Mobile Network Testing

MAXIMIZE NETWORK QUALITY AND PERFORMANCE

Test solution guide for targeted, QoE centric network improvements

ROHDE&SCHWARZ

Make ideas real

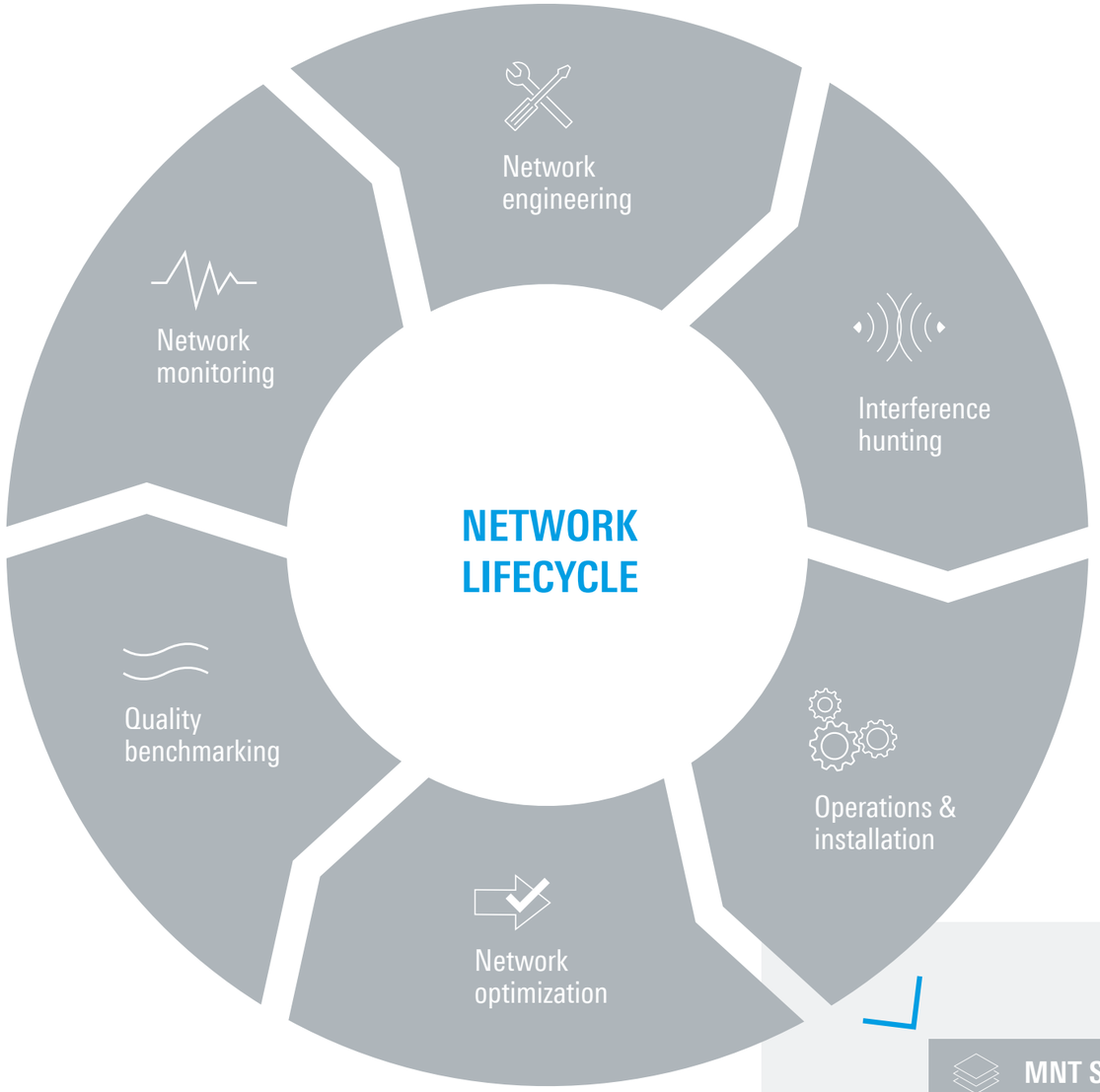
CONTENTS

MOBILE NETWORK TESTING

Rohde&Schwarz is a trusted and leading global supplier of standalone products, integrated solutions and managed services for testing and improving the quality and performance of mobile networks throughout the entire network lifecycle – from lab verification, spectrum clearance, interference hunting and base station installation to site acceptance, benchmarking, optimization, troubleshooting and monitoring. Our comprehensive solutions portfolio supports all cellular technologies up to 5G, and addresses all wireless test and measurement scenarios from RF to end user quality of experience (QoE).

Our innovative products and solutions allow top-tier mobile network industry players to accurately collect data and gain machine learning assisted deep insights into the QoE delivered to end users. As a managed service provider, we plan and run large-scale optimization and benchmarking campaigns. We empower our customers to make QoE centric business decisions with confidence, to deliver better services with higher quality for end users, to reduce time to market for new technologies and services and to safeguard and increase the value of their business.

More information on mobile network testing is available at:
https://www.rohde-schwarz.com/mnt
https://www.rohde-schwarz.com/mnt/stories

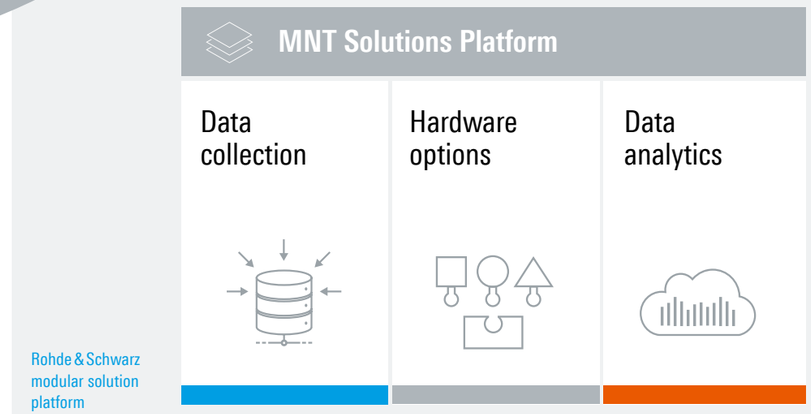


Supported use cases in the mobile network lifecycle

SOLUTIONS TO TEST THE ENTIRE NETWORK LIFECYCLE

In an increasingly complex and technology-driven market, mobile network operators are facing the challenges of reducing costs and increasing competitiveness. At the same time, investments in infrastructure and resources are required to ensure the successful rollout of new services and technologies such as 5G, IoT, Open RAN, Industry 4.0 etc.

Rohde&Schwarz offers a complete integrated range of solutions that are coordinated and compatible across different applications and use cases and cover the entire value chain from data collection to automatic insights into network quality and identification of targeted improvements.



Rohde&Schwarz modular solution platform

EMERGING TECHNOLOGIES AND USE CASES

Emerging technologies such as 5G will enable many new, unseen use cases and services across many industries. Rohde&Schwarz offers a complete solution portfolio for current and future testing needs for both human and machine end-users that help ensure ideal network quality and performance in public and private networks

Private networks

5G enables faster and safer operations as well as new capabilities and efficiencies in industrial processes. However, networks also face increased complexity and performance demands. Private networks play a strong role in manufacturing, warehouses, logistics, mining, oil/gas exploration, critical infrastructure and many other use cases that have to cope with more demanding quality requirements than public mobile networks. Accurate and insightful testing at every phase of a mobile network rollout helps prepare, deploy, and operate private networks faster, while using network resources more efficiently and alerting operators of issues before they become critical.

Smart factories

Smart factories must quickly adapt to production line changes to improve productivity and minimize downtime when retooling factories. Currently wired connections for production equipment, such as robots with Ethernet cables, must be wireless in the future. However, these wireless connections must also be highly reliable with very low latency. Reliability and latency are key mobile network KPIs for smart factories.

The fast, reactive and fully connected capabilities of 5G networks enable smart factories (Industry 4.0) to provide an agile, adaptable and automated manufacturing and warehouse environment. 5G is an extremely flexible technology that can address different smart factory requirements.

- Initial smart factory implementations focus on eMBB use cases such as virtual reality (VR) that deliver rich information about objects and systems and help remotely control them.
- URLLC in 5G and mobile edge computing enables real-time control of manufacturing and warehouse processes while artificial intelligence enables systems to "learn" from experience to make smarter and more reliable decisions. In a hyper-connected environment, devices and assets can be used for the tracking and efficient use of inventory.
- With 5G, a private campus network can be deployed in a dedicated spectrum using the operator-owned spectrum as dedicated network slices to support the allocation of appropriate network resources to match a specific usage.

Find more information about our solutions for private network test use cases here.

C-V2X

Cellular-V2X (C-V2X) uses 3GPP standardized LTE or 5G NR mobile connectivity to send and receive signals between a vehicle and other vehicles, pedestrians or infrastructure to improve road safety and speed up progress in autonomous driving. Since C-V2X enables safety-critical functions such as emergency brake warning, proper operation is critical. Road side units (RSU) provide safety-critical warnings and information to vehicles and pedestrians at intersections or roadwork sites. The critical infrastructure components require thorough and regular testing.

Find more information about C-V2X here.

Open RAN

Open RAN success depends on E2E performance and full customer satisfaction, which both require extensive lab and field testing. Testing must include radio network functions, such as network access and mobility, network performance, capacity and service performance (QoS and QoE). Proper network synchronization for time division duplex (TDD) operations is also required since problems with slot and frame synchronization can significantly degrade network performance.

Find more information about Open RAN testing here.

Critical infrastructure

All mission-critical communications that require higher than normal quality of service (QoS) for performance, reliability and security need a specialized communications network. The networks are called "critical infrastructure" and include police, fire brigade and emergency service communications (with TETRA, Public-Safety LTE, etc.) along with air traffic control and other safety-critical services and business-critical use cases such as smart manufacturing (using LTE and 5G with higher guaranteed network quality). Verifying critical infrastructure network quality and performance is vital safeguarding public trust and increasing the value of the critical infrastructure business.

Find more information about our solutions for critical infrastructure on our dedicated webpages here and here.

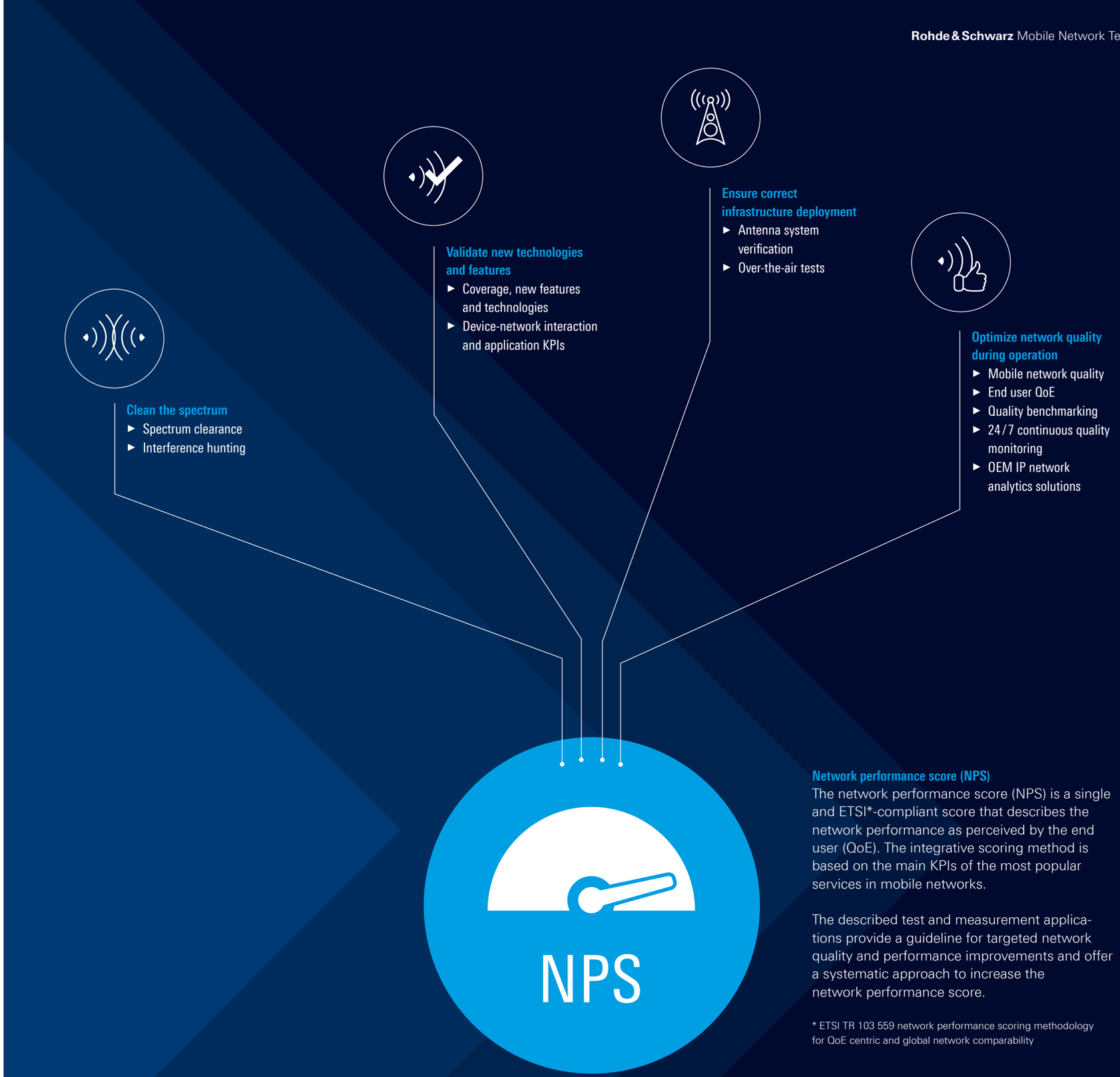
KEY ACTIVITIES TO MAXIMIZE NETWORK QUALITY AND PERFORMANCE IN A MOBILE NETWORK

Mobile operators are facing multiple challenges and increasing complexity due to high cost pressure, strong competition and the necessity to deploy new technologies (incl. 5G, IoT), services and devices to deliver optimal subscriber QoE. With the emergence of 5G and even more with arising 6G, advanced techniques are required to test machine-type communications and access new markets such as automotive, Industry 4.0 and smart cities. Rohde&Schwarz provides a comprehensive portfolio of targeted test and measurement applications for the mobile network lifecycle. They allow users to improve network quality and performance with a strong focus on the end-user quality of experience (QoE) which is the ultimate indicator of the successful delivery of a service to an end user.

