PROTOCOL, APPLICATION OF CHIPSETS AND TCUS	GNSS TESTING	NETWORK COVERAGE AND PERFORMANCE	CONFORMANCE AND CARRIER ACCEPTANCE TESTING	ANTENNA CHARACTERIZATION TEST SYSTEM	ANTENNA CHARACTERIZATION ANECHOIC CHAMBER	VEHICLE LEVEL TESTING
Description	Complete network emulation for all NTN implementations	GNSS emulation to test receiver and complete system	Check NTN coverage KPIs such as RSSI and active service KPIs such as voice MOS	Conformance testing of the TCU according to 3GPP standards and carrier acceptance testing according to satellite operator-defined test cases	OTA validation of active and passive antenna characteristics	Antenna characterization including beamforming	Full-vehicle OTA testing of antennas and end-to-end system
Products	**CMX500**	 **R&S®SMBV100B**	 **TSMx and QualiPoc Android**	 **TS8980**	 **TS8991**	 **Ku/K/Ka bands: ATS1800C**	 **Full Vehicle Antenna Test (FVAT) system**
Features	Multi-band, multi-orbit, internal fading and channel emulation Application testing, (pre-)conformance testing Doppler shift, fading and timing effects	Emulation of GPS, GLONASS, BeiDou and QZSS/SBAS Realistic modeling of orbits, propagation effects and system errors	Active service quality tests for voice, data and video Scanner decodes all channels for multiple technologies	Coverage of PCT, RF, RRM and throughput test cases Automatic pass/fail testing Coverage of operator-specific test plans	OTA testing for all major cellular and non-cellular technologies Near field to far field transformation	3GPP compliant CATR test chamber Up to 40 cm quiet zone size	Active antenna performance characterization Wireless technology coexistence testing End-to-end NTN system evaluation in controlled environment

NTN characteristics and associated challenges

NTN characteristic	Details	Challenges
Signal propagation distance from vehicle to satellite	The signal propagation distance to connect from a vehicle to NTN satellites is hundreds of kilometers for LEOs, and around 36,000 km for GEO constellations.	Large pathloss due to signal propagation, shadowing from buildings and topology, particularly for shallow elevation angles. The signal propagation time limits the ability to support reactive use cases.
Dynamic nature of network	Maintaining the connection from a moving vehicle to a non-geostationary satellite, which may only be visible from the ground for a matter of minutes, adds new complexity.	Variation in signal propagation time creates synchronization challenges. Doppler frequency shift creates receiver challenges. Active antennas may be required to track the satellite.
Diverse range of frequency bands	NTN can use a wide range of frequency bands from L and S-band up to Ku, K and Ka-bands.	Frequency diversity creates variation in link budgets and signal propagation and fading considerations, both on the vehicle and in the satellite. Complex RF transceiver design for Ku/K/Ka bands.
Complex handover requirement	NTN has several extra mobility dimensions compared with TNs, including intra-satellite/inter-beam handover, inter-satellite handover, NTN to TN and TN to NTN handover.	Demanding operation and convergence with TNs makes it difficult for network architects to ensure seamless mobility.

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