

# R&S® ROMES4 DRIVE TEST SOFTWARE

Mobile coverage and QoS measurements  
in mobile networks



Product Brochure  
Version 24.00

**ROHDE & SCHWARZ**

Make ideas real



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R&S®ROMES4 with test devices.



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# AT A GLANCE

The R&S®ROMES4 drive test software, in combination with one of the unique Rohde & Schwarz drive test scanners and the R&S®ROMES4NPA network problem analyzer tool, provides an all-in-one solution for network analysis and optimization.

## Universal software platform

R&S®ROMES4 is the universal software platform for network engineering and network optimization systems from Rohde & Schwarz. In combination with other test and measurement equipment such as wireless communications scanners and test mobile phones, it provides solutions for all essential tasks involved in coverage measurements, interference identification, performance measurements and quality analysis in mobile networks. In addition to measuring and displaying test parameters, data is processed instantly and statistics are calculated in real time.

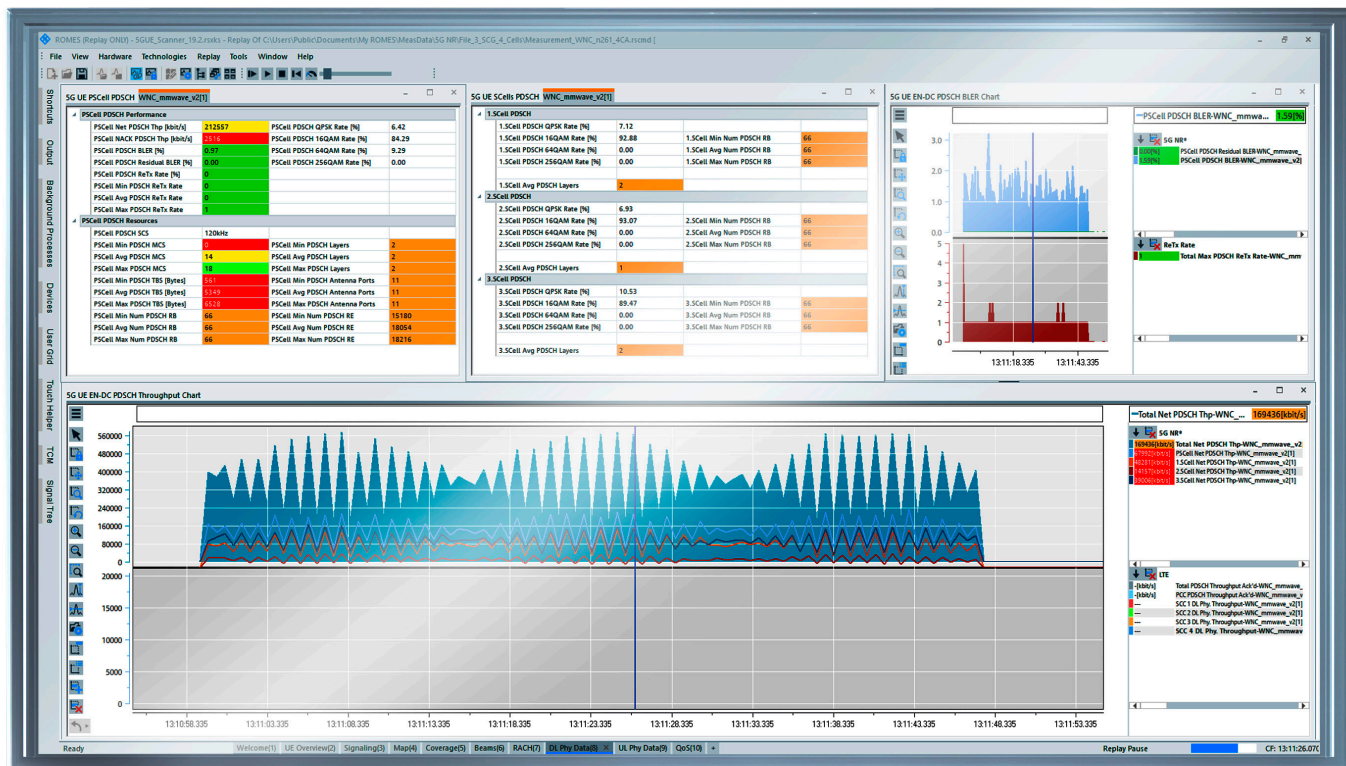
## Support of multiple protocols and standards

R&S®ROMES4 supports 5G NR, GSM/EDGE, WCDMA/HSPA+, CDMA2000® 1xEV-DO Rev. A, WLAN (IEEE 802.11a, b, g, n), WiMAX™ (IEEE 802.16e), LTE, NB-IoT/Cat NB1, LTE-M and TETRA. Standard-compliant RF level measurements can be time and route-triggered over a very wide frequency range (9 kHz to 7 GHz). Due to its highly modular structure, the platform can be expanded at any time for new technologies. The test software runs on a Windows 10 (64 bit) PC.

## Combination with R&S®TSMx scanners

When R&S®ROMES4 is combined with the R&S®TSMx band-unlimited scanners, the measurements help typical users (such as network operators, regulatory authorities, service providers, chipset manufacturers and government authorities) complete their work quickly and easily.

Straightforward R&S®ROMES4 drive test software user interface.



# KEY FACTS

- ▶ One software for all technologies from a single source
- ▶ Flexible software licenses that meet user requirements reduce startup costs
- ▶ Analysis of R&S®TSME6 and R&S®TSMA6 5G NR scanner measurements and 5G Qualcomm and Samsung (Exynos) based UE measurements
- ▶ Parallel measurements with up to eight mobile devices per license save time, allowing more effective utilization of existing resources and saving operating expenses (OPEX)
- ▶ High-precision, fast RF test and measurement equipment (Rohde & Schwarz scanners) delivers a large quantity of reliable measurements and results
- ▶ Automated analysis at the end of the measurement using the integrated replay function or the network problem analyzer (NPA) considerably reduces OPEX
- ▶ Automatic identification of GSM interference considerably reduces OPEX (up to 80% potential savings compared to standard analysis)
- ▶ Unique scanner for 5G NR, GSM, WCDMA, CDMA2000® 1xEV-DO, WiMAX™, LTE, NB-IoT/Cat NB1 and TETRA in all bands and decoding of broadcast information



R&S®ROMES4 running on a tablet  
with an R&S®TSMA6 scanner.



# EASY OPERATION AND HIGH FLEXIBILITY

## Easy-to-use interface that adapts to the user's level of knowledge

Featuring different user levels, R&S®ROMES4 can adapt to the user's level of knowledge. The different levels make it possible to adjust the displayed views and signals to what is most important for the individual user. Experienced and novice users alike finish their work faster.

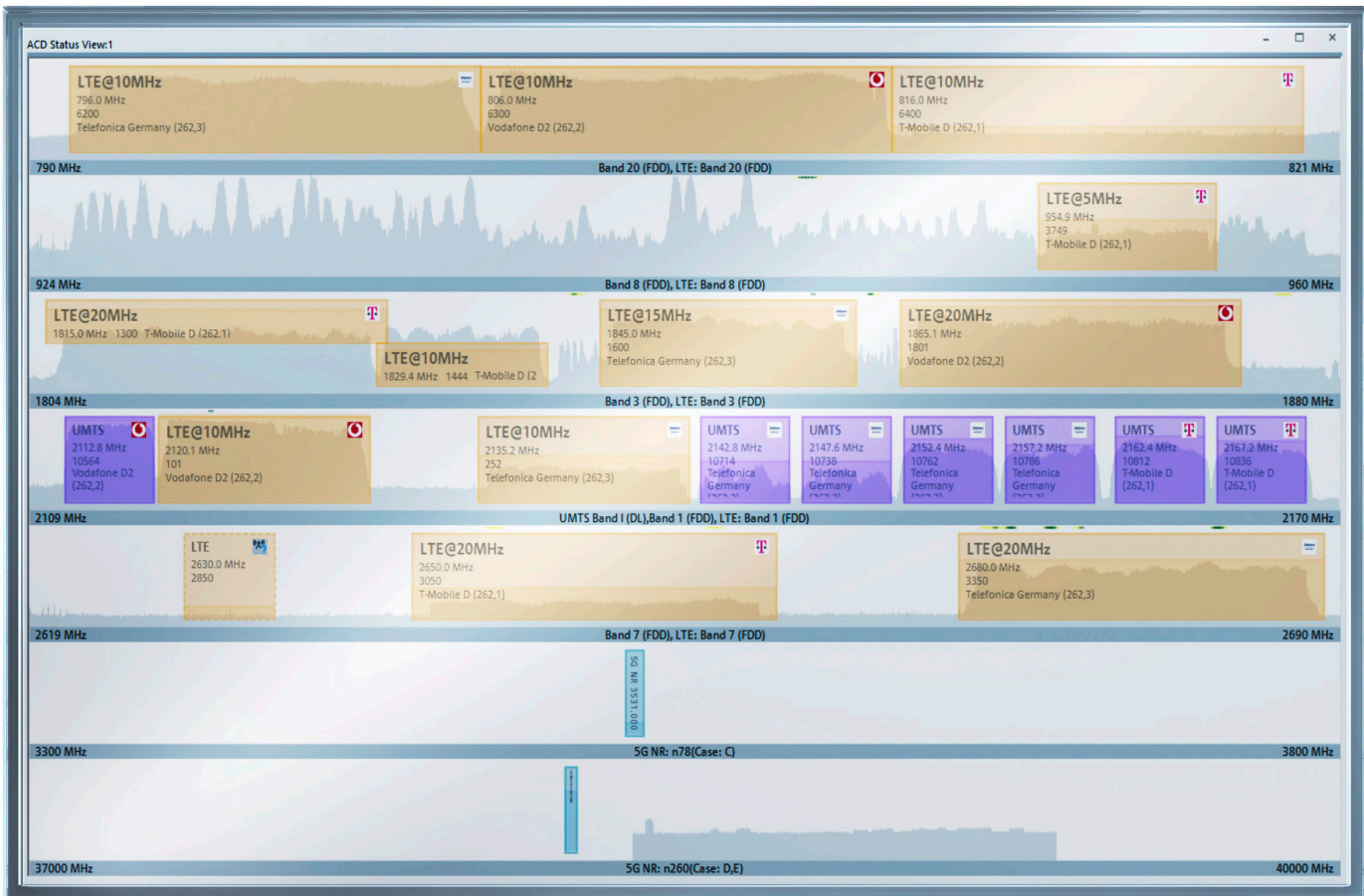
## Ready to use in no time thanks to predefined workspaces and composite signals