The QoE centric network performance score (NPS) methodology, in line with ETSI* TR 103 559, is a harmonized approach to characterize the overall network quality and performance, making it the ideal point of reference for:

- Transparent, independent, neutral, technology-agnostic and accurate QoE centric characterization and assessment of a network's quality and performance
- Comparing network quality and performance within a country, in time, between infrastructure vendors, before and after network improvements or internationally in accordance with ETSI-approved methodology
- Efficient identification of critical factors that have the greatest impact on the network's quality and performance and how they compare with competitors
- Prioritizing targeted actions for improvements

Only Rohde&Schwarz provides a fully integrated and future-proof set of harmonized solutions for high-quality RF and QoE centric data collection and sophisticated, machine learning assisted analytics allowing the identification of key areas for QoE centric network improvements and strategic network Investments.



Network performance score (NPS)
The network performance score (NPS) is a single and ETSI*-compliant score that describes the network performance as perceived by the end user (QoE). The integrative scoring method is based on the main KPIs of the most popular services in mobile networks.

The described test and measurement applications provide a guideline for targeted network quality and performance improvements and offer a systematic approach to increase the network performance score.

* ETSI TR 103 559 network performance scoring methodology for QoE centric and global network comparability

NPS – REDUCING COMPLEXITY FOR TARGETED NETWORK IMPROVEMENTS

Use a transparent industry standard for systematic network improvements

The globally renowned European Telecommunications Standards Institute (ETSI) published the technical report TR 103 559, which describes the best practices for robust mobile network QoS benchmark testing and scoring. This scoring approach of networks, operators, regions and technologies is based on a harmonized and integrative scoring methodology, where the main KPIs of the most popular services in mobile networks are collected, weighted and aggregated to a single, integrative score that describes the network performance as perceived by the end user (QoE).

The integrative scoring method – called network performance score (NPS) in solutions from Rohde&Schwarz – is the ideal entry point in data analysis for deep drilldown and uncovering the most problematic areas and services. Moreover, the NPS is also an essential feature for network-wide optimization. Therefore, Rohde&Schwarz offers the integrative scoring method per ETSI TR 103 559 as an integral part of its postprocessing and reporting solutions. Starting from the QoE centric NPS, the collected network testing data can be fully exploited with a seamless user interface and direct drilldown functions to obtain root cause information. This provides visibility of critical factors that have the greatest impact on the network's quality and performance, how they change over time, be deployed in regions, compare with competitors and enables prioritization of targeted actions for improvements.

The fastest way from QoE centric data to actionable insights

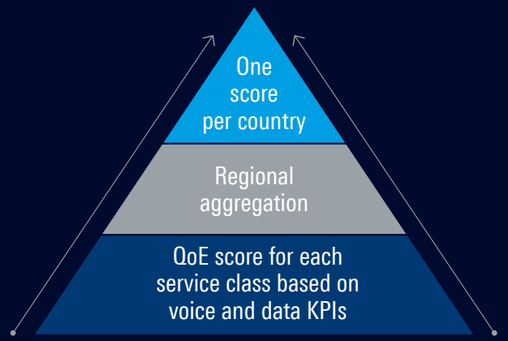
The integrative network performance score (NPS) methodology consists of three layers:

- The scoring methodology is based on the integrative QoE evaluation of service classes. It is essential to combine and weight a service class's different dimensions (availability of the service, waiting time and the perceived service quality itself).
- Each of the three dimensions has its own impact on the end user QoE and each dimension needs to be normalized to a common scale (e.g. 0 to 1000) and assigned its own weighting.
- All dimensions of a service class can be aggregated to a single performance number for this service class. All services and applications are evaluated separately following the same multidimensional concept.
- All these performance numbers for each service class are weighted again and aggregated to an overall score describing the network's performance in the region where the measurements were made.
- The performance in the different regions can again be weighted by importance (e.g. population density) and combined to an overall, e.g. countrywide, network performance score NPS.

The ultimate goal: maximized QoE from an optimized network

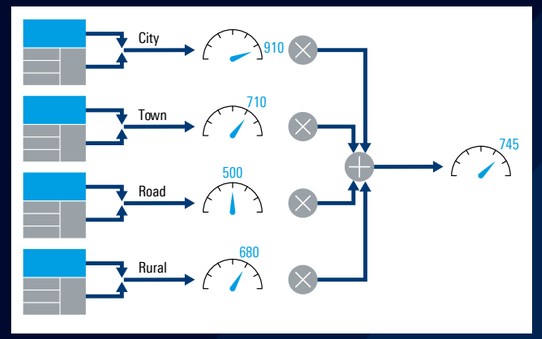
The NPS methodology ats implemented in the Rohde&Schwarz software suite SmartAnalytics provides insights into the potential for improvement and the foundation for network optimization based on the actual vs. the maximum achievable score per test category/service/region/technology/etc. SmartAnalytics identifies and prioritizes exactly which parameters to optimize to achieve the greatest QoE improvement and give the mobile network operator a competitive advantage.

Integrative NPS scoring model based on ETSI TR 103 559

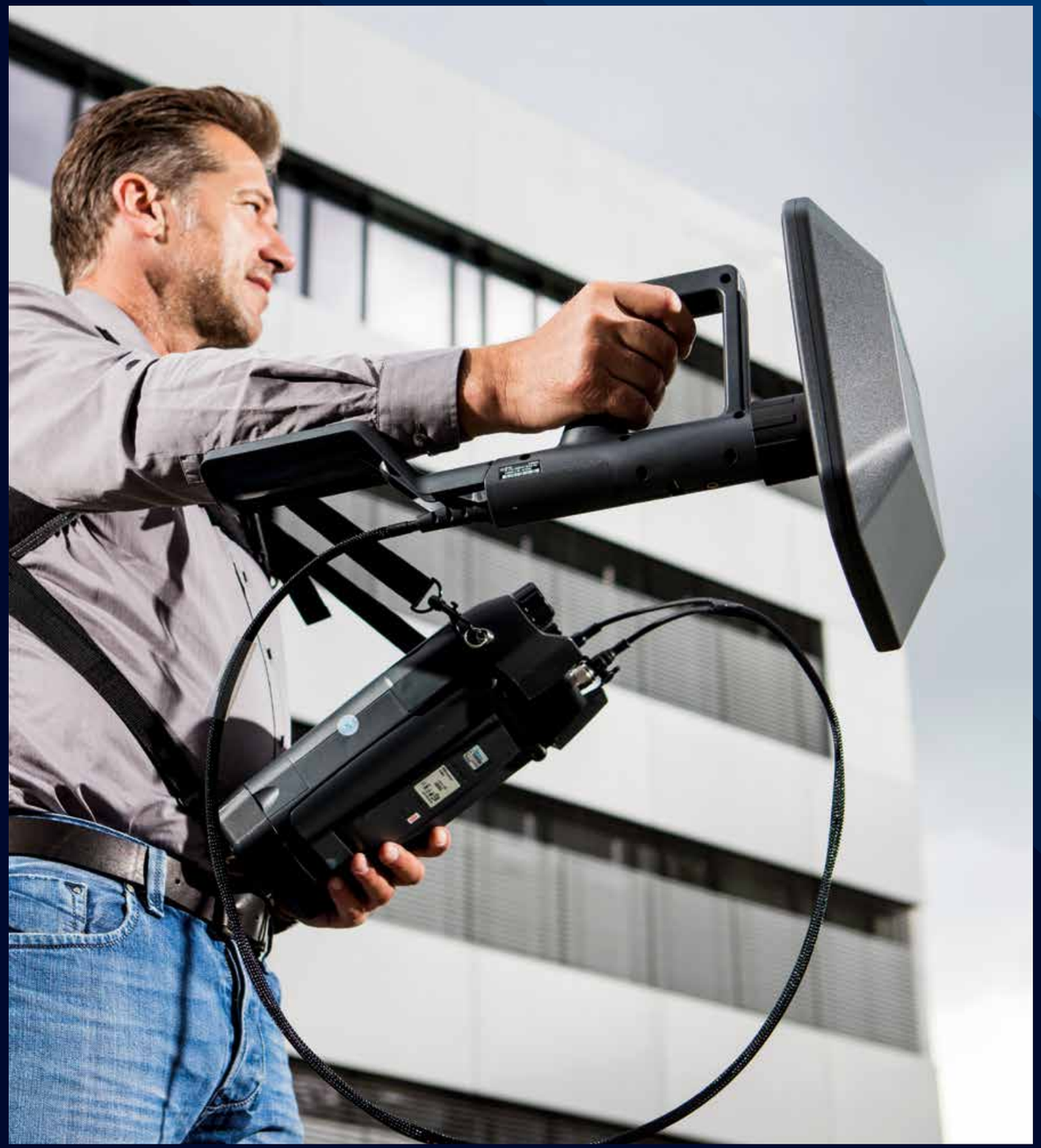


Level 3 Weight and aggregate all regions to a countrywide score (the "CxO level")
Level 2 Weight and aggregate QoE of all service classes per region
Level 1 Evaluate QoE of all service classes (different dimensions of a service class)

KPI aggregation to regional scores and to country wide network performance score



Visualization of network performance score for two different mobile network operators



CLEAN THE SPECTRUM

The number of transmitting devices is constantly increasing. To ensure a good user experience, mobile network operators have to monitor the quality of the spectrum even more than before. Rohde&Schwarz solutions enable fast and efficient spectrum clearance and interference hunting.

Each deployment of new mobile technology makes it more and more necessary to obtain a clean spectrum in order to achieve the expected data rates. However, as the quantity of transmitting devices increases, the number of RF interference sources also grows.

A mobile network operator may be tempted not to invest in interference hunting and spectrum clearing if the network continues to function in the presence of these interferers. But from a user point of view, degraded network performance can lead to low data rates, distorted audio and video or dropped calls. A lower end user QoE can reduce operator revenue. It may cause subscribers to change to a different service provider, which benefits competitors in an already competitive market. A clean spectrum is a necessity in a world that is increasingly mobile data dependent.

Investigating the origin of interference can be a challenge for the operator not only because of the ever-growing number of possible sources, but also because the nature of interfering signals can vary. Any electronic device can behave as an interferer. Even properly working devices can create unwanted emissions. The search for clean signals requires the expertise of specialists in the field.

To ensure the best results in obtaining a clean spectrum, Rohde&Schwarz offers industry-leading solutions that quickly and efficiently identify and map out the sources of various types of interference. They provide mobile network operators with the necessary tools for monitoring network quality, locating interference sources and neutralizing their effects on the network. The innovative solutions feature user-friendly characteristics, combining portability with leading measurement speed and sensitivity to effectively identify and locate interferers.

Rohde&Schwarz solutions range from the most competitively priced tools for entry-level technicians to high-end instruments for the experts. The company has decades of experience in producing novel, class-leading test and measurement and radiolocation solutions. By providing high-quality, compatible, extremely precise products, Rohde&Schwarz has earned the trust of customers ranging from industry experts to intelligence bodies and national authorities.

SPECTRUM CLEARANCE

Radio interference is caused by internal network sources or external, unknown sources. Internal interference results from planning mistakes, defective base station components such as damaged antennas or filters, and corroded connectors that create passive intermodulation (PIM). For more details on internal interference sources, see the "Ensure correct infrastructure deployment" section.

Any electric or electronic device can be a source of external interference. Noisy LED displays on the street, indoor repeaters, consumer devices and faulty industrial equipment are all potential interferers. Even properly working devices can create unwanted emissions due to harmonics and intermodulation. Illegal and unlicensed transmitters also cause interference, usually in the form of high-power signals that affect a wide coverage area.

