

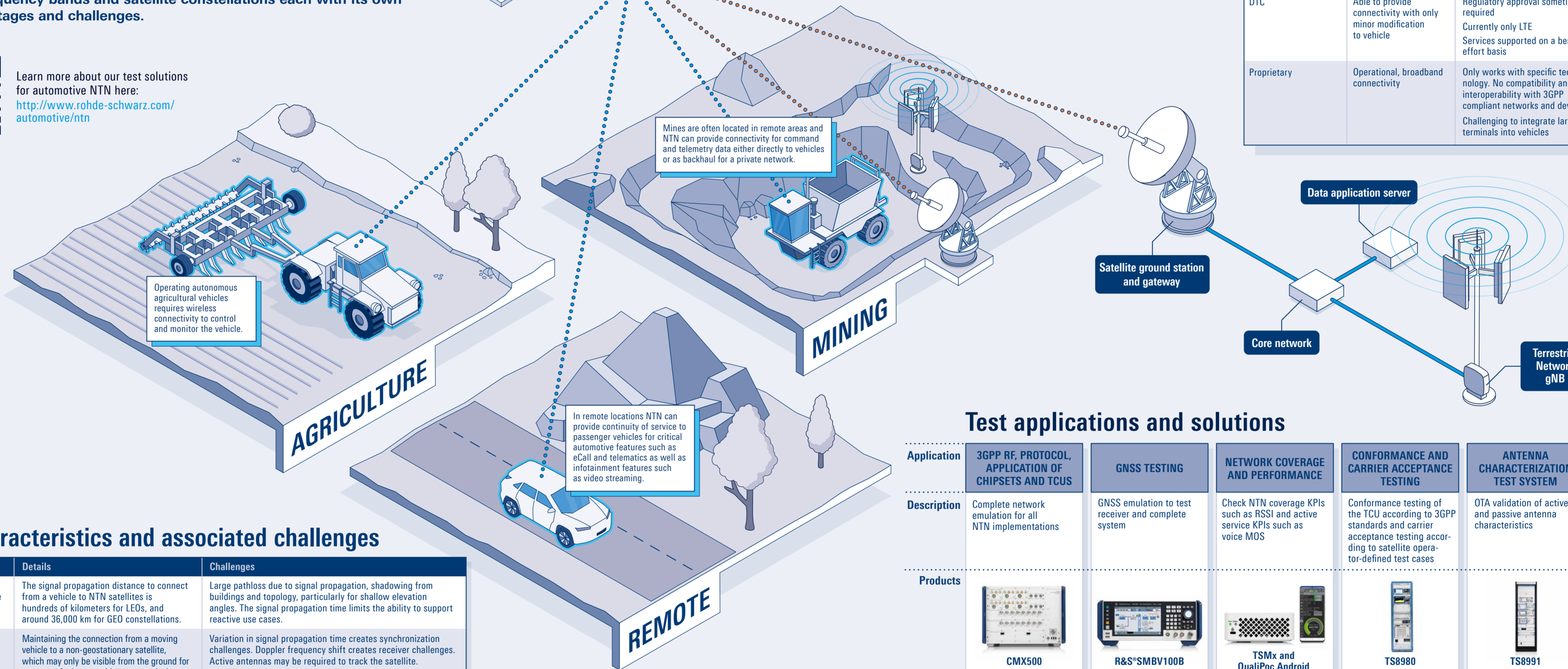
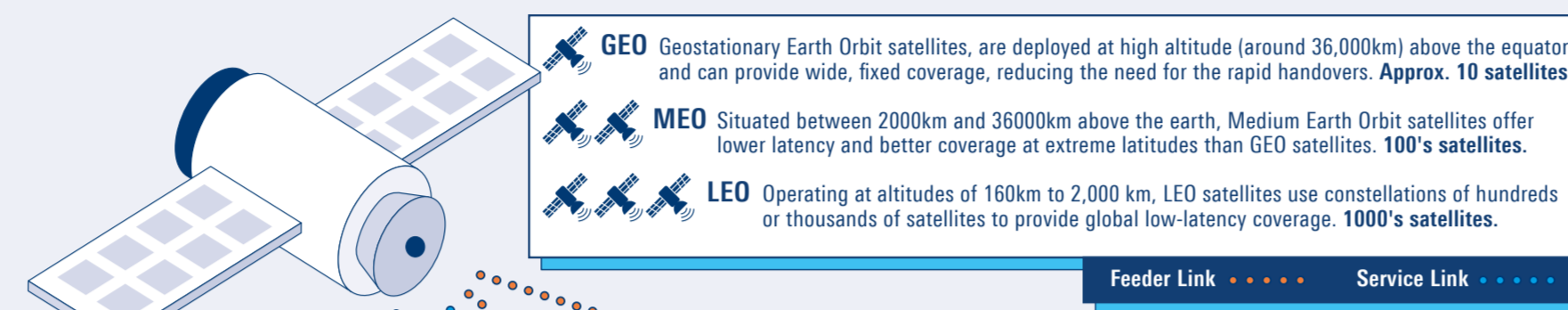
AUTOMOTIVE APPLICATIONS OF NON-TERRESTRIAL NETWORKS