Users can create a workspace in which to store all settings and loaded drivers. At the start of a new drive test, all they need to do is load this workspace and the test system is immediately ready to use. To further simplify and speed up this procedure, users can create a project. A project contains all the settings of a workspace and reduces the overall volume of the modules to be loaded when the software is started. The startup wizard makes it possible to fully automatically load and start a project, workspace or test file.

## Easy system configuration with device manager and wizards

Multiple wizards help users configure a test mobile phone in order to perform application tests such as FTP or HTTP downloads. In just three quick steps, the user is ready to start testing. The device manager integrated in R&S®ROMES4 automatically finds and displays all connected test mobile phones and R&S®TSMx scanner options. With just three mouse clicks, the user can configure numerous application tests such as an FTP download. After successfully loading the drivers, R&S®ROMES4 automatically opens a selection of important windows that display measured data. The test can then be started.

Quick overview thanks to automatic channel detection.



### Fast setup due to automatic channel detection

The R&S®ROMES4ACD automatic channel detection feature enables the R&S®TSMW and R&S®TSMx drive test scanners to automatically detect active channels in a specified band. 5G NR, LTE, UMTS, CDMA2000® 1xEV-DO, TETRA and NB-IoT networks are supported. The feature can be optionally enhanced by a spectrum scan that significantly speeds up the detection process. This feature eliminates the need to set up channel lists prior to a measurement campaign. The measurement system dynamically identifies new channels and adds them to the workspace during the drive. This is particularly relevant in networks deployed in a shared spectrum with other cellular standards, where channel frequency and channel bandwidth frequently change.

### Support of numerous map data formats

In addition to the MapInfo map data format, R&S®ROMES4 also supports OpenStreetMap (OSM). Once downloaded, maps are also available offline. This is particularly important when testing data calls to ensure that measurement results are not affected by map downloads. Measurement results can be exported in ASCII format or converted to a Google Earth format. With the Google Earth format, a drive test can be displayed on a map with no additional effort.

### Powerful analysis tools

When multiple, long drive tests need to be automatically evaluated for network errors and the cause for these errors determined, the R&S®ROMES4NPA network problem analyzer is the ideal tool. The base module for displaying ETSI key performance indicators (KPI) and providing an overview of the data in the measurement files is included with R&S®ROMES4. Optional modules for dedicated error analysis of voice or data calls automatically evaluate and display the error causes. Other modules enable analysis of coverage test data and neighborhood relationships as well as delta and comparative analysis. LTE MIMO measurements can also be analyzed and evaluated (see page 38 for more details).

#### **OpenStreetMap (OSM)**

OpenStreetMap (OSM) is a user-editable world map that is available at the following Internet address: <http://www.openstreetmap.org/>

OSM is a wiki project in which users can participate by uploading and editing geographical information such as GPS tracking data or the course of a road or river. This world map is growing daily.

OpenStreetMap data can be used freely under the terms of the Creative Commons Attribution-ShareAlike 2.0 license.

# 5G NR NETWORK TESTING

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®TSME6 or R&S®TSM6 scanner with R&S®TSME6-K50/R&S®TSM6-K50 option
- ▶ R&S®ROMES4T1E scanner driver
- ▶ For 5G NR mmWave measurements: R&S®TSME30DC/R&S®TSME44DC ultracompact downconverter and R&S®ROMES4T30D downconverter hardware driver
- ▶ Appropriate Samsung or Qualcomm chipset drivers (for connecting devices to R&S®ROMES4), depending on whether an unmodified device with external diagnostic ports or a fully integrated one is used

5G NR is expected to become the leading radio access technology in mobile networks during the next few years. New use cases such as ultra high speed internet access, massive numbers of connected devices and low latency connections require a completely new radio interface compared to LTE. This leads to a very flexible physical layer that can be adapted to different use cases to enhance network availability and maximize quality of service – from low latency to ultra high data rate applications.

Another essential building block of the 5G NR physical layer is the use of beamforming technology. It is the key to overcoming the issue of higher path loss due to operating on higher frequencies. Beamforming is even used for synchronization signals that UEs traditionally use to synchronize with the network. In 5G NR, synchronization signals are also used for channel quality estimations, which are the basis for establishing effective data transmissions.



Measurement setup example for 5G NR.



## Analysis of 5G scanner measurements on 5G NR synchronization signal blocks (SSB)

With the R&S®TSME6-K50 or R&S®TSM6-K50 option, users can measure 5G NR synchronization signal blocks (SSB) and decode the PBCH/MIB content of each detected SSB. 5G NR SSB measurements help verify 5G NR coverage and the effect of beamforming, which is a very complex technology with several components involved. Each SSB can be transmitted on different beams (depending on the network configuration), which can be decoded by the scanner. With different SSBs and beams, the scanner results become three dimensional: power, signal-to-noise and interference measurements for each PCI and SSB/beam index deliver a complete set of data to verify the transmission of each SSB/beam. 5G NR SSB measurements are supported for all SSB subcarrier spacings and transmission cases defined for sub-6 GHz bands (FR1) and mmWave bands (FR2) from 24 GHz to 44 GHz, where a downconverter is needed.

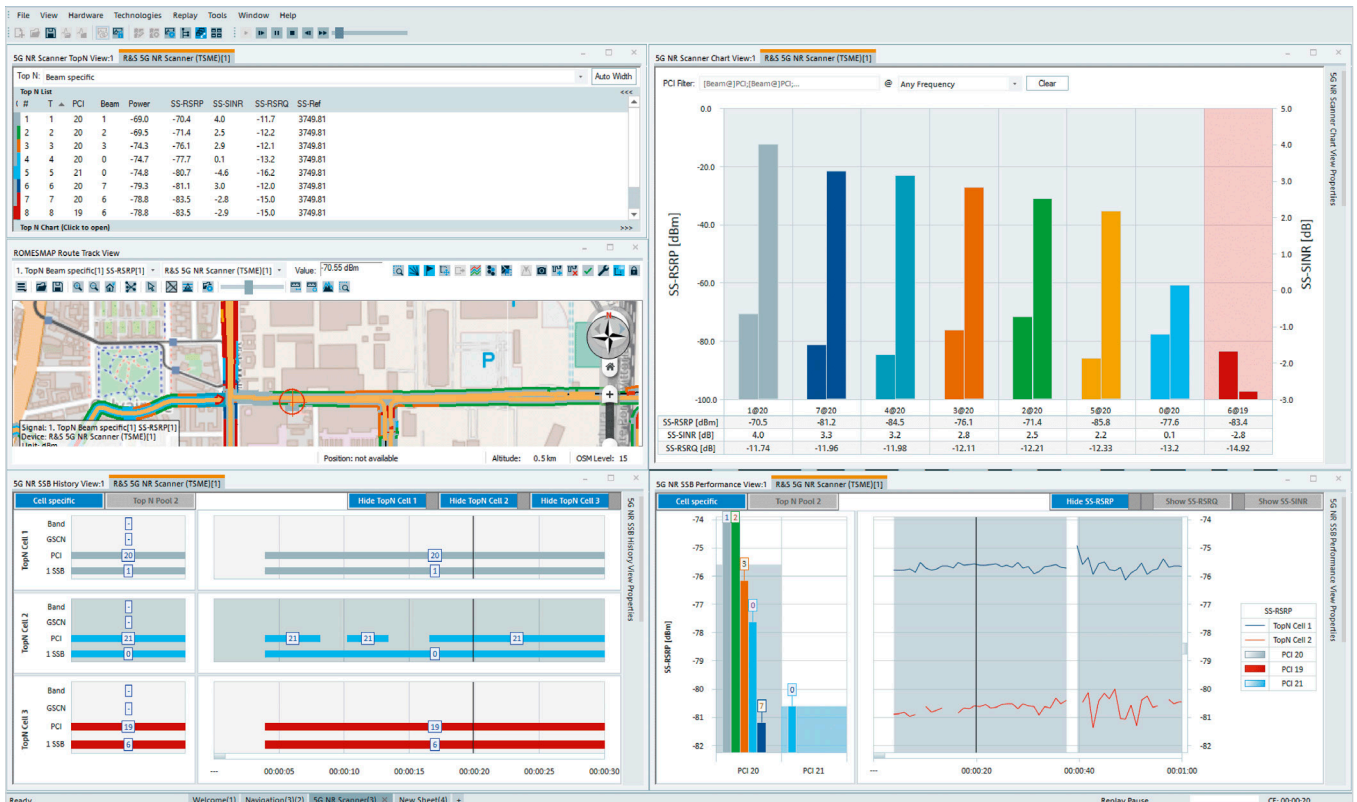
Validation of dynamic spectrum sharing (DSS) network functionality is also supported in combination with scanners, which are able to deliver accurate measurements of both LTE and 5G broadcast channels if the DSS feature is activated. Another scanner capability is verification of 5G TDD synchronization accuracy by delivering accurate time of arrival measurements.