Interference causes subscribers to experience distorted audio or video, low data rates and dropped calls. It is imperative to address this bad user experience.

Spectrum clearance

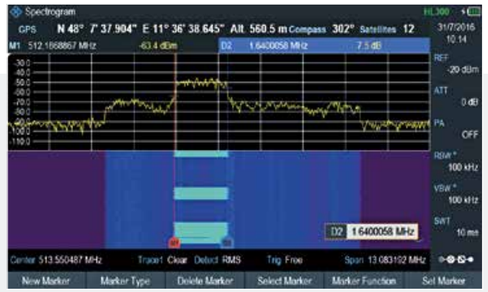
Spectrum clearance is the process of characterizing the RF spectrum and removing unwanted transmitters. Spectrum clearance takes place before deploying a network in a new or refarmed frequency band to ensure a clean operating environment.

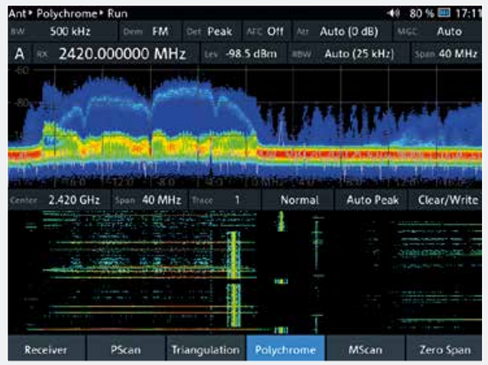
1 The walk and drive test solutions that combine Rohde&Schwarz scanners and R&S®ROMES4 allow users to quickly and easily collect spectrum data in a wide area. Back in the office, the Network Problem Analyzer (NPA) automatically generates a list of interferers and displays the measurement locations on the map. The hunting process starts at these locations.

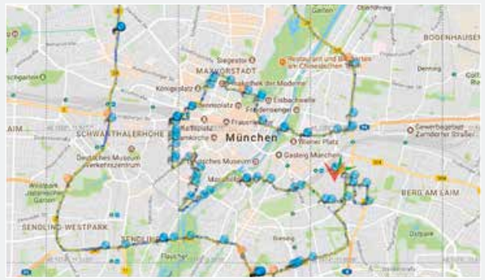
Identifying interferers

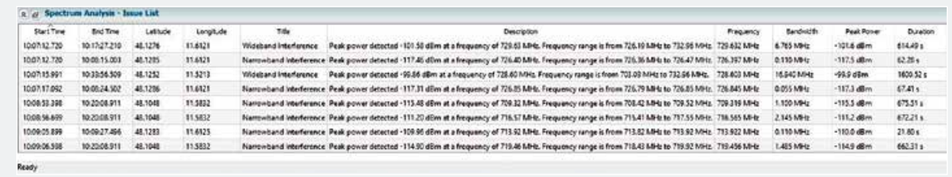
2 The R&S®Spectrum Rider FPH detects interference signals with a combination of spectrum and spectrogram measurements. Long-term recording captures up to 999 hours of activity, making it easy to identify sporadic interference by triggering on events.

3 The polychrome spectrum display on the R&S®PR200 portable monitoring receiver and R&S®MobileLocator enables users to visually separate two or more pulsing signals that occupy the same frequency spectrum.









Start Time	End Time	Latitude	Longitude	Title	Description	Frequency	Bandwidth	Peak Power	Duration
10:07:12.720	10:17:27.210	48.1276	11.6421	Wideband Interference	Peak power detected -101.50 dBm at a frequency of 729.63 MHz. Frequency range is from 726.10 MHz to 732.96 MHz.	729.632 MHz	6.765 MHz	-101.6 dBm	614.49 s
10:07:12.720	10:08:15.003	48.1295	11.6421	Narrowband Interference	Peak power detected -117.46 dBm at a frequency of 726.40 MHz. Frequency range is from 726.36 MHz to 726.47 MHz.	726.397 MHz	0.110 MHz	-117.5 dBm	62.28 s
10:07:15.991	10:33:56.509	48.1252	11.5213	Wideband Interference	Peak power detected -99.86 dBm at a frequency of 728.60 MHz. Frequency range is from 703.09 MHz to 732.96 MHz.	728.603 MHz	16.040 MHz	-99.9 dBm	1609.52 s
10:07:17.092	10:08:24.302	48.1286	11.6421	Narrowband Interference	Peak power detected -117.31 dBm at a frequency of 726.85 MHz. Frequency range is from 726.79 MHz to 726.85 MHz.	726.845 MHz	0.055 MHz	-117.3 dBm	67.41 s
10:08:53.398	10:20:08.911	48.1048	11.5832	Narrowband Interference	Peak power detected -113.48 dBm at a frequency of 709.32 MHz. Frequency range is from 708.42 MHz to 709.52 MHz.	709.319 MHz	1.100 MHz	-113.5 dBm	675.51 s
10:08:56.699	10:20:08.911	48.1048	11.5832	Narrowband Interference	Peak power detected -111.20 dBm at a frequency of 716.57 MHz. Frequency range is from 715.41 MHz to 717.55 MHz.	716.565 MHz	2.145 MHz	-111.2 dBm	672.21 s
10:09:05.899	10:09:27.496	48.1283	11.6925	Narrowband Interference	Peak power detected -109.95 dBm at a frequency of 713.92 MHz. Frequency range is from 713.82 MHz to 713.92 MHz.	713.922 MHz	0.110 MHz	-110.0 dBm	21.60 s
10:09:06.598	10:20:08.911	48.1048	11.5832	Narrowband Interference	Peak power detected -114.90 dBm at a frequency of 719.46 MHz. Frequency range is from 718.43 MHz to 719.92 MHz.	719.456 MHz	1.485 MHz	-114.9 dBm	662.31 s

Locating interference sources

After identifying the interferer, the process used to locate the source depends on the environment.

4 Indoor or outdoor signal strength mapping provides a good estimation of the area where the interference source is located.

5 In line-of-sight scenarios, triangulation with a directional antenna isolates the location of an interferer. For the last mile, a tone function helps the operator reach the source.

6 In dense multipath scenarios, the fully automated direction finder R&S®MobileLocator guides the user towards the interference source via a heat map and ultimately pinpoints its exact location thanks to its sophisticated statistical analysis.

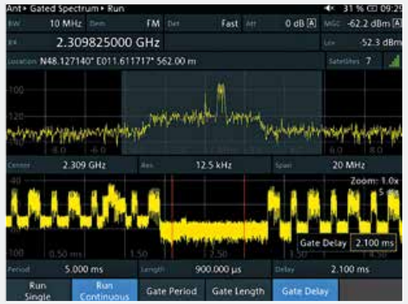
Rohde&Schwarz solutions combine portability, measurement speed and sensitivity to effectively identify and locate sources of interference.

INTERFERENCE HUNTING

Interference hunting in TDD networks

In TDD networks where the downlink signals mask the uplink signals and any other signals, technicians in the field may be unable to identify interference with conventional spectrum measurements, and certainly not locate the interferer.

The R&S®Spectrum Rider FPH handheld spectrum analyzer and R&S®PR200 portable monitoring receiver feature a gated trigger that enables users to separate uplink and downlink signals in the time domain.



The unique parallel time and frequency domain analysis on the R&S®PR200 allows the user to keep an eye on the gate configuration without losing sight of the spectrum signal

Spectrum and QoS/QoE monitoring

The measured quality of services indicates the impact of interference. Voice, data, video streaming and messaging tests on dedicated test smartphones such as the QualiPoc Android assess and reflect the real network QoS/QoE experienced by end users. R&S®TSMx scanners and R&S®ROMES4 software perform spectrum measurements in parallel with network measurements (coverage, BCH demodulation, QoS/QoE).

R&S®PR200
Portable receiver
Up to 18 GHz

R&S®Spectrum Rider FPH
Up to 31 GHz

R&S®FSH
All-in-one BTS analyzer
Up to 20 GHz

R&S®TSMx and R&S®ROMES4
Network scanner and software
Up to 44 GHz

DATA COLLECTION

R&S®HE800-PA
Handheld directional antenna for locating transmitters and interferers

R&S®HE800-DC30
Portable antenna with integrated downconverter

R&S®HE400
Active directional antenna
Up to 20 GHz

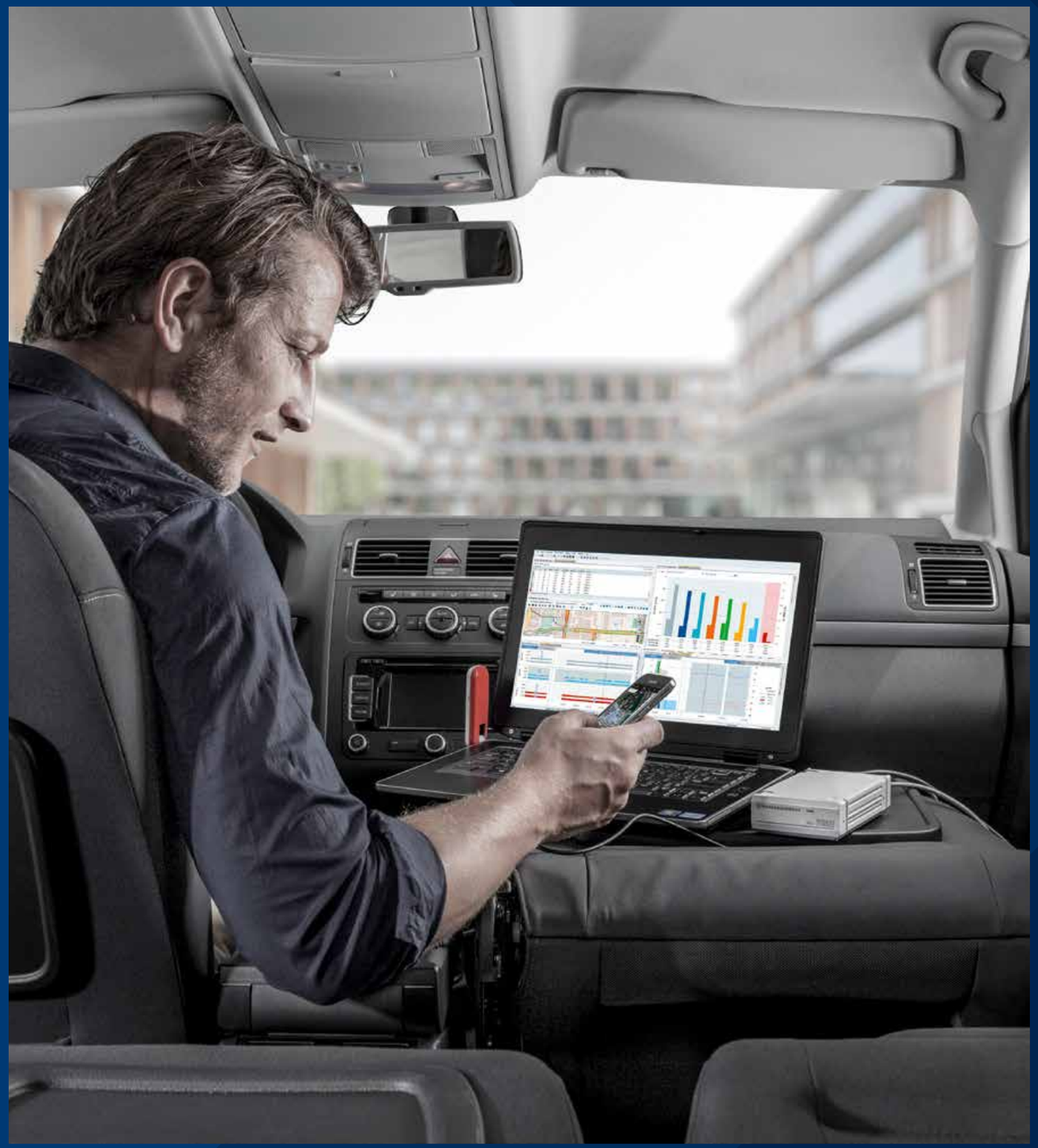
R&S®ADD207P
Direction finding antenna
Up to 6 GHz

HARDWARE OPTIONS

Network Problem Analyzer (NPA)
Postprocessing software

R&S®MobileLocator
Advanced interference hunting and emitter location software

DATA ANALYTICS



VALIDATE NEW TECHNOLOGIES AND FEATURES

As the world enters the age of 5G NR and IoT, mobile network operators are busy living up to expectations and adapting to the technical requirements of these new technologies. To help them master these challenges, Rohde&Schwarz offers high-quality, long-term solutions that closely correspond to the real-world experience.

Committing to a new technology can be challenging for a mobile network operator. Competition is tough and network operators are required to keep up to date with current developments. On a daily basis, the media creates high expectations for 5G implementations. Both the mobile technology industry and operators need to respond to these needs.