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 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/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. |

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/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 |



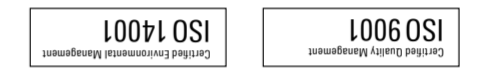


RS® is a registered trademark of Rohde & Schwarz GmbH & Co. KG
 Trade names are trademarks of the owners
 PD 3673.35/19.82 | Version 01.00 | May 2026
 Automatic updates for network maps
 Data without binding | Subject to change
 © 2026 Rohde & Schwarz GmbH & Co. KG | 81671 Munich, Germany



Rohde & Schwarz training
www.training.rohde-schwarz.com

Rohde & Schwarz customer support
www.rohde-schwarz.com/support



Sustainable product design

- ▶ Environmental compatibility and eco-footprint
- ▶ Energy efficiency and low emissions
- ▶ Longevity and optimized total cost of ownership

www.rohde-schwarz.com

The Rohde & Schwarz technology group is among the trailblazers when it comes to paving the way for a safer and connected world with its leading solutions in test & measurement, cybersecurity, technology systems and networks & cybersecurity. Founded more than 90 years ago, the group is a reliable partner for industry and government customers around the globe. The independent company is headquartered in Munich, Germany and has an extensive sales and service network with locations in more than 70 countries.

- Service at Rohde & Schwarz**
- ▶ Worldwide
 - ▶ Local and personalized
 - ▶ Customized and flexible
 - ▶ Improving quality
 - ▶ Long-term dependability

AUTOMOTIVE APPLICATIONS OF NON-TERRESTRIAL NETWORKS

AUTOMOTIVE APPLICATIONS OF NON-TERRESTRIAL NETWORKS

The automotive industry is facing a paradigm shift towards autonomous driving, which requires a high level of reliability and availability. Non-terrestrial networks (NTN) offer a promising solution to these challenges by providing global coverage and high bandwidth. This infographic explores the various applications of NTN in the automotive sector, from agriculture and mining to remote areas and autonomous vehicles.

NTN technologies comparison

| Technology | Frequency | Bandwidth | Latency | Power | Deployment |
|---------------|-----------|-----------|---------|-------|------------|
| 5G NR | Sub-6 GHz | High | Low | Low | Easy |
| 4G LTE | Sub-6 GHz | Medium | Medium | Low | Easy |
| 3G UTRAN | Sub-6 GHz | Low | High | Low | Easy |
| 2G GSM | Sub-6 GHz | Low | High | Low | Easy |
| 1G IS-130 | Sub-6 GHz | Low | High | Low | Easy |
| ISAT | Sub-6 GHz | Low | High | Low | Easy |
| VSAT | Sub-6 GHz | Low | High | Low | Easy |
| LEO | Sub-6 GHz | Low | High | Low | Easy |
| MEO | Sub-6 GHz | Low | High | Low | Easy |
| Geostationary | Sub-6 GHz | Low | High | Low | Easy |

Test applications and solutions

| Application | Solution |
|-----------------------|---|
| Autonomous Driving | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Remote Areas | ISAT, VSAT, LEO, MEO, Geostationary |
| Autonomous Vehicles | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Cars | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Trucks | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Buses | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Trains | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Ships | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Planes | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Helicopters | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Drones | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |
| Connected Satellites | 5G NR, 4G LTE, 3G UTRAN, 2G GSM, 1G IS-130, ISAT, VSAT, LEO, MEO, Geostationary |

NTN characteristics and associated challenges

| Characteristic | Challenge |
|-------------------|------------------------|
| Global Coverage | High Latency |
| High Bandwidth | High Power |
| Low Latency | High Deployment Cost |
| Low Power | High Maintenance Cost |
| Easy Deployment | High Security Risk |
| Easy Maintenance | High Interference Risk |
| High Security | High Jamming Risk |
| High Interference | High Spoofing Risk |
| High Jamming | High Spoofing Risk |
| High Spoofing | High Spoofing Risk |

ROHDE & SCHWARZ
 Make sense.™