## 5G NR UE measurements

With UE-specific options (listed under Requirements at the beginning of this chapter), users are able to perform measurements for both non-standalone (NSA) and standalone (SA) mode. 5G NR UE NSA support provides LTE information related to 5G as well as the 5G specific NR serving cell information such as NR DL ARFCN, PCI and SSB index, L1 measurement values such as RSRP and RSRQ, L2 PDSCH and PUSCH information, L3 signaling together with services testing data, CSI-RS or 5G carrier aggregation related metrics. In addition to complete layer 3 and NAS layer message decoding, an intelligent event view provides insight into specific 5G NSA/SA network events (such as RRC reconfigurations or SCG link failures).

5G SA and 4G/5G dynamic spectrum sharing (DSS) measurements with Qualcomm Snapdragon 888 or Exynos 2100 based UE connected to R&S®ROMES4 are fully supported. This capability makes it easy to investigate different aspects of 5G SA network functionality (access procedure via layer 3 messages, mobility events, QoS/QoE), as well as DSS related parameters (DSS band and frequency, ratio of traffic carried over 4G versus traffic carried over 5G).

R&S®ROMES4 5G NR GUI displaying the results measured with the R&S®TSME6 scanner.



# NUMEROUS APPLICATION TESTS

## Requirements

- ▶ R&S®ROMES4
- ▶ Test mobile phone
- ▶ Appropriate Samsung or Qualcomm chipset drivers (for connecting devices to R&S®ROMES4), depending on whether an unmodified device with external diagnostic ports or a fully integrated one is used

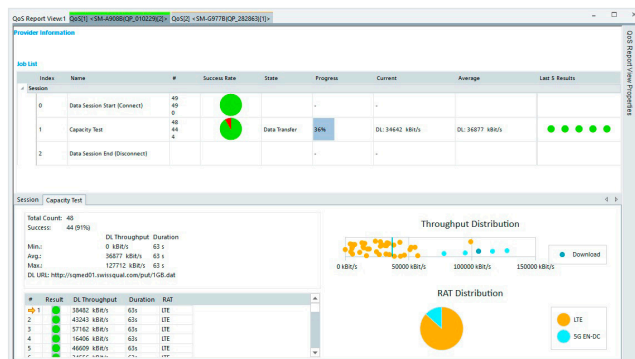
## Creation of different application jobs

Mobile data calls are the standard today. It is therefore essential that data services be optimized with respect to quality and data throughput. This requires tools that can be used to configure, display and evaluate the different data measurements and packet-switched services. R&S®ROMES4 offers three different test solutions that are based on differing test concepts.

## Data throughput measurement on a PC

The R&S®ROMES4 data quality analyzer (DQA) makes it possible to perform data tests using a commercially available mobile device (mobile phone, data stick), where the mobile device either acts as a modem or is connected via NDIS. The test is evaluated on a PC. This ensures that the latest devices are always used for testing and enables a fast response to new technologies such as LTE carrier aggregation or 5G NR testing. DQA jobs can be run in parallel so that users need just a few mouse clicks to generate the high data loads required for LTE CA and start testing. By appropriately linking parallel and sequential jobs, the behavior of internet users can be simulated. The R&S®ROMES4 data quality analyzer supports the following applications, which can be combined in an individual job list: SMS, email (POP3 and IMAP), ping, UDP, FTP, HTTP and video streaming.

The QoS report view reveals the status of data and voice tests.



## Innovative on-device testing with a smartphone

When used together with a suitable QualiPoc Android phone, the R&S®ROMES4QP smartphone option sends all of the messages and analyses directly to the smartphone. This ensures an almost exact simulation of user behavior. R&S®ROMES4 GUI makes configuration easy and convenient. Up to six wired devices can be controlled in parallel. Depending on the device, voice quality analyses and VoLTE measurements can be performed in addition to data tests (incl. carrier aggregation). R&S®ROMES4 includes the following jobs, which can also be assigned to a job list: email, ping, FTP, HTTP, HTTP capacity test, Iperf3, Call2AnyNumber, double-ended voice quality, MOC DL voice quality, network performance tests and application testing such as YouTube, OTT services, Facebook or WhatsApp.

The QualiPoc Android phone can also be used as a stand-alone device, for instance for indoor measurements. This increases the flexibility and saves costs, since only one device is needed.

## Innovative on-device testing with commercial smartphones

Today's applications often call for very high-speed mobile data transfer, where a USB connection can be a limiting factor. To overcome that limitation, R&S®ROMES4 supports on-device testing for unmodified commercial or pre-commercial Android smartphones. Users can test data throughput directly on the device without the limitations imposed by a USB connection. For example, tests can be performed on precommercial devices during initial testing of new features (e.g. carrier aggregation<sup>1)</sup>, licensed-assisted access (LAA) and MIMO 4x4) in the lab or field. The R&S®ROMES4 data quality analyzer (DQA) supports on-device testing for devices with external diagnostic ports for various tests, such as FTP, HTTP, interactivity or capacity tests. Fully integrated QualiPoc devices provide additional possibilities, such as 5G technology forcing or voice testing.

## Output of KPIs and the most important network parameters in a report

Automatic real-time analysis generates multiple reports containing key benchmark data. ETSI KPIs are calculated automatically.

<sup>1)</sup> Up to 8 aggregated carriers supported.

# DRIVE TEST ANALYSIS IN A 3D ENVIRONMENT

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®ROMES43DM driver for 3D maps

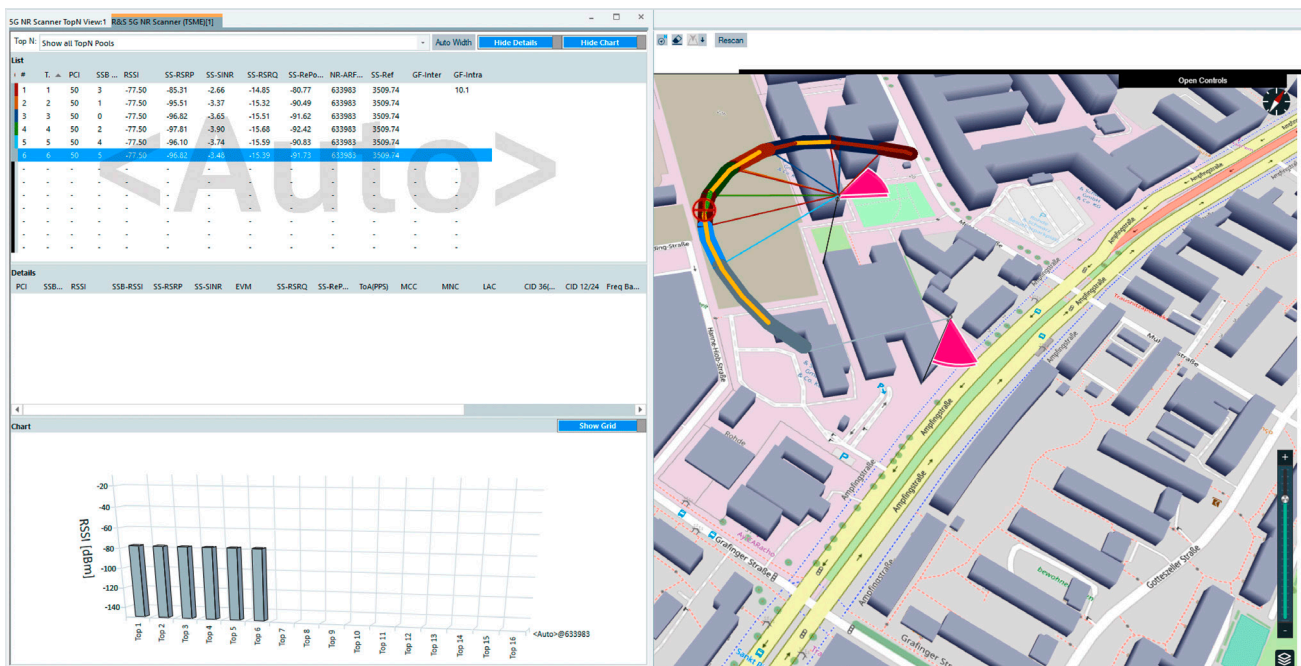
## Complete 3D environment analysis capability