The first versions of 5G were rolled out to improve and build on the currently used LTE technology, with a focus on enhanced mobile broadband (eMBB). The new frequency bands around 3.5 GHz (FR1) and mmWave frequency bands (FR2) are or will be auctioned in many parts of the world. Early deployments prove that they are game changers in enabling unprecedentedly high capacities.

One of the major challenges is the complexity of 5G NR and IoT combined with the fact that development of the technologies continues as they are deployed. Every new 3GPP Release will provide new features also in the range of ultra-reliable low latency communication (URLLC) and every year smartphone flagships come up with improved sets of UE capabilities.

Another matter is how devices using this new technology will behave and interact with the new network. Different devices supporting 5G and IoT should be able to access the network equally reliably and offer the required performance.

Testing is the starting point for making sure that products and services deliver the expected results. Rohde&Schwarz offers industry-leading, innovative T&M solutions and procedures. The company has been involved in the development of mobile technology testing since 2G, and has already been working closely with 5G for years. Rohde&Schwarz has leveraged this comprehensive experience to build a wide portfolio that provides a reliable basis for the introduction of new technologies and gives customers a well-researched path into mobile network testing for services based on 5G and IoT.

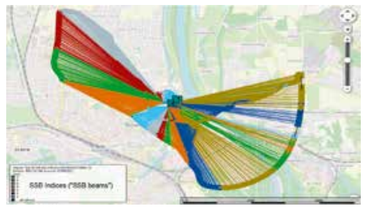
A customer using Rohde&Schwarz mobile network testing solutions can be confident that both laboratory and field based testing correspond with real-world conditions. Customers can plan implementations of the new technologies with confidence and leverage their products to the full potential of their products.

COVERAGE, NEW FEATURES AND TECHNOLOGIES

Measurement setup example for 5G NR

R&S®TSME6 and R&S®TSMA6 scanners connected to a downconverter (R&S®TSME30DC or R&S®TSME44DC) are ideal for data collection in the mmWave frequency range. Together R&S®ROMES4 they form the first 5G NR network measurement solution that measures true 5G NR network coverage and verifies the impact of beamforming for sync signals and broadcast channels.

Typically, network scanners investigate and verify new features often even before smartphones support them. This reduces risks for network operators and infrastructure vendors during the commercial launch.



R&S®ROMES4: outline color represents the best SSB index beam received by a scanner on the drive test route

As with all new technologies and frequencies, coverage and the impact of new features are important issues that affect the QoS/QoE. Coverage measurements are essential, particularly in the early phases of the network lifecycle of new technologies (e.g. 5G NR Non-Standalone/NSA as well as Standalone/SA), for instance during network engineering.

- Precommercial network trial: provides insights into the performance of the new technology and features and prevents uncertainties before the commercial launch
- Commercial network rollout: verifies network planning and site installation

R&S®ROMES4 drive test software supports the connection of 5G NR routers and precommercial and commercial smartphones to monitor 5G NR device-network interaction and execute various network performance tests, including UL tests. This allows manufacturers of 5G NR devices to gain early insights into how their devices perform and how they interact with real 5G NR networks.

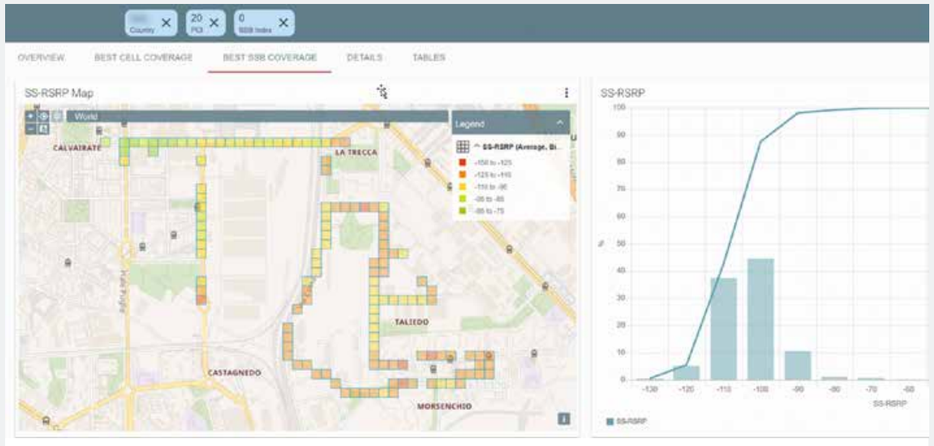
R&S®TSME6
Ultracompact network scanner with R&S®ROMES4 running on a laptop

R&S®TSMA6
Autonomous network scanner

R&S®TSME30DC/ R&S®TSME44DC
Ultracompact downconverters

QualiPoc Android
Smartphone based RF and QoE testing

DATA COLLECTION



SmartAnalytics post processing and analytics suite showing RSRP distribution of one cell and one SSB

Mass rollout of a new technology or new network requires a sophisticated postprocessing tool for data analysis. This tool has to handle big data, provide deep insights into network quality and create recommendations for network optimization. SmartAnalytics interactively processes big data and very quickly analyzes large data-sets. It helps users see at a glance the best cell coverage (all PCIs) and filter on a specific PCI to focus on specific cell coverage and statistics. The software visualizes all SSB beams received from this PCI and filters on a specific SSB beam to focus on beam specific coverage and beam direction. SmartAnalytics is fully customizable, allowing users to configure and generate graphs of interest.

Customer benefits:

- Easy to use indoors and outdoors (small scanner size), long battery life, future-proof
- OPEX savings due to SmartAnalytics (subscription based model, single postprocessing suite for all Rohde&Schwarz tools) and scanners (two-year calibration interval, three-year warranty)
- CAPEX savings (scalable and modular solutions)

R&S®ZCB2
Shoulder bag for comfortable walk and drive tests

HARDWARE OPTIONS

R&S®ROMES4
Universal software platform for real-time, in-field data analysis

SmartAnalytics
Software suite for QoE data analytics, including network performance score

DATA ANALYTICS

DEVICE-NETWORK INTERACTION AND APPLICATION KPIS

The introduction of a new technology usually requires a new generation of end user devices. Experience from previous technology generations has shown that there is uncertainty about the performance of these early devices and their protocol (how they interact with the network). The most important criterion for the success of a mobile network operator is user satisfaction, and that is closely linked to the quality of experience (QoE). This subjective measure from the user perspective is influenced by the device itself, the network and the application servers.

Network testing involves using network scanners and different data collection devices (UE) such as evaluation boards, USB dongles, precommercial and commercial smartphones to perform UE based measurements (network engineering). Scanners are passive measurement tools, but the SIM based UEs will set up an active connection with networks in order to run end-to-end applications. This provides insights into network quality related to the QoE of applications and how devices interact with the real networks, for instance the beam mobility procedure in 5G.

These 5G NR UE based measurements include NR serving cell and measured neighbor cell information, for example NR DL ARFCN, PCI and SSB index, beam level measurements, layer 1 RSRP/RSRQ, layer 2 PDSCH/PDCP/PUSCH information, LTE-NR EN-DC L3 signaling and application layer information. An additional detailed set of information is available for carrier aggregation and includes information such as MCS, BLER and the retransmission rate on each carrier. More advanced 5G NR networks provide UE specific CSI-RS RSRP information. R&S®ROMES4 software can process all this information.

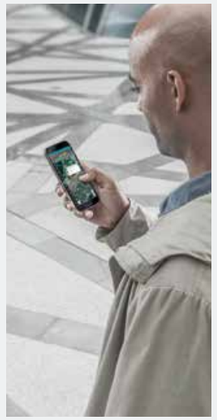
R&S®ROMES4 drive test software supports the connection of 5G NR routers, precommercial and commercial smartphones and network scanners. Scanners are passive devices for monitoring cell and beam environment of multiple networks. Adding 5G UEs enables monitoring of 5G NR device-network interaction and UE specific channels and data streams, including special features and metrics such as 5G carrier aggregation, dynamic MCS, access procedures, 5G mobility and application performance.

This allows manufacturers of 5G NR devices to gain early insights into device verification, device performance and how the device interacts with real 5G NR networks. **The R&S®TSME6 and R&S®TSMA6 scanners in combination with R&S®ROMES4 offer reference measurements to evaluate the device performance in the downlink direction.**

Using commercially available UEs from well-known smartphone manufacturers, the R&S®ROMES4 universal software platform for network engineering, optimization and troubleshooting measures critical UE based parameters such as data performance KPIs, serving cell information, signaling and RF metrics. R&S®ROMES4 is compatible with rooted phones and commercial off-the-shelf (COTS) UEs with open diagnostic ports.

The number of 5G smartphones in the market is increasing every day. The 5G software package for QualiPoc Android supports leading smartphones, delivering results from application layer tests (end user QoE) down to layer 1 RF measurements.

By processing data acquired from the end user perspective, the Rohde&Schwarz data analytics tool SmartAnalytics provides a precise and clear assessment of an operator's network quality (QoE from the end user perspective) and its competitive position on the market.



Customer benefits:

- Faster time to market and less risks for new technologies and features due to early experience with prototype devices in a live network trial
- Better measurement result overview thanks to receiving real-time, in-field analysis results from R&S®ROMES4 and to big data postprocessing with SmartAnalytics
- User perceived QoE measured – the most important success factor for operators
- Network scanner provides reference measurements to support in-field device verification

QualiPoc Android
Smartphone based RF and QoE testing

R&S®TSMA6
Autonomous network scanner

Any 5G commercial UE
can be connected to R&S®ROMES4

DATA COLLECTION

R&S®ZCB2
Shoulder bag for comfortable walk and drive tests

HARDWARE OPTIONS

R&S®ROMES4
Universal software platform for real-time, in-field data analysis

SmartAnalytics
Software suite for QoE data analytics, including network performance score

DATA ANALYTICS

ENSURE CORRECT INFRASTRUCTURE DEPLOYMENT

The quality of the installation and maintenance of mobile network infrastructures has a huge impact on network performance. This process involves numerous teams and many steps. Performing measurements after each step is the only way to ensure that both the expected network quality and increase in capacity are achieved. Time is of the essence in field activities. The leading solutions from Rohde&Schwarz focus on efficiency so users can quickly perform all required measurements when there is no time to lose.

Constructing and deploying infrastructures is a key task for mobile network operators. Many teams are involved in the project at different times. In order to ensure matching settings and optimal connectivity, operators have to thoroughly test and monitor the network and its performance. Otherwise, the robustness of the installation/system and consequently the quality of experience for the end customer may suffer.

The newly introduced 5G adds more challenges to the network infrastructure. Operators may feel reluctant to commit to an untried 5G technology that requires technological investments in order to enable conformity with new features such as active antennas, beamforming, new frequencies and increased data rates. The emergence of new 5G technology also requires new testing methods. The new FR2 frequency range, for instance, has to be tested over the air (OTA). In addition, 5G still relies on LTE and its existing network infrastructure, which highlights the importance of continuing to service existing networks.

Rohde&Schwarz offers comprehensive T&M equipment for both LTE and 5G based technologies, including over-the-air (OTA) measurements. The mobile network testing product portfolio also contains robust, handheld and versatile alternatives. In fieldwork, mobility and ease of use are key. Rohde&Schwarz offers suitably priced solutions that focus on the user experience and portability of the equipment.

Since more than 50 % of coverage and communication issues for users originate from the antenna systems, Rohde&Schwarz has developed tools for antenna measurements, including reflection and optical power measurements. Rohde&Schwarz T&M solutions support automated test sequences and easy report generation to shorten test times and increase efficiency in the field.

ANTENNA SYSTEM VERIFICATION

Reflection measurements

Return loss measurements are the traditional way to assess an antenna system. The amount of return loss indicates how effectively an antenna radiates RF energy.

Distance-to-fault measurements help identify and locate high reflection sources such as pinched cables and broken connectors.

Expect fast

With its short boot and warm-up times and fast measurement speed, the R&S®Cable Rider ZPH starts analyzing extremely quickly. There is no need to calibrate the analyzer before use; it is reliably and accurately calibrated before leaving the factory. Should calibration be needed to eliminate the effects of additional cables or adapters, the automatic calibration unit performs the calibration in just a few seconds.

Transmission measurements

Reduced uplink gain on a tower mounted amplifier (TMA) can lead to signal distortion and spurious emissions in neighbor channels.

Transmission measurements characterize components such as amplifiers, filters and repeaters. They also determine the isolation between transmit and receive antennas.

The convenient built-in DC voltage supply (bias) in the R&S®Cable Rider ZPH and R&S®ZVH cable and antenna analyzers powers active components.

R&S®Cable Rider ZPH
Cable and antenna analyzer

R&S®ZVH
Cable and antenna analyzer

R&S®5G STS
5G Site Testing Solution

DATA COLLECTION

Optical power measurements
Simply connecting the R&S®HA-Z360/Z361 USB optical power meter to the Rohde&Schwarz handheld analyzers allows users to perform absolute power and insertion loss measurements on fiber-optic cables.

Expect efficient

From test configuration to test reports in only three steps

1. Centralized test configuration
Test sequences are predefined on a PC using R&S®InstrumentView and the built-in wizard and transferred to all Rohde&Schwarz analyzers in a project.