R&S®ROMES4 is capable of analyzing drive tests in 3D environments. Measured parameters or 5G NR beams, for example, can be displayed in the route track view on a 3D rendered map. The map with plotted parameters can be moved as desired, including pan, tilt and zoom capability. Base station lists can be imported with BTS heights and azimuth angles and displayed on the map. The best server (BTS) lines for the measured route can be displayed to understand the beam coverage from available base stations. This capability provides users with a powerful tool to understand and evaluate the coverage and related attenuation in real networks.

## Innovative testing capabilities

Drones are being used for mobile network testing in various innovative use cases. Whether addressing site survey related activities or more future oriented use cases such as package delivery with drones, analysis tools are facing a new requirement, i.e. they need to be able to handle the altitude component of mobile network coverage. R&S®ROMES4 offers complete capability to analyze those measurements. Drone based testing with scanners and smartphones is fully supported, including reading MAVLink protocol data for improved accuracy. If base stations with their heights and azimuth angles are imported, users get a complete overview of the coverage and quality up in the air, since the best server lines and best servers can also be displayed.

Drone based R&S®TSME6 scanner measurement in a 3D environment.



# AUTOMATIC HANDOVER AND NEIGHBORHOOD ANALYSIS

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®ROMES4HOA
- ▶ R&S®TSMW, R&S®TSME or R&S®TSMa scanner
- ▶ R&S®TSMx GSM/UMTS scanner
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver
- ▶ Test mobile phone
- ▶ Chipset drivers for connecting devices to R&S®ROMES4

## Improvement of network coverage

Unlike test mobile phones, the R&S®TSMx scanners see all signals. These signals can be allocated to the relevant neighboring cells. R&S®ROMES4 is thus able to automatically compare the measured data from the scanners and the test mobile phones against a base station list to identify any missing neighboring cells. These missing cells may originate during the setup of a network and, in the worst case, can terminate a call.

## Automatic detection of missing neighboring cells during drive testing

Automatic neighborhood analysis is based on a base station list and the base stations' broadcast signals that are decoded by the R&S®TSMx scanners. These system information blocks (UMTS and LTE) or system information types (GSM) include information that is normally used by test mobile phones to identify and monitor relevant neighboring cells. The report containing the measured values of the neighbor channels is forwarded to the base station. If necessary, the base station can use this response to initiate a handover.

The SIB analyzer integrated in R&S®ROMES4 compares the neighboring cells measured by the scanner against those in the base station list. Neighboring cells that were detected but do not appear in the list are marked in yellow, indicating a missing neighborhood. This automatic neighborhood analysis works for UMTS; a comparable functionality exists for GSM. Both work in real time. For TETRA and LTE, this functionality is included in the R&S®ROMES4NPA network problem analyzer (see page 25).

## Detecting a missing neighborhood at a glance.

The screenshot shows the 'UMTS Neighbourhood Analyser:1' window. At the top, there are filter settings for SIB11, PI, 3G MN, 2G MN, Distance (10 m), Duration (10 s), and # of Samples (5). Below this is a table with columns: Problem Node (Best Server), Type, Time, Distance, and Samples. The table lists various SIB11 mismatch events and one PI2 event. The PI2 event is highlighted in yellow, indicating a missing neighborhood. Below the table is the 'Analyzer Messages' section, which displays a list of messages in red text, such as 'GSM BTS MxBT84A found in SIB11 but not in Database as neighbour' and 'GSM BTS MxBM56A found in SIB11 but not in Database as neighbour'.

# TESTING OF VOICE QUALITY – INCL. VoLTE

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®ROMES4QP

## User-friendly configuration for checking voice quality

Mobile networks face increasingly high quality demands. For testing voice quality, R&S®ROMES4 offers an innovative, full-featured, end-to-end solution that exactly simulates user behavior.

The test mobile phone is connected to the R&S®ROMES4 via USB and configured using a job list. A POLQA algorithm (ITU-T P.863) evaluates the voice quality directly on the phone. The results are displayed live in R&S®ROMES4. The greater the difference between the transmitted voice signal and the reference signal, the poorer the voice quality. This is indicated by the usual mean opinion score (MOS) and can lie between 1 (poor) and 5 (very good).

## Complete end-to-end measurement from the user perspective

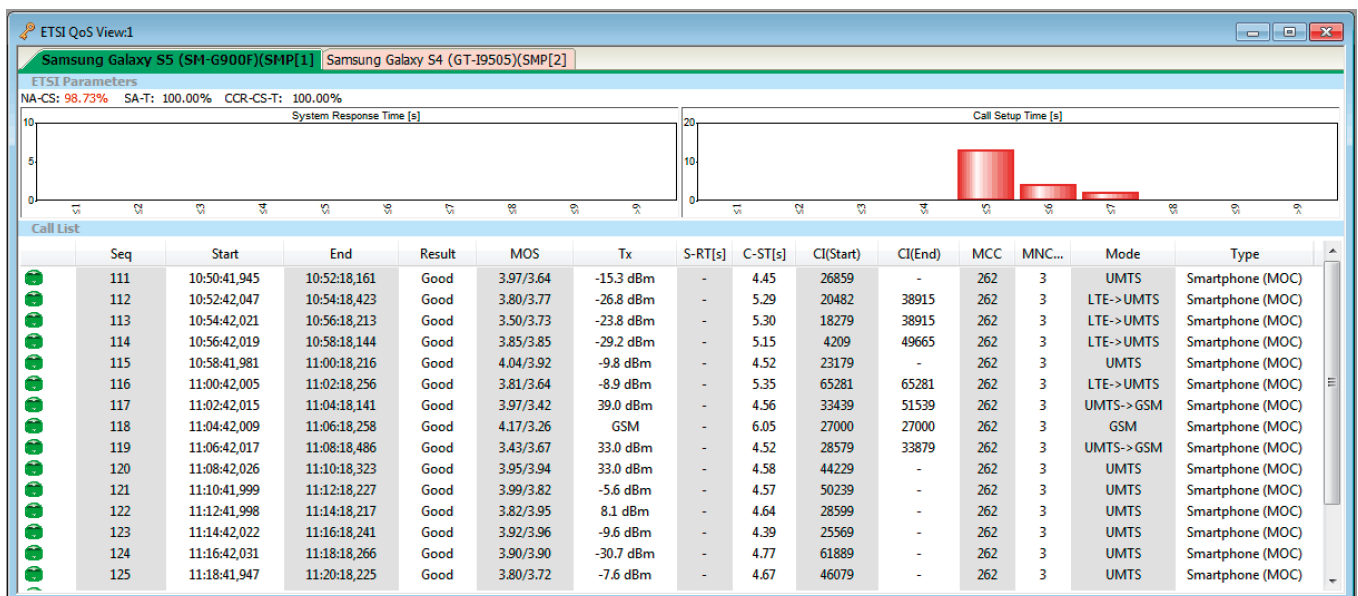
The measurements can be performed using a fixed-network station, usually a voice-quality server, or another mobile phone. The mobile phone reflects the quality as experienced by a mobile user and also permits HD voice measurements. In contrast, a fixed-network station serves as a reference, enabling the cause of a poor MOS to be found more quickly.

## Based on POLQA standard

The R&S®ROMES4QP option and a suitable QualiPoc Android QA can be used to measure calls for the downlink and uplink. For the downlink, the server replays a reference voice signal, and the QualiPoc Android QA connected to R&S®ROMES4 evaluates this received signal. For the uplink, the R&S®ROMES4 test system replays a voice signal and the server uses a POLQA algorithm to evaluate it.

Following a drive test, the measured data can be merged so that the uplink and downlink measurements are available in one log file. The merge process can be skipped if two phones connected to R&S®ROMES4 call each other.

Voice quality measurement (MOS).



# LTE BROADCAST (EMBMS) NETWORK OPTIMIZATION

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®TSMW scanner with R&S®TSMW-K29 and R&S®TSMW-K32, or R&S®TSME scanner with R&S®TSME-K29 and R&S®TSME-K32, or R&S®TSMA scanner with R&S®TSMA-K29 and R&S®TSMA-K32
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver
- ▶ Chipset drivers for connecting devices to R&S®ROMES4

## R&S®ROMES4 in combination with a Rohde & Schwarz LTE scanner and an LTE eMBMS test mobile

LTE broadcast, using the evolved multimedia broadcast multicast service (eMBMS) feature of LTE, allows operators to more efficiently provide services to a large number of subscribers. Instead of transmitting video and data content separately to individual users, broadcast saves network resources, making it attractive for areas such as event venues where a multitude of subscribers request the same type of content.

Enabling broadcast in an LTE network poses challenges for the network operator. It is necessary to ensure continued high-quality unicast services and simultaneously provide high-performance broadcast services. The broadcast network consists of a virtual single frequency network (SFN) inside the LTE network, where a set of eNodeBs that are part of the same broadcast area transmit the same downlink signal at the same time. This requires accurate eNodeB synchronization, which is typically not the case in LTE-FDD networks. In addition, intersymbol interference becomes important in the SFN.

The eMBMS feature already makes use of the extended cyclic prefix, but when planning and commissioning the broadcast network, it is crucial to validate that the network footprint at the given operating frequency does not lead to intersymbol interference.

R&S®ROMES4 in combination with an LTE scanner, such as R&S®TSMW, R&S®TSME or R&S®TSMA, and an eMBMS capable test mobile is the ideal solution for optimizing such a network.



Typical measurement setup with R&S®ROMES4, R&S®TSMA and an eMBMS smartphone.

## Network planning

With the scanner, the LTE network can be baselined in the planning phase, and the network synchronization can be checked against GPS. This allows the network planner to predict potential areas of intersymbol interference and allows planning of the MBSFN area IDs, similar to PCI planning in an LTE unicast network.

## Network rollout

During the network rollout and tuning of the broadcast network, the scanner can measure the power (RSRP) and quality (SINR) of each MBSFN area. The engineer can then check the validity of the network planning by comparing it to the results from the field.

## Intersymbol interference detection

The scanner can also be used to detect intersymbol interference. Due to the impulse response measurement per PCI, it can also detect which eNodeB is causing this interference, allowing the engineer to take corrective measures.

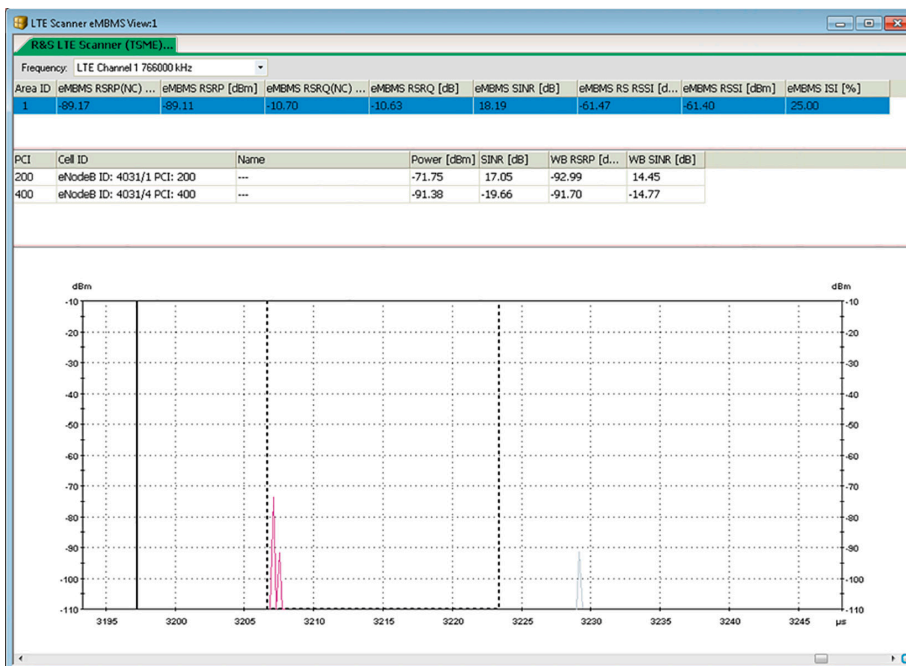
## Network configuration check

The scanner decodes the SIB2 and SIB13 broadcast messages that include information on the eMBMS configuration in the network, such as MBSFN subframe configuration from SIB2 and MCCH configuration per MBSFN area from SIB13. Engineers can check that the network is configured correctly in the field.

## Network performance validation

While the scanner allows optimization of the RF environment, it is also crucial to validate the network performance with a test mobile. R&S®ROMES4 supports eMBMS test mobiles with a Qualcomm chipset, so the engineer can test the connection to the eMBMS network, view layer 3 and flute messages, capture the IP trace and analyze problems in the broadcast network. While testing eMBMS, it is important to continue testing the unicast services (data and VoLTE) to ensure that service quality stays at a high level when introducing the eMBMS feature.

R&S®ROMES4 eMBMS scanner view with intersymbol interference analysis.



# NB-IOT/CAT NB1 AND LTE-M MEASUREMENTS

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®TSMW scanner with R&S®TSMW-K29 and R&S®TSMW-K34/R&S®TSMW-K35, or R&S®TSME scanner with R&S®TSME-K29 and R&S®TSME-K34/R&S®TSME-K35, or R&S®TSMA scanner with R&S®TSMA-K29 and R&S®TSMA-K34/R&S®TSME-K35
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver
- ▶ R&S®ROMES4NBQ for Qualcomm NB-IoT UE support
- ▶ R&S®ROMES4NBN for Neul NB-IoT UE support

For coverage validation, troubleshooting and optimization, R&S®ROMES4 in combination with a Rohde&Schwarz scanner delivers signal power, signal quality, and carrier to interference and noise ratio (CINR) measurements for each available physical cell ID.

## Support of all operating modes defined in NB-IoT/Cat NB1

The NB-IoT/Cat NB1 standard defines three operating modes to integrate NB-IoT carriers efficiently into the available spectrum. R&S®ROMES4 supports all three modes. The LTE in-band mode makes the most efficient use of the available spectrum. In this mode, one NB-IoT carrier uses the spectrum of one LTE PRB. The other operating modes – guard-band and standalone – allow NB-IoT deployments independently of the LTE spectrum.

## Combination with a Rohde & Schwarz scanner

In combination with an R&S®TSMW, R&S®TSME or R&S®TSMA scanner, R&S®ROMES4 enables IoT measurements in both NB-IoT and LTE-M networks. NB-IoT/Cat NB1 and LTE-M are 3GPP standards for connecting a huge number of things such as smart meters to the internet (IoT).

While traditional LTE standards are mainly aimed at increasing throughput and network capacity, NB-IoT/Cat NB1 and LTE-M focus on low power consumption for IoT devices and highest availability of the connecting links, especially indoors. Indoor measurements require lightweight, ultracompact scanners with low power consumption.

## Simultaneous measurements of NB-IoT and other technologies

NB-IoT measurements can be performed simultaneously with measurements for other technologies such as GSM, LTE or (W)CDMA. During network optimization or troubleshooting, the impact of the NB-IoT spectrum on adjacent GSM/LTE/(W)CDMA spectra and vice versa can be validated.

Procedure	Time	Result	Tx Po...	ReTx	Ty
RACH	00:01:21	Success	-31 ...	1	Cc
RACH	00:01:22	Success	-26 ...	2	Cc
Trigger	00:01:22	---	---	---	---
MSG1	00:01:22	---	---	---	---
Attempt	00:01:22	---	---	---	---
MSG1	00:01:22	---	---	---	---
MSG2	00:01:22	---	---	---	---
MSG3	00:01:22	---	---	---	---
MSG4	00:01:22	---	---	---	---
Attempt	00:01:22	---	---	---	---
RACH	00:01:22	Success	-30 ...	1	Cc
RACH	00:01:22	Success	-29 ...	1	Cc
RACH	00:01:23	Success	-29 ...	1	Cc
RACH	00:01:23	Success	-29 ...	1	Cc
RACH	00:01:23	Success	-29 ...	1	Cc
RACH	00:01:24	Success	-29 ...	1	Cc
RACH	00:01:24	Success	-29 ...	1	Cc
RACH	00:01:24	Success	-29 ...	1	Cc

RACH Procedure	
Final Result	Success
Final Tx Power	-26 dBm
Final ReTx Count	2
Trigger Count	1
MSG1 Count	2
MSG2 Count	1
MSG3 Count	1
MSG4 Count	1
Attempt Count	2

NB-IoT RACH retransmission.