2. Wizard-guided test execution
On site, the wizard guides the field engineer through the test sequence with customized, predefined instructions.

3. Standardized test reports
Results are transferred via LAN, USB or memory card to a PC where a standardized test report can be created.

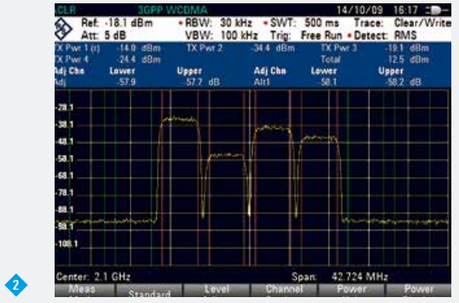
OVER THE AIR TESTING

Every generation of cellular communications technology has increased the density of network infrastructure and base stations. This is now happening with 5G. Functional tests are a standard and essential procedure after installing a base station. Field technicians typically use handheld spectrum analyzers to verify transmission power in the relevant frequency bands. However, deeper analysis of other parameters is very time consuming and complicated using only spectrum analyzers. The measurement results need to be allocated to a specific base station for targeted measurements or to a specific antenna beam (5G beamforming) for even greater detail.

Spectrum analyzers are powerful devices that reflect the entire network environment, including signals from every base station within range. However, they only offer a simple signal decoder for identification of specific base station signals making it far more complicated to implement specific measurements. Moreover, identifiers are only submitted on specific frequencies in a 5G network, these frequencies are not defined and differ from network to network. As a result, field technicians have to know the broadcast signal frequencies beforehand and manually configure these frequencies for every measurement. Every new frequency band in this process also needs to be manually repeated. Overall, it is a very time consuming and error-prone process, limiting measurement to known frequencies.

A measurement solution with advanced features and automated functions is needed. A solution that selectively filters and automatically displays all signals from each base station based on identifiers in real time, with a clear structure and a user-friendly interface is needed. R&S®5G STS is the first and only solution on the market that offers an advanced feature set for the effective implementation of over-the-air site testing.

1

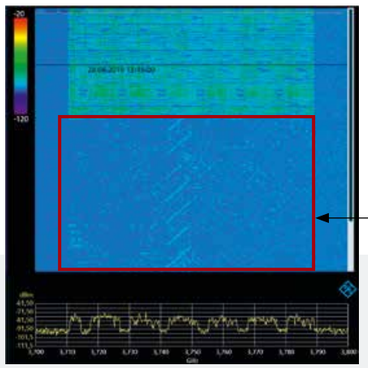


2

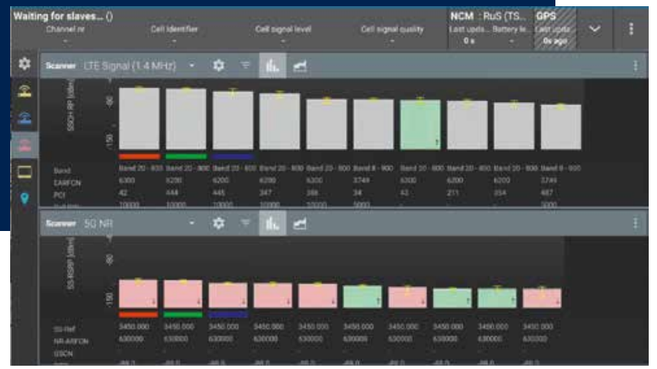
Layer 1 spectrum measurements
Standard spectrum measurements such as channel power, occupied bandwidth (OBW), spurious emissions and adjacent channel leakage power ratio (ACLR) measurements are quick and easy ways to verify the signal waveform.

1. Spurious emissions can interfere with adjacent transmit signals, resulting in reduced signal quality and lower data rates. Rohde&Schwarz handheld spectrum analyzers use the spectrum emission mask (SEM) function to measure if the signal lies within the limits defined by wireless communications standards.

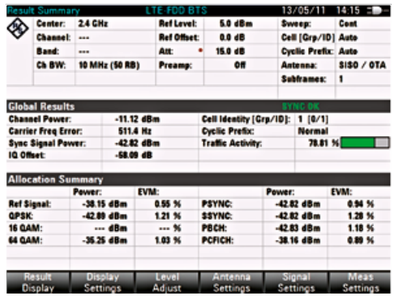
2. The ACLR measurement shows how far a base station carrier signal reaches into the adjacent channel. A too low ACLR indicates poor signal quality and can lead to interference on the adjacent useful signals.



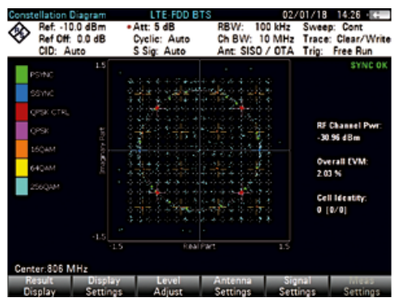
Uplink interferer measurement with handheld spectrum analyzer R&S®FPH
In Zero Span mode the unique gated trigger can separate downlink and uplink for dedicated interferer measurements in the uplink time period.



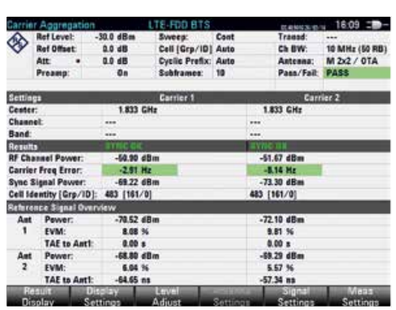
SSB measurements
help verify 5G NR coverage
and the impact of beamforming.



LTE OTA
measurement
results



LTE OTA
constellation



LTE-A carrier
aggregation
pass/fail
analysis

Game changer – Over The Air tester R&S®5G STS

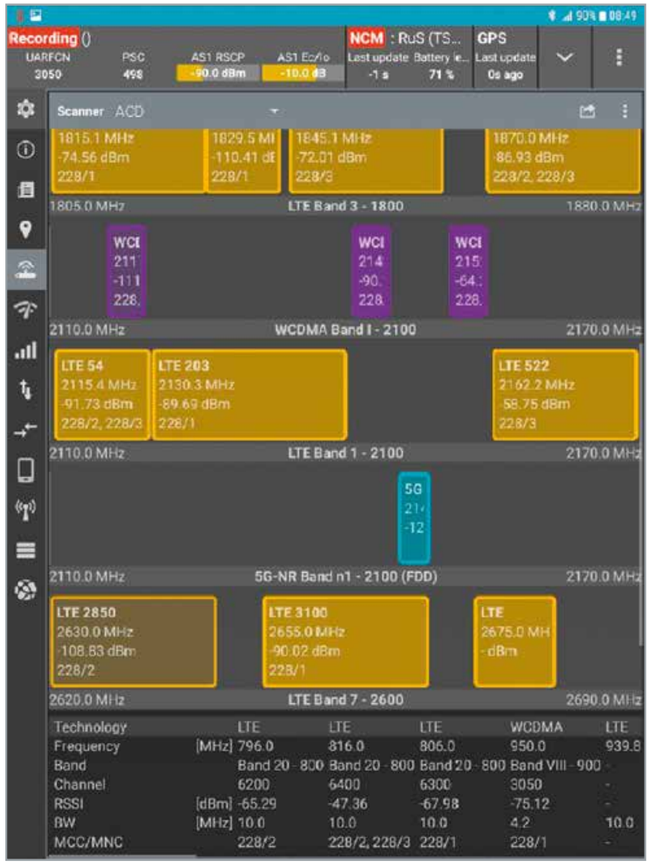
To get a quick overview of the radio environment and conditions, an equipment with easiest configuration capabilities is needed. When installing and maintaining base stations, users need a quick overview of the radio situation, the power of the broadcast channels, the signal quality, modulation characteristics and the network synchronization.

The R&S®STS supports all cellular technologies up to 5G including features like DSS, FR1, FR2 and carrier aggregation covering LTE and 5G.

The unique automatic channel detection supported by the R&S®5G STS (Site Testing Solution) automatically detects the active channels in selected bands within a few seconds, providing a complete view of all operating mobile networks: technology, frequency, channel, bandwidth and network operator.

Scenarios such as 5G non-standalone mode require parallel measurements on different technologies, in this case LTE and 5G NR. Features such as 5G NR beamforming add another level of complexity to measurements in the field.

The simultaneous signal analysis of multiple technologies supported by R&S®5G STS (Site Testing Solution) delivers detailed signal information: Country/network code, cell identity, power level, signal quality, best servers/SSB, layer 3 protocol and synchronization messages and much more useful information for troubleshooting.



Automatic
channel detection
Simply unique:
multitechnology
multifrequency

Site acceptance testing

After an installation or maintenance on site, a dedicated test call and/or data session is mandatory to close the related incidents or service tasks. During this call, the technician measures the service from the end user viewpoint: network availability and the quality of voice calls, data sessions and video streaming.

QualiPoc Android enables automation of site acceptance tests. Configuring a test sequence with channel and cell locking capabilities allows faster verification of the QoS and QoE for various technologies and specific cells. Additional diagnostics for e.g. signal levels, signal quality and L3 protocol decoding are available in the background.

In case of issues with the simple functional test (QualiPoc Android), the R&S®5G STS (Site Testing Solution) with 5G signal decoding capabilities helps the trouble-shooting with:

- Parallel measurements of LTE anchor (sub 6 GHz) and 5G NR up to FR2 (no switching times)
- Various 5G RF measurements over the air
- Measurements in FR1 and FR2 up to 44 GHz via downconverters

Electro-magnetic field strength (EMF) measurements

With commercial 5G NR network roll-out and due to regulations from authorities, there is a strong need for EMF measurements to prove that the radiation of a cell site is below a certain limit. With the frequency selective and code-selective measurement there are two methods for EMF testing. The frequency-selective approach measures the current exposure in a certain frequency band over a defined period of time (depending on the regulation): Equipped with an R&S®TS-EMF isotropic antenna, the R&S®FSH determines the direction-independent field strength in the frequency range from 9 kHz to 6 GHz. The antenna includes three orthogonally arranged antenna elements. The R&S®FSH sequentially activates the three antenna elements and calculates the field strength. The code-selective approach measures and decodes available signals and extrapolate them to the maximum possible exposure:
The code-selective EMF measurement is supported by the R&S®5G STS or the R&S®TSMA6 in combination with QualiPoc Android.

If we consider 5G rollouts currently happening, it is very important to identify where the signals are coming from due to the beamforming functionality (which technology? which operator? which frequency carrier? which cell? which beam?) in order to provide counter measures in case the maximum possible exposure is above a certain limit.