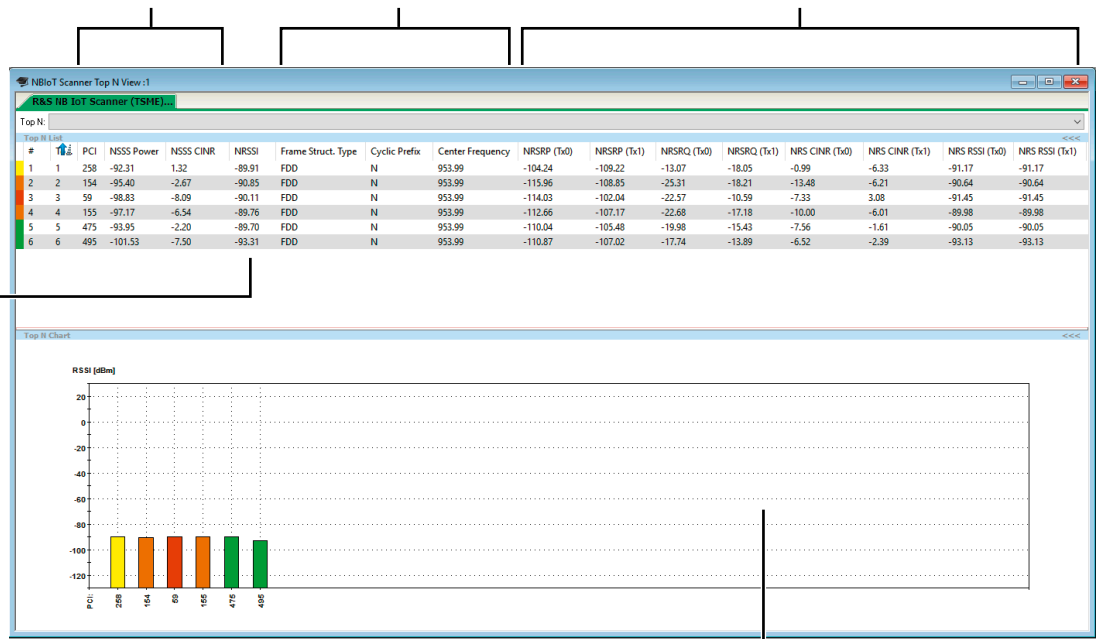
## NB-IoT scanner TopN view

PCI, power and carrier to interference and noise ratio (CINR) based on S-SYNC

Frame structure type, cyclic prefix information and NB-IoT carrier center frequency

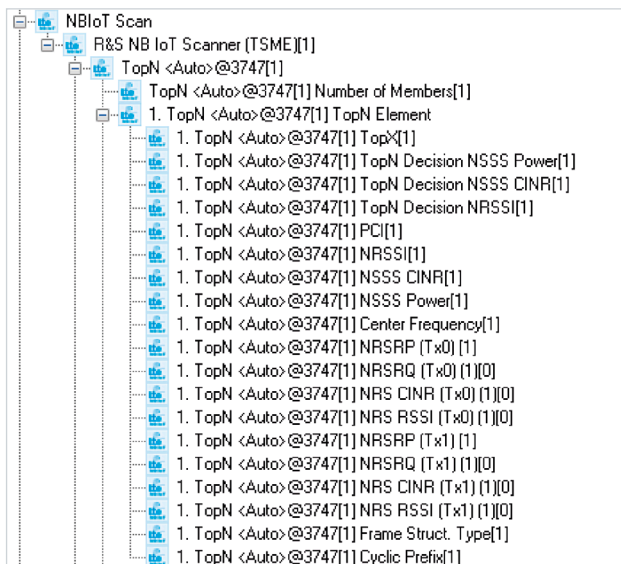
Power, quality, CINR and RSSI based on reference signal measurements for both eNodeB antenna ports (TX0, TX1)

Total power received inside the NB-IoT carrier bandwidth (received signal strength indicator, RSSI)

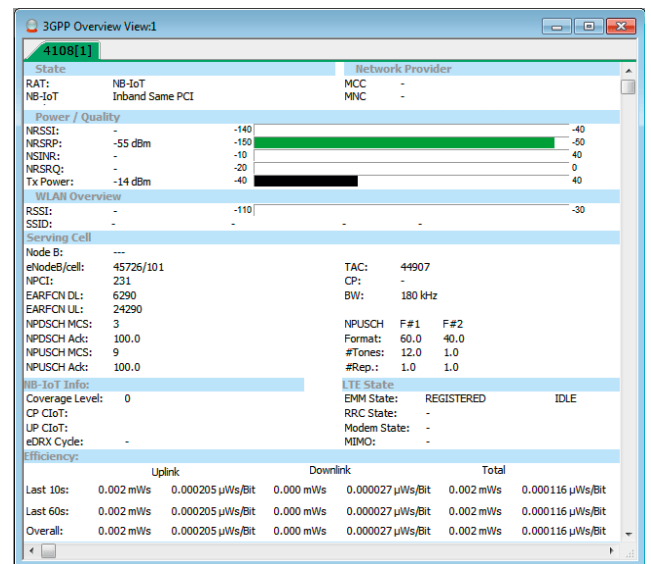


TopN chart, received power bar for each PCI

## NB-IoT scanner TopN signals.



## NB-IoT UE overview view.



### Layer 3 decoding

The NB-IoT scanner supports layer 3 BCH demodulation (MIB/SIB1). Layer 3 BCH data offers deep network configuration insight and helps optimize troubleshooting. Demodulation is performed on the fly during standard NB-IoT synchronization and reference signal measurements.

BCH/broadcast messages include master information block (MIB) and system information block (SIB) messages. They are demodulated for each cell/PCI and displayed in a tree structure in the new NB-IoT scanner BCH view.

### Combination with an NB-IoT UE

In combination with an NB-IoT UE, R&S®ROMES4 enables network performance and service quality measurements in NB-IoT/Cat NB1 networks. This setup permits traditional mobile network testing measurements such as RF conditions (including serving cell allocation and identity, downlink (DL) and uplink (UL) channel performance), the random access channel (RACH) procedure and various jobs executed directly on the NB-IoT stick (e.g. FTP jobs executed on the device).

It additionally provides information about NB-IoT specific features such as cellular IoT (CIoT), coverage enhancement levels (CE) and eDRX. Dedicated NB efficiency KPIs offer analysis of the used energy and transmission efficiency as power consumption is a key NB-IoT metric.

### LTE-M (Cat M1/eMTC) support

LTE-M is fully compatible with existing LTE networks. R&S®ROMES4 supports LTE-M measurements in combination with both a scanner and an LTE-M device. LTE-M is standardized for the LTE in-band mode only. By performing subband measurements with a Rohde&Schwarz scanner, it is possible to evaluate the RF conditions for each LTE-M narrowband or identify e.g. the best narrowband for LTE-M data transmission. In combination with an LTE-M device, R&S®ROMES4 can deliver traditional UE based mobile network measurements (UL/DL RF conditions, UE state, operator information, serving cell information, RACH procedure). LTE-M specific measurements supported by R&S®ROMES4 include, for example, decoding eDRX, power save mode and coverage enhancement (CE) mode parameters.

NB-IoT measurements with R&S®ROMES4  
and the R&S®TSM6 autonomous mobile network scanner.



# FULL OVERVIEW OF LAYER 1 AND LAYER 3

## Requirements

- ▶ R&S®ROMES4
- ▶ Test mobile phone
- ▶ Chipset driver for connecting devices to R&S®ROMES4

## Display of mobile phone activities in layers 1 and 3

The basic functionality of R&S®ROMES4 in combination with the required test mobile phone drivers provides a large amount of information from layers 1 and 3. Users can investigate various procedures executed in 5G and other technologies at a glance. An important functionality for 5G – NAS layer message decoding – is also fully supported and enables comprehensive investigation of 5G SA procedures.

If at the same time measurements are taken by a scanner, the scanner's measured data is displayed in the same window, allowing a direct comparison. Layer 3 View displays all layer 3 protocol messages, sorted by uplink and downlink. Each message is decoded and can be opened if necessary.

## Fast analysis of interrupted connections

In addition to protocol messages, interrupted/blocked and successful connections are also displayed. When jumping to a trouble spot, all views will show measurements taken at this point in time. This makes it considerably easier to find the cause of a problem. In addition, a filter function in Layer 3 View enables users to evaluate only specific messages.

EN-DC layer 3 protocol messages and RRC parameters.

The screenshot displays three windows from the R&S ROMES4 software interface:

- Layer 3 View:** A timeline showing protocol messages between two devices (SM-A9088[CP\_01022902] and SM-G9778[CP\_2028630]). Messages include Down and Up directions for radioResourceConfigDedicated, rrcConnectionReconfigurationComplete, measurementReport, and PCCH Message.
- DCA Message View:** A list of decoded messages with timestamps, such as "QualPoc Test Name: Capacity DL Test", "Capacity Test OK", "HTTP DL Transfer Data Rate: 34556 kB/s", and "QualPoc session 5 finished successfully".
- Alphanumeric View:** A table of RRC parameters for the selected message. The table lists parameters like PSCell servCellIndex, PSCell physCellId, PSCell sub-PBCH-BlockPower, and PSCell absoluteFrequencySSB, along with their values for the two devices.