Measuring setup for EMF measurements, R&S®TSMA6 scanner controlled by QualiPoc

Overview QualiPoc monitors

5G technology monitor

5G signalling monitor

5G download monitor

UE capability monitor

Test result monitor

Log monitor

R&S®Spectrum Rider FPH
Spectrum analyzer

R&S®FSH
All-in-one BTS analyzer

R&S®Cable Rider ZPH
Cable and antenna analyzer with spectrum analysis

R&S®ZVH
Cable and antenna analyzer with spectrum analysis

R&S®PR200
Portable monitoring receiver

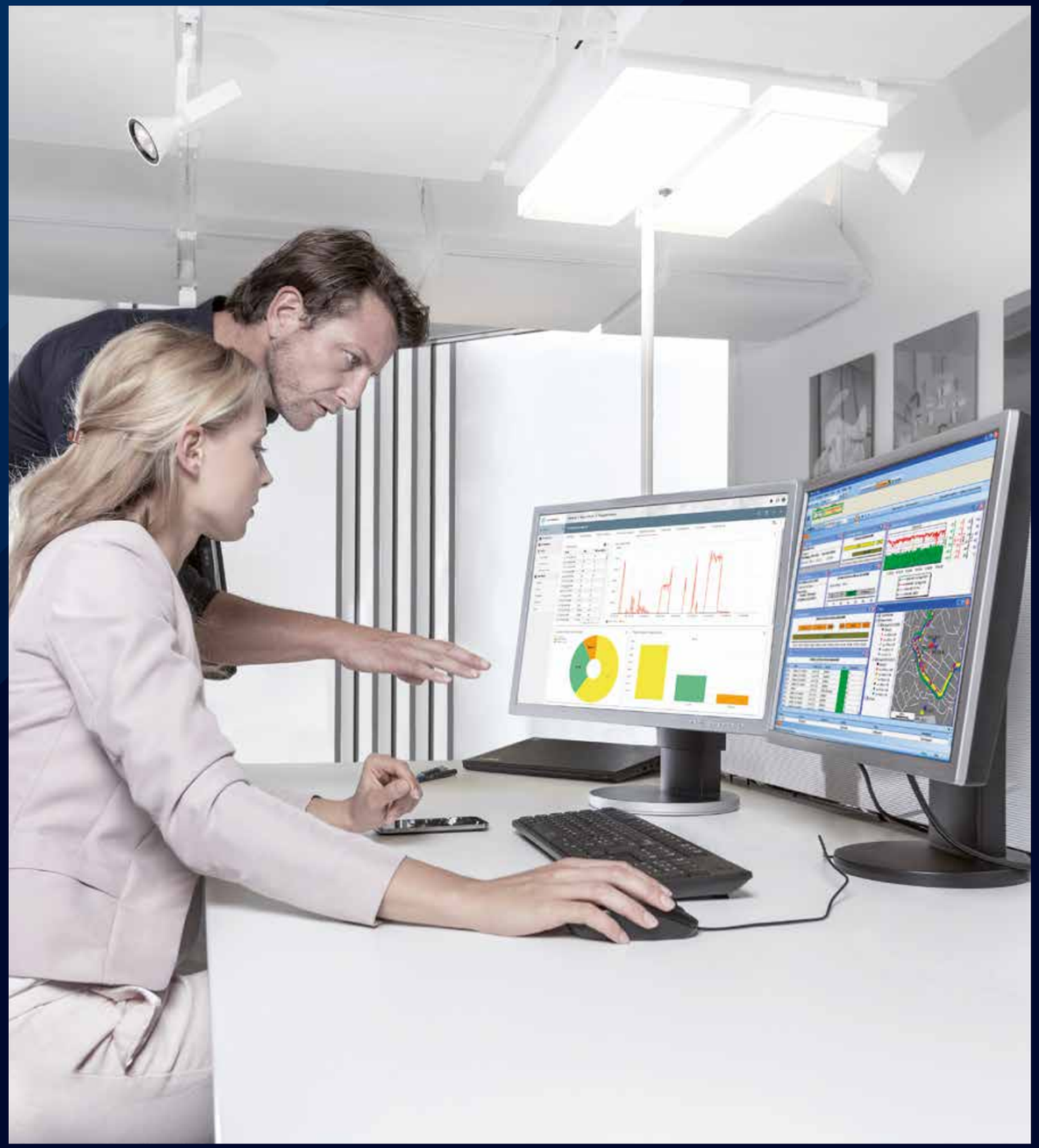
R&S®5G STS
5G Site Testing Solution

QualiPoc Android
Site acceptance test

DATA COLLECTION

Network Problem Analyzer (NPA)
Postprocessing software

DATA ANALYTICS



OPTIMIZE NETWORK QUALITY DURING OPERATION

Data consumption continues to increase exponentially in the upcoming years with no end in sight. The importance of network connections continues to grow due to business- and mission-critical applications. Rohde&Schwarz offers comprehensive, innovative tools for measuring network quality.

Mobile network operators are well aware of the increasingly high data consumption in their networks. Their key performance indicators are approaching the limits and capacities in their network have to constantly increase.

In many areas of the world, the ongoing technological evolution e.g. related to the introduction of 5G NR and new spectrum proves to fulfill the increasing capacity demand – and will continue to do so in other regions.

But, not investing in new spectrum and new technologies may rapidly change the operators' competitive market position and even endanger their business success. Many market studies have proven that a decrease of end-user Quality of Experience (QoE) goes hand in hand with a decrease in operator revenue.

Industry-leading solutions from Rohde&Schwarz support operators ensure the quality of their network, whether it is running on LTE or upgraded to 5G. Operators benefit from obtaining an end-to-end QoE from the user perspective both before and after a network change. SmartAnalytics based postprocessing gives the operator deep insights into how and where to optimize the network.

Rohde&Schwarz offers solutions enabling benchmarking of a network against all other networks in an area, using a QoE centric single metric that characterizes the overall network performance. This approach enables operators prove their position in the market and create claims to attract customers away from their competitors.

MOBILE NETWORK QUALITY

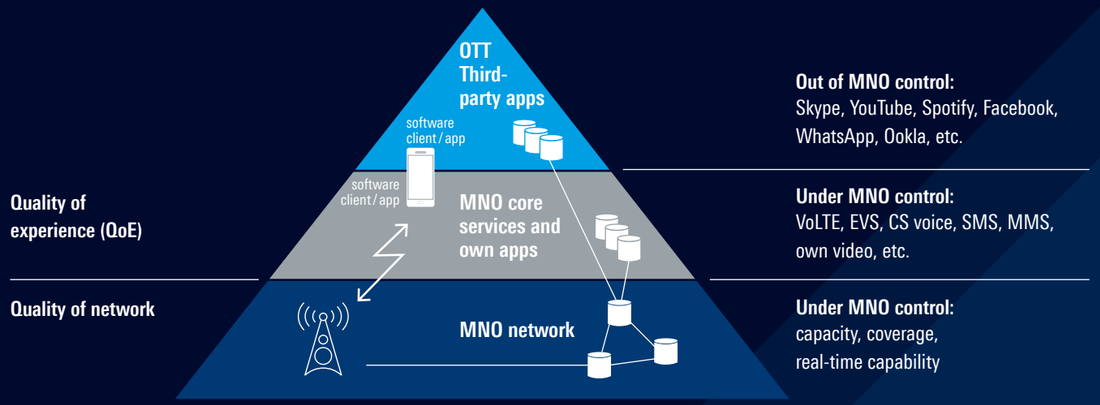
Mobile network quality is mainly characterized by the coverage area (in terms of signal level and quality) and the capacity offered in a geographical area. These network KPIs contrast with the user perceived quality of applications. Operators responsible for mobile network quality face the challenge of finding the right method for testing coverage and capacity during operation. Most capacity testing apps are over-the-top (OTT) applications and provide results that are influenced by the mobile network, the phone's software client and connectivity to unknown application servers on the internet. With increasingly powerful technologies such as LTE and 5G, the communication bottleneck is not always the air interface, as it was in previous decades.

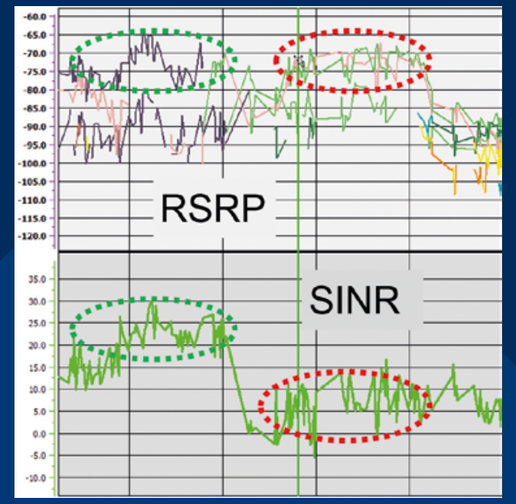
A network scanner is the right tool for reference RF measurements such as RSRP, RSRQ and SINR. It has the necessary measurement accuracy, speed and ability to measure all available cells of all operators. RSRP is a measure of coverage; SINR (in combination with throughput estimation) indicates the maximum possible capacity in an area.

Real-world conditions can be met using a smartphone that actively measures data throughput, latency and, with limited accuracy, RF KPIs of its serving cell and a limited number of neighboring cells of its home operator.

Different use cases require different data collection tools.

- In a single smartphone scenario, QualiPoc Android is the controlling software. It configures test jobs and collects the results from the smartphone and, optionally, from a control scanner.
- SmartBenchmarker is the controlling software. It controls, configures and performs RF measurements on multiple smartphones and one or more scanners.
- R&S®ROMES4 is the controlling software. It provides more detailed real-time analysis results from one or more scanners and multiple smartphones.





Correlation of RSRP and SINR shows network quality issues

A network scanner together with QualiPoc Android or R&S®ROMES4 identifies and provides an overview of all received signals/cells from multiple technologies in multiple frequency bands by multiple operators within seconds. This automatic channel detection (ACD) delivers a quick overview of spectrum usage and indicates mobile network quality.

The tests run with servers located very closely to the operator's infrastructure so that only the mobile network/RAN is tested and not the influence of clients/servers and OTT apps.

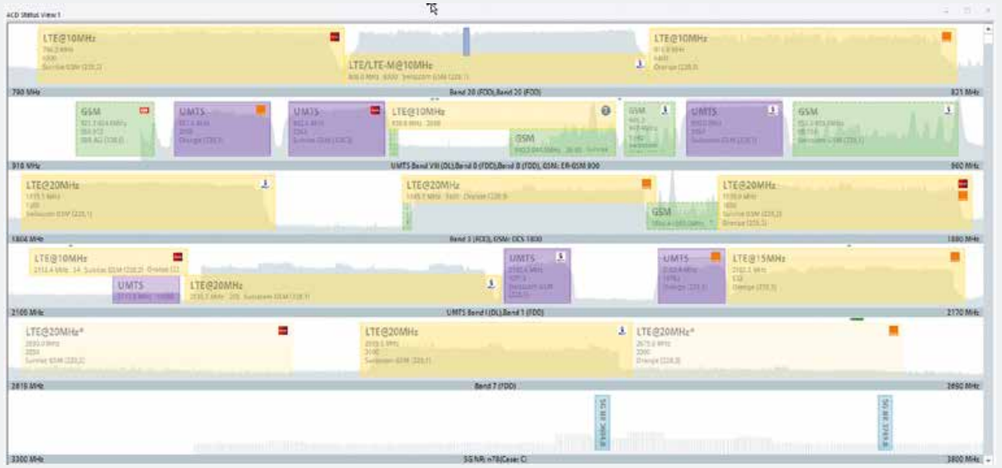
SmartAnalytics, the next generation, web based software suite, analyzes all this network quality data. This key tool allows users to effectively store, process and visualize data from network measurements, gain deep network insights and ultimately build intelligence for investment prioritization and network optimization based on the most critical factors influencing network performance.

Customer benefits:

- Future-proof, long-term investment due to flexibility of R&S®Freerider 4 and SmartAnalytics
- OPEX savings thanks to SmartAnalytics (easy to learn, intuitive web based GUI, single postprocessing suite for all tools), long battery life of walk test solution as well as customized and advanced remote control functions and high system stability, reducing repeat drives
- CAPEX savings due to scalable and modular solutions – from a single smartphone portable walk test solution to a comprehensive vehicle-installed benchmarking solution

Smartphone based network quality measurements work with the capacity test (multi-connection HTTP data transfer) and the coverage test (iperf3 test).

- Capacity test: uses all remaining air interface resources and shows unused capacity of a cell
- Coverage test: requests continuous unacknowledged data throughput (e.g. 1 Mbps in the DL)



Automatic channel detection (ACD)

QualiPoc Android
Smartphone based RF and QoE testing

R&S®TSMA6
Network scanner with R&S®ROMES4 software running on laptop or integrated network PC

SmartBenchmarker
Local controller software for drive test based network testing

DATA COLLECTION

R&S®Freerider 4
Portable modular hardware platform for walk and drive tests

R&S®ZCB2
Shoulder bag for comfortable walk and drive tests

HARDWARE OPTIONS

SmartAnalytics
Software suite for data analytics

DATA ANALYTICS

END USER QOE (PERCEIVED APPLICATION QUALITY)

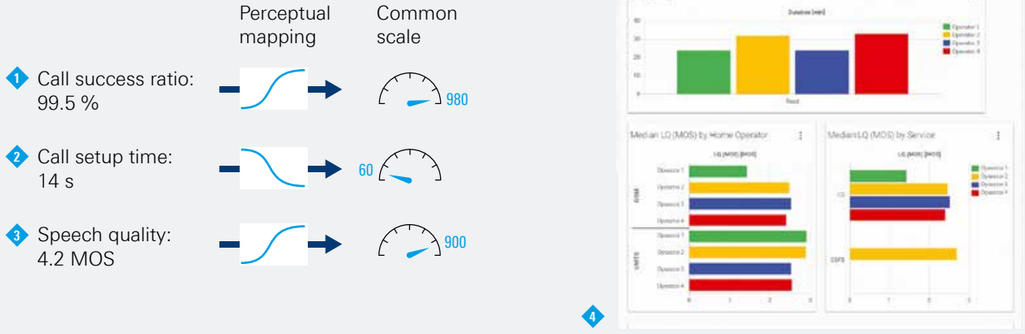
The quality of experience (QoE) is a measure of how end users perceive the quality of applications running in a mobile network. Knowing the QoE is essential since it has a direct impact on the mobile network operator's success. If an operator clearly wins in a public benchmarking campaign, this operator will be more attractive to end users and financially more successful than its competitors. Since QoE is such an important business criteria, the following challenges need to be addressed during network testing:

- What contributes to the QoE of applications?
- How can user perception be "measured" in predominantly automatic network test solutions?
- How do subscribers use services? Which customers cannot access services? Which device models cause the most problems for customers?

The QoE of applications is best evaluated using smartphones. They are the test devices of choice for all our QoE measurement tools. The QualiPoc Android local controller software executes the most popular applications – telephony service, data transfer, video streaming, browsing and social media – and collects all relevant KPIs influencing customer perception of a service. SmartBenchmarker is the local controller software for bigger benchmarking solutions that measure multiple channels (QualiPoc powered smartphones) in parallel, e.g. vehicle based drive test solutions and backpack solutions.