# PARALLEL SPECTRUM MEASUREMENT

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®TSMx scanner with R&S®TSMW-K27 RF power scan
- ▶ R&S®TSME scanner with R&S®TSME-K27 RF power scan
- ▶ R&S®TSMA scanner with R&S®TSMA-K27 RF power scan
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver

## Detection of broadband interferers, neighborhood interference and uplink activities

The waterfall diagram gives the user a general idea of the air interface and its history. This makes it very easy to locate broadband interferers or external interference. All the user needs to do is move the mouse pointer over the waterfall diagram. At any desired spot, timestamp and frequency are displayed, enabling the user to find the center frequency of an unknown signal faster.

## Broadband spectrum measurement

In combination with an R&S®TSMW, R&S®TSME or R&S®TSMA scanner, R&S®ROMES4 can be used to perform a spectrum scan. The user can select up to 32 frequency ranges from 80 MHz to 3 GHz (R&S®TSMW: 30 MHz to 6 GHz; R&S®TSME/R&S®TSMA: 350 MHz to 4.4 GHz). The frequency range is not limited. R&S®ROMES4 offers different display options, e.g. envelope spectrum measurement, RMS, peak or a predefined channel mask. In this case, the power per channel is displayed.

Marker functions make it easy to precisely measure dedicated frequencies and detect changes. A marker can also be defined as a reference and compared against the maximum value.

The spectrum function is based on FFT analysis. Various FFT sizes allow users to set measurement bandwidths down to min. 140 Hz. The smaller the measurement bandwidth, the greater the measurement accuracy. This permits very fast spectrum measurements without the usual sweep time of a normal spectrum analyzer. Fast measurements are especially important during drive tests in order to obtain a sufficiently high density of results during the drive.

A special threshold value is provided for monitoring the spectrum. Spectra that do not show any test points above this threshold value are not displayed. Any data that is not of interest is not recorded.

Frequency markers and the entire spectrum can be exported in the ASCII format.

## Spectrum measurement



# LOCATION ESTIMATION OF 2G/3G/LTE/5G AND NB-IoT BASE STATIONS

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®ROMES4LOC driver
- ▶ R&S®TSMW or R&S®TSME or R&S®TSMA scanner
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver

## Creation of a base station list during a drive test

The R&S®TSMW, R&S®TSME and R&S®TSMA scanners enable users to estimate the geographic position of base stations. This can even be done for 5G, LTE, WCDMA, GSM, CDMA2000® 1xEV-DO and NB-IoT sectors and base stations in parallel.

## Requires only scanners and GPS

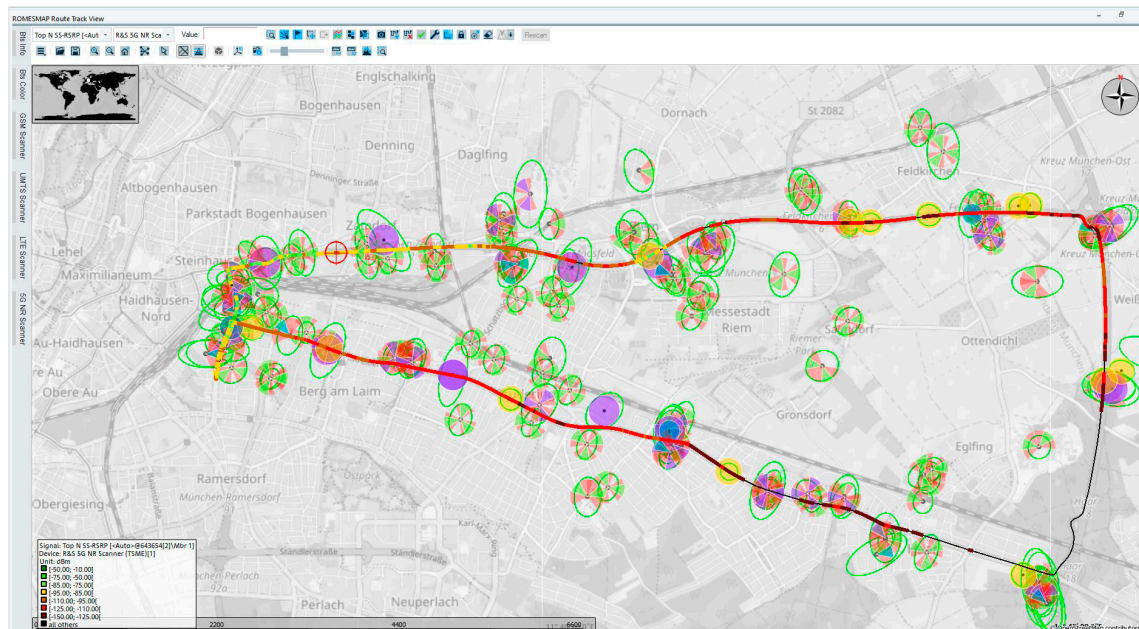
For the calculation algorithm, all that is needed are the measurement parameters from a highly accurate GPS receiver with output of the PPS time reference signal (pre-installed in the R&S®TSMW, R&S®TSME and R&S®TSMA) and from the scanner.

The R&S®ROMES4 software and the R&S®ROMES4LOC driver allow the scanners not only to detect the main levels of the BTS (2G: RxLev, 3G: RSCP, 4G/5G: RSRP) but also to demodulate the broadcast channels (BCH). This delivers important time information as well as details of the transmitting BTS.

The maximum likelihood method is used to calculate the geographic position of the individual BTS from the measured data provided by the GPS receiver, the BCH time information and level changes during the drive test. A recent improvement of the algorithm enables location estimation also for the sectors of a BTS.

Following the drive test, the calculation results are exported to a base station list and the located base stations are displayed on a street map. The estimated location of each BTS sector lies within an error ellipse with a user-defined range (meters) and can be exported. Base stations can be filtered based on the accuracy of location estimation.

Results of the measured geographic position of base stations using the R&S®ROMES4 software and the R&S®ROMES4LOC driver.



# GSM INTERFERENCE ANALYSIS WITH AUTOMATIC INTERFERER IDENTIFICATION

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®ROMES4COI
- ▶ R&S®TSMx GSM scanner
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver
- ▶ Test mobile phone
- ▶ Chipset driver for connecting devices to R&S®ROMES4

## Automatic measurement and identification of interferers from own GSM mobile network

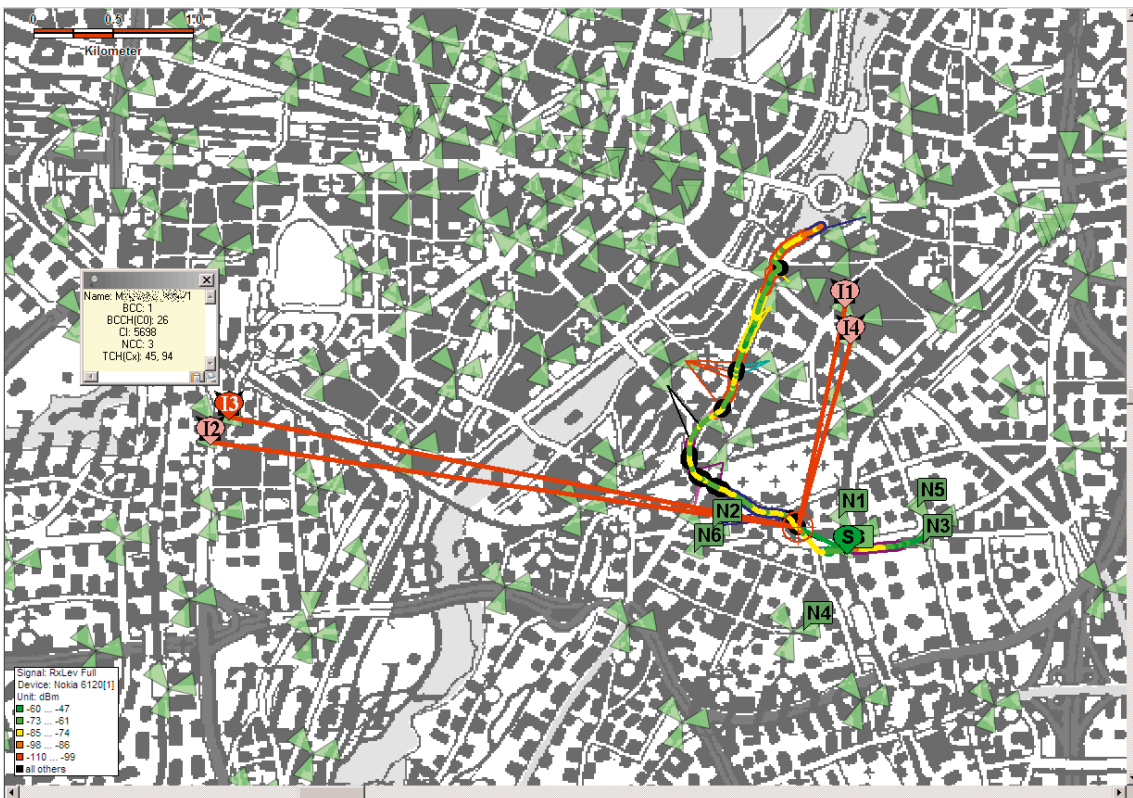
R&S®ROMES4 allows GSM interference to be determined automatically and clearly from the own GSM network during the drive test. The actual interferers can be displayed on the underlying street map in Route Track View. This makes it considerably easier to use the software and perform tests, reducing costs dramatically in comparison with conventional methods.