Hardware options such as the R&S®Freerider 4 backpack and Benchmarker II with test device containment modules (TCM) inside a vehicle roof box (VRB) ensure the scalability of the QoE test solutions and that data is measured accurately and reflects the QoE provided by the network:

- The temperature of smartphones is controlled to make sure the QoE provided by the network is not impacted by poor smartphone data performance caused by overheating.
- The smartphones are located outside the vehicle to avoid the influence of metal and glass shielding



Applications show different dimensions that contribute to the perceived quality:

1. Service availability: Can users access the service?
2. How long does the user have to wait for an action (e.g. time to first picture in a video)?
3. What is the user perceived quality of the media itself (e.g. speech quality or video quality)?
4. The SmartAnalytics software suite analyzes the collected data, applies perceptual mapping and normalizes the result to a common scale. User perceived quality always has a certain saturation at poor and excellent perception.

Customer benefits:

- OPEX savings thanks to SmartAnalytics (easy to learn, intuitive web based GUI, single postprocessing suite for all tools), long battery life of walk test solution
- CAPEX savings: future-proof long-term investment thanks to the flexibility of all hardware options (from the portable R&S®Freerider 4 to the large-scale Benchmarker II solution), all of which use the same QualiPoc powered smartphones as data collectors and a common postprocessing suite (SmartAnalytics)
- Accurate drive test data collection thanks to unique VRB/TCM combination (temperature control and avoiding electromagnetic shielding)
- Reliability: complete comparability in benchmarking campaigns by executing the same test at the same time at the same location in line with ETSI TR 103 559

QualiPoc Android
Smartphone based RF and QoE testing

SmartBenchmarker
Software for local control of walk and drive test benchmarking campaigns

DATA COLLECTION

R&S®Freerider 4
Portable modular hardware platform for walk and drive tests

TCM
Test device containment module for stable and uniform test conditions

VRB
Vehicle roof box for multi-channel setup for drive test benchmarking campaigns

HARDWARE OPTIONS

SmartAnalytics
Software suite for QoE data analytics, including network performance score

DATA ANALYTICS

QUALITY BENCHMARKING

For mobile operators, quality of experience (QoE) is one of the key factors driving revenue and reducing churn. But how good does a mobile network or a service need to be? Where in the network are improvements required to stay ahead of the competition? Benchmarking tests are an effective way to measure the necessary marginal improvements and to trigger targeted improvements and focused investments. It is also an effective way of getting to know the competition and gathering valuable information for focused promotional campaigns.

A mobile network is not homogeneous. Measuring at just one location is inconclusive and insufficient, especially since there is no "uniquely typical location". Only a large-scale measurement campaign that takes into account all "typical locations" can deliver conclusive results. The focus should be on locations where connectivity and availability of services are critical for users.

Performing extensive walk and drive tests within a very short timeframe requires equipment that is highly reliable, up and running quickly and capable of continuously collecting masses of data for hours.

Every interruption during the collection process and every repeated drive or revisiting of a specific location impedes the campaign and increases costs.

Large-scale benchmarking campaigns produce huge amounts of measurement results and KPIs. This data needs to be processed and efficiently analyzed in order to gain actionable insights.

Rohde&Schwarz offers the industry's leading benchmarking solution. It consists of a modular set of hardware and software for high-quality data collection and a next generation analytics suite to obtain actionable QoE centric insights based on NPS, the ETSI ratified scoring methodology (see pages 6 and 7).

Modular concept for all benchmarking data collection use cases
The SmartBenchmarker web based software platform combined with a complete set of hardware options addresses all use cases for walk and drive test based benchmarking data collection. Users can control benchmarking tests on site or remotely from the office.

SmartBenchmarker

Drive test benchmarking

Benchmarker II + VRB + TCM

Benchmarker II + PMW

Benchmarker II go

Indoor/walk test benchmarking

R&S®Freerider 4

Stationary

Mobile B-side

Vehicle roof box setup: TCMs can be installed in the specifically designed Vehicle roof box (VRB) and connected to Benchmarker II. The VRB can contain up to 16 TCMs (measurement channels) and ensures uniform RF and temperature conditions. The roof box and the IP65 rated cable duct for the cable entry into the vehicle can withstand any weather conditions.

The modular solution configuration allows multiple setups for:

- Large-scale drive test campaigns in all environments (highways, urban areas, the countryside, etc.)
- Walk test campaigns in indoor locations and pedestrian zones (shopping malls, event venues, trains, etc.)
- Stationary testing

The smartphone based multichannel solution measures multiple operators and their services in parallel. It collects voice, messaging, video, data and app based KPIs to assess quality of service (QoS) and QoE from a real end user perspective. It supports a multitechnology RF scanner to provide a full representation of the physical RF environment.

SmartAnalytics – from QoE centric data to actionable insights

SmartAnalytics, the next generation, web based software suite, is a key tool that allows users to effectively store, process and visualize big data from benchmarking campaigns, gain deep network insights and ultimately build intelligence for investment prioritization based on critical factors influencing network performance and QoE.

SmartAnalytics supports the QoE centric network performance score (NPS), which is the ideal point of reference for facilitating benchmarking and reducing the complexity of targeted improvements in network quality and performance.

The NPS methodology enables transparent, independent and accurate QoE centric characterization of a network's quality and performance. It allows users to compare KPIs across countries and competitors and effectively identify key areas for strategic network investments.

The SmartAnalytics drilldown functions allow users to start with the QoE centric NPS and fully exploit the network testing data to obtain root cause information. The seamless user interface visualizes critical factors that have the greatest impact on network quality and performance. Operators see how they compare with competitors and can prioritize targeted actions for improvements.

Customer benefits:

- Rohde&Schwarz is the recognized market leader and its benchmarking products are widely considered the de facto industry standard
- Simplified, efficient processes for targeted network improvements and strategic decisions for network investments based on consolidated benchmarking results with NPS
- Lower capital expenditures thanks to fully modular, scalable, future-proof concept for walk and drive test benchmarking and repurposing of mobile devices and scanners for other testing purposes
- Lower operational costs thanks to customized, advanced remote control functions and high system stability, reducing the number of repeat drives

Smartphone with QualiPoc Android
Smartphone based RF and QoE testing

R&S®TSME6, R&S®TSMA6
Scanner for walk and drive tests

SmartBenchmarker
Software for local control of walk and drive test benchmarking campaigns

DATA COLLECTION

R&S®Freerider 4
Portable modular hardware platform for walk and drive tests

Benchmarker II
Modular hardware platform for drive testing

VRB
Vehicle roof box for multichannel setup for drive test benchmarking campaigns

HARDWARE OPTIONS

TCM
Test device containment module for stable and uniform test conditions

Benchmarker II Go
Portable modular hardware platform for ad hoc drive test benchmarking campaigns

PMW
Phone mounting wall for drive test benchmarking campaigns

Mobile B-side
Cost efficient solution for a stationary B-side

SmartAnalytics
Software suite for QoE data analytics

DATA ANALYTICS

24/7 CONTINUOUS QUALITY MONITORING

Monitoring user experience and immediately sending alerts when network and service instabilities are detected can drastically reduce the negative effect that network problems have on end user applications.

When voice, data, video and messaging services fail to deliver the expected quality levels, network and service operation centers need to be notified instantly to take prompt action. This is particularly important in critical hotspots such as shopping malls, airports, commercial centers, train stations, highly populated areas, key commuting routes and public transport.

SmartMonitor from Rohde&Schwarz is a modular, scalable solution for 24/7 service quality monitoring with end user centric smartphone based probes. The cost-effective probes allow versatile and tailored setups, from single static probes at strategic hotspots to vehicle fleets with multiple moving probes.

Smartphone based network probes

Rohde&Schwarz uses smartphone and scanner based network probes. For smartphones, a compact and robust casing ensures a reliable operation. Scanners can also be mounted in 19" racks. This enables multiple applications in fixed or moving locations and ensures uninterrupted and reliable 24/7 service. SmartMonitor remotely controls the probes, delivering a continuous stream of KPIs in real time and providing insight into network quality as an end user would perceive it.

Web based software for remote real-time network monitoring and fleet management

SmartMonitor is a web based application that provides a real-time overview of the current network situation using QualiPoc smartphones and R&S®TSMA6 probes. SmartMonitor offers easy and straightforward fleet management, drag and drop job configuration, real-time map based information, test results, statistics – all in one tool. The data from the fleet of network probes is immediately displayed on SmartMonitor dashboards and provides an instantaneous overview of the service quality and network performance from a true end user perspective.

SmartMonitor features a new communications concept for the probes that makes it an essential component to cost-effectively monitor network and service quality status in real time from a true end user perspective. SmartMonitor helps reduce operational costs in the field and seamlessly ensures quality of service.

Customer benefits:

- Real-time, 24/7 problem identification through targeted network and service monitoring, enabling immediate reaction before the end user experience is substantially affected and results in churn
- Web based, future-proof modular product concept for economical, large-scale deployments

SmartMonitor is a web based application that provides a real-time overview of the current QoE centric network status based on decentral QualiPoc Android probes. The autonomous probes can be operated at strategic static hotspots or in vehicle based fleet setups.

Smartphone with QualiPoc Android
Smartphone based RF and QoE testing

R&S®TSMA6
Scanner for walk and drive tests

SmartMonitor
Software for remote real-time network monitoring and fleet management

DATA COLLECTION

QPCB
Compact hardware module for remote operation in cars

HARDWARE OPTIONS

OEM IP NETWORK ANALYTICS SOLUTIONS

Platform agnostic application awareness

To meet future service demands, carriers and enterprises are not only enhancing their network infrastructure for greater speed and quality of service (QoS), but also looking for tools to manage their data flows more intelligently. Deep packet inspection software can look for protocol non-compliance, spam, viruses, intrusions, or other defined criteria to decide whether the packet may pass or needs to be routed to a different destination.

The key to maintaining integrity, ensuring security and optimizing the efficiency of a multi-Gbps network is a high-performant, efficient and accurate deep packet inspection software. Our high-performant DPI engine R&S®PACE 2 delivers full visibility of IP-based network traffic in real time despite encryption and frequent application changes. Likewise, our VPP DPI engine R&S®vPACE delivers unparalleled, real-time traffic insights for virtualized and cloud-native functions (VNF/CNF) as well as 5G user plane functions (UPF) hosted and managed in the cloud. This makes deep packet inspection technology a crucial tool for advanced network management and IT security solutions.

Additional subscriber awareness for full network visibility

With multiple millions of GPRS tunneling protocol (GTP) sessions running concurrently across mobile networks, GTP session correlation — i.e. correlation of user plane and data plane traffic — is essential to achieve complete mobile subscriber awareness. IP probes, network packet brokers, and other network monitoring and management tools are limited in their capacity to analyze subscriber sessions unless they are designed to perform GTP session correlation.

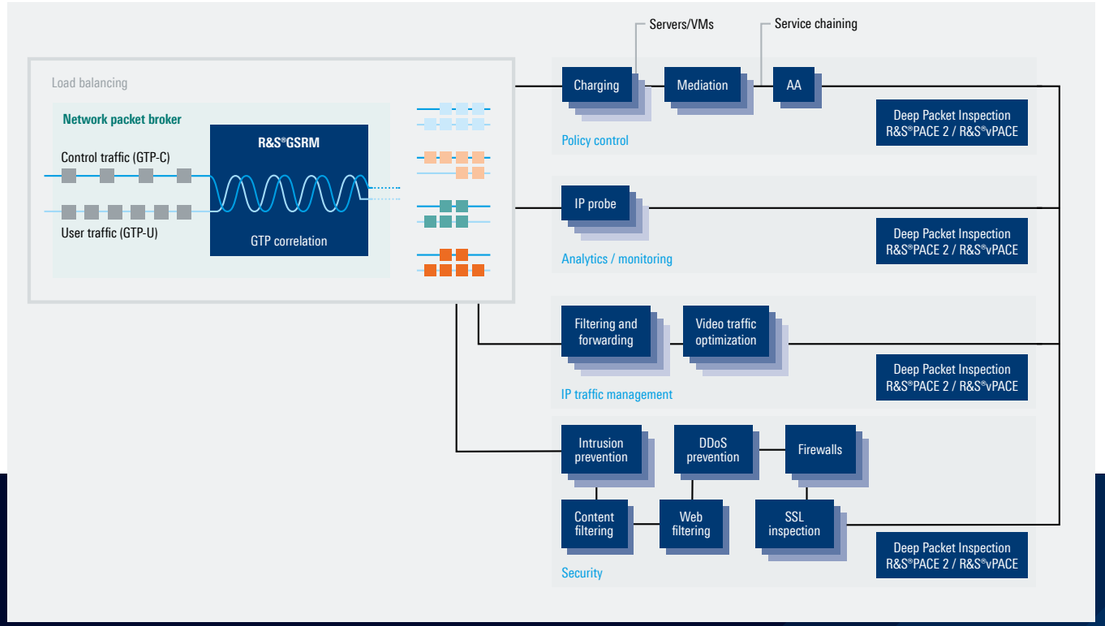
The GTP subscriber resolving module R&S®GSRM is an OEM software module that equips networking, IP traffic management and cybersecurity tools with real-time subscriber-awareness and session-awareness across 3G, 4G and 5G NSA networks enabling communication service providers to optimize network performance and assure superior quality of experience for their subscribers.

In combination with our DPI engine R&S®PACE 2 application and subscriber awareness work hand in hand, delivering enhanced network intelligence to manage and improve mobile network security. The full visibility into user sessions provided by R&S®GSRM enables meaningful and effective management of subscriber traffic and empows network security tools and operators to analyze attacks and network anomalies on a granular level. This way, risks across different applications, users and geographies can be identified and used to design responsive policies for network security.

The Benefit of licensing OEM software products

We provide you with easy-to-integrate and simple-to-manage OEM software for physical, virtual, and cloud environments. Our next-generation application and subscriber awareness products comes with flexible licensing options and committed support.

- Rely on decades of experience in advanced DPI and precision made in Germany
- Get support wherever you need
- Focus on your core competencies by licensing leading-edge OEM software
- Innovate and differentiate your product offering with our help
- Speed up time to market by optimizing your development schedule



The deployment scenario shows the GTP correlation module R&S®GSRM and the DPI engines R&S®PACE 2 and R&S®vPACE embedded in a network architecture.

By deploying R&S®GSRM directly into network packet broker, a subscriber's session can fully be recreated by tapping the various control and data plane interfaces and directing all traffic belonging to a specific subscriber. This allows for filtering, forwarding and load balancing subscriber-specific GTP sessions to and across appropriate subsystems such as policy control, network analytics or security solutions to optimize network performance, service quality and user experience.

Embedded into policy control, network analytics or security solutions, R&S®PACE 2 and R&S®vPACE gain full visibility into IP network traffic up to layer 7 and beyond and give a complete view of the applications running on a network. By adding application awareness through DPI technology, IP traffic can be analyzed, optimized or managed – e.g. by enabling granular control of which applications are permitted, prioritized or deprioritized for access.

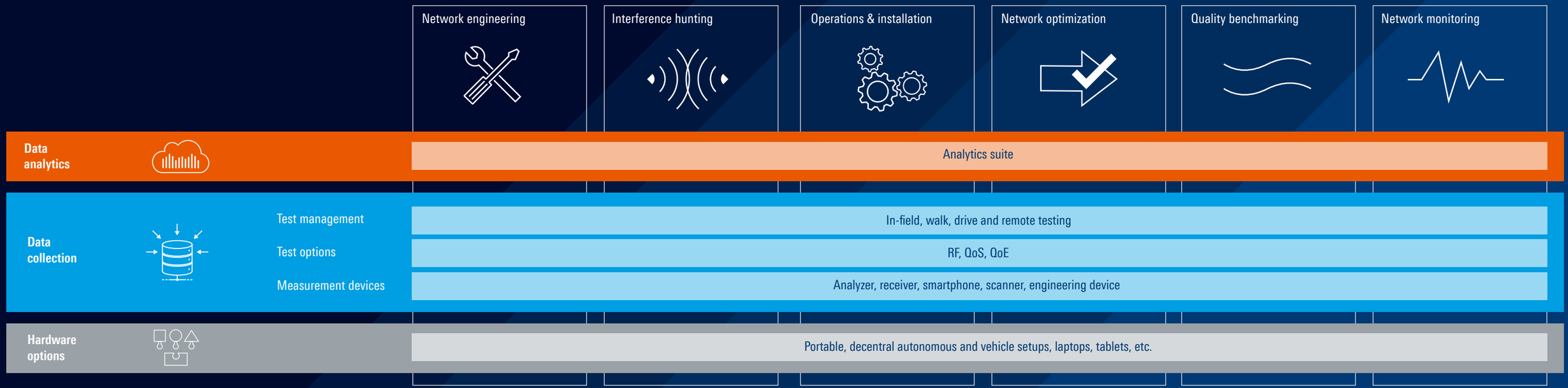
TECHNICAL SPECIFICATIONS

	Clean the spectrum		Validate new technologies and features		Ensure correct infrastructure deployment			Optimize network quality during operation				
	Spectrum clearance	Interference hunting	Coverage, new features and technologies	Device-network interaction and application KPI	Antenna system verification	Over-the-air tests: signal and spectrum analysis, field strength	Over-the-air tests: network analysis, site acceptance	Mobile network quality	End user QoE (perceived application quality)	Quality benchmarking	24/7 continuous quality monitoring	OEM IP network analytics solutions
 **R&S®PR200 portable monitoring receiver** ► Frequency range: 8 kHz to 8 GHz up to 18 GHz ► Real-time bandwidth up to 40 MHz ► Scan speed at 100 kHz resolution: 40 GHz/s ► Parallel time and frequency domain analysis, incl. gated spectrum ► Supports spectrum, spectrogram (waterfall), zero span and polychrome display, triangulation and level mapping	●	●				●						
 **R&S®Spectrum FPH handheld spectrum analyzer** ► Frequency range: 5 kHz to 31 GHz ► Supports spectrum (incl. gated trigger), spectrogram and optical power measurements, triangulation, signal strength mapping ► Easy operation thanks to user configurable, automatic test sequences (wizard)	●	●				●						
 **R&S®FSH handheld spectrum analyzer** ► Frequency range: 9 kHz to 3.6/8/13.6/20 GHz ► Supports spectrum (incl. gated trigger), spectrogram and optical power measurements, demodulation of cellular technologies, triangulation, signal strength mapping, VSWR analysis with built-in bias tee ► Field strength measurements with isotropic antenna ► Easy operation thanks to user configurable, automatic test sequences (wizard)	●	●			●	●						
 **R&S®TSME6 ultracompact network scanner** ► Frequency range: 350 MHz to 6 GHz ► > 10 technologies simultaneously in one scanner ► Supports downconverter for mmWave range ► Compact and lightweight, customized mechanical concept for cascading ► Low power consumption	●		●	●		●	●	●		●		
 **R&S®TSMA6 autonomous network scanner** ► Frequency range: 350 MHz to 6 GHz ► > 10 technologies simultaneously in one scanner ► Supports downconverter for mmWave range ► Compact and lightweight, customized mechanical concept for cascading ► Supporting additional scanner HW, Android based UEs and tablets ► Integrated high-performance Intel i7 CPU based PC	●		●	●		●	●	●		●		
 **R&S®TSME30DC ultracompact downconverter** ► Frequency range: 24 GHz to 30 GHz **R&S®TSME44DC ultracompact downconverter** ► Frequency range: 24 GHz to 44 GHz ► Simultaneous mmWave and sub 6 GHz measurements with a single scanner	●		●	●		●	●	●		●		
 **QualiPoc Android smartphone based RF and QoE testing** ► Supported on latest Android smartphones and tablets ► Comprehensive range of service test functions for voice, data, and video as well as for channel and cell locking for dedicated RF optimization ► Intuitive user interface, including customizable monitors and workspaces			●	●			●		●	●	(●)	
 **R&S®ROMES4 universal software for network engineering for all technologies** ► Supports latest technologies, e.g. 5G, NB-IoT and LTE-M ► Supports test smartphones, with on-device test capabilities ► 5G NR, GSM, WCDMA, CDMA2000®, 1xEV-DO, WiMAX™, LTE, NB-IoT, Cat-M1 and TETRA ► Unique scanner features: ACD, DLAA, NB-IoT ► RF and QoS testing capabilities in one tool	●		●	●		●	●	●	●	●		
 **SmartBenchmarker software for local control of drive and walk test benchmarking campaigns** ► Flexible, easy-to-use web interface ► Standard mode (SmartBenchmarker) offers easy to use web-based UI for data collection and quick analysis tasks ► Intuitive user interface, including customizable workspaces									●			

	Clean the spectrum		Validate new technologies and features		Ensure correct infrastructure deployment			Optimize network quality during operation				
	Spectrum clearance	Interference hunting	Coverage, new features and technologies	Device-network interaction and application KPI	Antenna system verification	Over-the-air tests: signal and spectrum analysis, field strength	Over-the-air tests: network analysis, site acceptance	Mobile network quality	End user QoE (perceived application quality)	Quality benchmarking	24/7 continuous quality monitoring	OEM IP network analytics solutions
 **R&S®MobileLocator advanced interference hunting and emitter location** ► Unique automatic location of a transmitter from a moving DF vehicle ► Fast, easy installation in commercial vehicles ► Optimized for interference hunting in urban areas (multipath propagation) ► Generation of an interference search report with all relevant information	●	●										
 **SmartAnalytics software suite for QoE data analytics** ► Analytics software that provides QoE use case driven machine learning-assisted insights ► Intuitive web based software for benchmarking, optimization and monitoring ► Analyzes RAN data to improve end user QoE and network performance ► Highlights network performance issues and analyzes their causes			●	●		●		●	●	●		
 **SmartMonitor software for remote real-time network monitoring and fleet management** ► Web based application running on Windows or Linux app server ► Informative dashboards, providing the latest results and status of the probes in real time ► Intuitive campaign configuration and fleet operation ► Fast and easy registering of new QualiPoc Android probes											●	
 **R&S®CableRider ZPH cable and antenna analyzer** ► Frequency range: 5 kHz to 3/4 GHz ► One-port model supports DTF, RL, CL, VSWR and optical power measurements ► Two-port model supports transmission measurement, spectrum and interference analysis, signal strength mapping ► Fast measurements – no calibration required ► Easy operation thanks to user configurable, automatic test	●	●			●	●						
 **R&S®ZVH handheld cable and antenna analyzer** ► Frequency range: 100 kHz to 3.6/8 GHz ► Supports full two-port transmission and reflection measurements, spectrum and spectrogram analysis ► Fast measurements – no calibration required ► Easy operation thanks to user configurable, automatic test	●	●			●	●						
 **R&S®5G Site Testing Solution (STS)** ► Automatic detection & demodulation of all cellular standards ► Simultaneous technology-related & spectrum measurements ► Voice, data and video testing (optional, smartphone based) ► 5G NR signal demodulation down to –142 dBm (SCS 30 kHz) ► Frequency coverage up to 30 GHz						●	●					
 **R&S®GSRM intelligent user- and control plane correlation** ► GTP correlation in real time based on subscriber ID ► Multi-core architecture with linear scalability to satisfy high bandwidth demands ► Supports 3G, LTE and 5G NSA networks including GTPv1 and GTPv2								●	●		(●)	●
 **R&S®vPACE next-level vectoring-based DPI engine** ► A significantly improved average clocks-per-packet ratio, resulting in up to three times the speedup compared to SPP DPI engines ► Small memory footprint – less than 400 bytes per 5-tuple connection and 700 bytes per network endpoint ► Runs in cloud and virtualized environments with support for vector-based frameworks								●	●		(●)	●
 **R&S®PACE2 advanced protocol and application classification with metadata extraction** ► Powerful DPI engine without dependency with respect to CPU architecture or operating system ► Always up to date ensured with weekly signatures updates ► High traffic detection accuracy and reliability with virtually no false positives								●	●		(●)	●

MODULAR SOLUTION PLATFORM ADDRESSING ALL TEST & MEASUREMENT USE CASES IN THE NETWORK LIFECYCLE

Rohde&Schwarz offers the industry's most advanced testing solutions in an integrated, modular and flexible software and hardware platform. The platform is highly structured, modular and future-proof and addresses all key use cases along the network lifecycle. The components can be tailored and configured to the specific needs required by the user.Its ultimate goal is to increase network performance and maximize QoE (quality of experience) with higher productivity and efficiency.



Data analytics
From data to insights

A powerful and effective big data analytics tool is crucial in order to fully exploit the data from mobile network assessments and gain deep network insights for targeted improvements.
SmartAnalytics is a new generation analytics suite that offers all features necessary for data management and validation, statistical and diagnostic analysis (root cause analysis), as well as descriptive and predictive analysis and reporting. SmartAnalytics supports use cases for installation and maintenance, interference huntig, network engineering, network optimization, quality benchmarking and network monitoring.

Data collection
Quality data for quality results

Mobile network operators have to make well-informed, fact-based decisions for strategic investments. This is only possible based on intelligent insights generated from reliable and accurate data. The MNT platform provides a set of specialized, modular test equipment to collect accurate, validated and reproducible data.
Key components for data collection
The MNT platform offers a modular set of components for data collection comprising:
- Measurement devices
- Test options
- Test management

Hardware options
Flexible hardware options

The MNT platform offers a range of hardware options that are specially engineered for different test scenarios, including in the field, walk and drive test-based and remote testing as well as unattended static or mobile single probe or fleet setups. The flexible hardware concept allows components to be reused for different use cases and therefore reduces CAPEX.

Service that adds value

- Worldwide
- Local and personalized
- Customized and flexible
- Uncompromising quality
- Long-term dependability

Rohde&Schwarz

The Rohde&Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

www.rohde-schwarz.com

Sustainable product design

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

Rohde&Schwarz customer support

www.rohde-schwarz.com/support

PD 3608.1781.62 | Version 04.01 | June 2022
Mobile Network Testing – Maximize network quality and performance
Data without tolerance limits is not binding | Subject to change

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PD 3608.1781.62 | Version 04.01 PDP 1 en