The evaluation is performed in three steps:

- ▶ Automatic detection of an interference situation (type, length, location)
- ▶ Automatic analysis of the detected interference (test on BCCH and TCH)
- ▶ Classification of the actual interferers on the basis of the individual interference situation and pinpointing of the interferers on the street map (interfering base station with channel indication: BCCH, TCH, adjacent channel)

GSM interference analysis with automatic interferer identification – map display.

The map shows the position of the interference (crosshairs), the cell currently providing coverage (S) and the four interfering cells (I1, I2, I3 and I4). The markings N1 to N6 show the current neighboring cells. The color of the route indicates the received signal strength of the GSM mobile phone.



To optimize interference analysis, more than just selectable trigger thresholds (e.g. RxLevFull, RxLevSub, RxQualFull, RxQualSub, FER) are used. Some of the test mobile phones supported by R&S®ROMES4 also provide a C/I value for the traffic channels being used (TCH). Because the SIM connection only allows the test mobile phone to see the data from the allocated mobile network, and because it is not very RF-sensitive, the use of high-grade scanners is absolutely essential.

### Evaluation of BCCH and TCH channels allows full-featured analysis

The R&S®TSMW, R&S®TSME and R&S®TSMa scanners are able to instantly detect all selected RF channels (BCCH) and demodulate the BCH information. As a result, all the data from the BTS transmitting the signals is available. This is especially relevant when performing measurements in the vicinity of national borders (faulty frequency allocation, roaming, etc.).

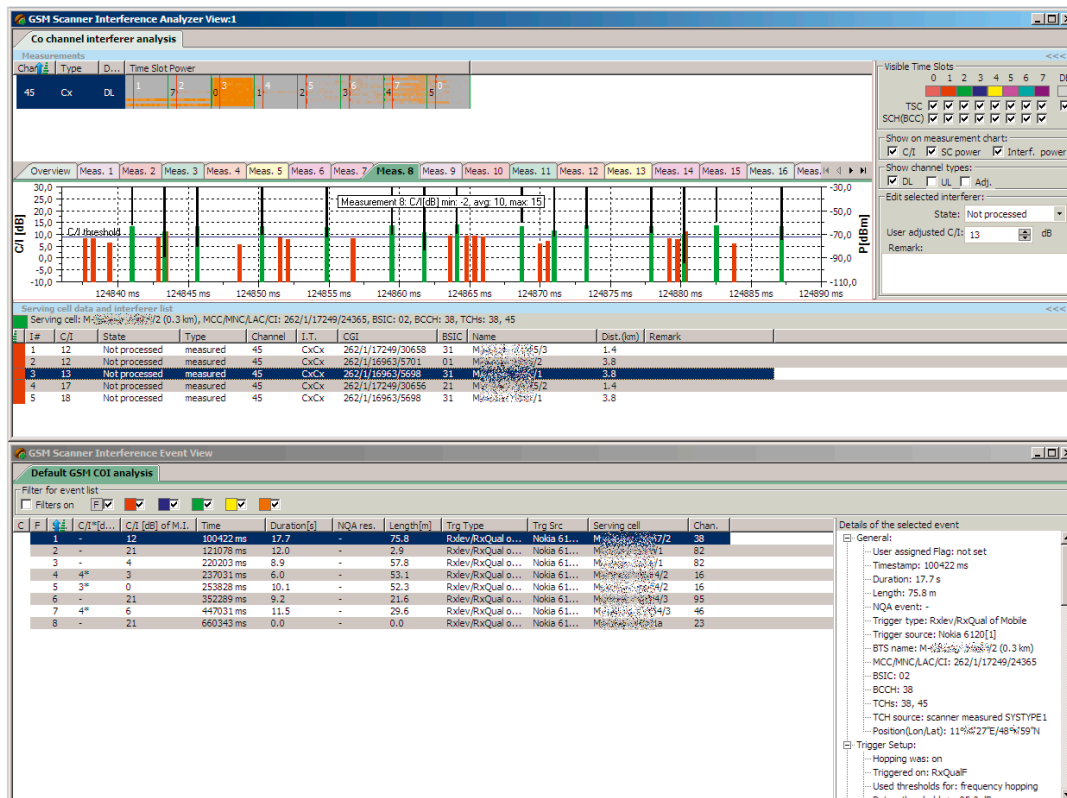
### Detection of adjacent-channel and co-channel interferers

The combination of scanner and test mobile phone can even be used to measure the power in the time slots being used (TCH, TS Time Slot), making it possible to identify not only interfering BCCH channels but also TCH interferers.

#### GSM interference analysis with automatic interferer identification – detailed display.

Eight interference situations were detected during the drive (bottom window). The interference marked on the map was 17.7 s in duration and extended over a distance of 75.8 m. The BCCH of the cell providing coverage is channel 38; the interference occurred on TCH 45.

The upper part of the screen shows the scanner measurements from channel 45 of the cell providing coverage (green) as well as the measurement of the interferers (red). The list shows the individual interferers together with the measured signal strength, the identification of the cell and its distance to the location of the interference.



# INDOOR MEASUREMENTS

## Requirements

- ▶ R&S®ROMES4
- ▶ R&S®ROMES4IND
- ▶ Test mobile phone and/or scanner
- ▶ Chipset driver for connecting devices to R&S®ROMES4

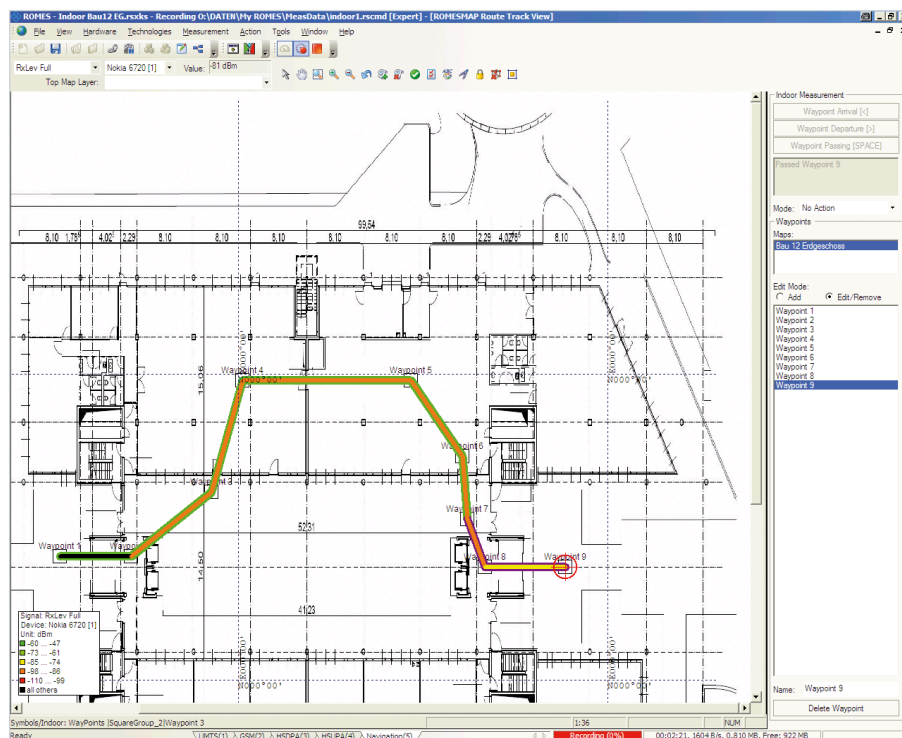
## Stationary or moving measurements indoors without a GPS signal

High-quality wireless communications coverage inside buildings, e.g. at airports, shopping malls and exhibition halls, is gaining in significance, especially with respect to data traffic. Since GPS reception indoors is limited or nonexistent, R&S®ROMES4 offers an alternative to conventional navigation display (GPS data on a map).

## Combined indoor/outdoor measurements

The R&S®ROMES4IND indoor driver option provides a separate means of navigation that makes it possible to display positions on a floor plan. Measurements can be taken at specific points (hot spots, e.g. in conference rooms) or along a specific path (continuous, e.g. in a corridor). Combined DUTs (comprising buildings and outdoor areas such as company premises) can be optimally measured and georeferenced. The software also displays a smooth transition to areas covered by GPS. Measurements of multi-floor buildings are easily handled by displaying the various floors as multiple layers on the map. The wide support of georeferenced and non-georeferenced map formats (tab, jpg, tif, bmp, png) and included import functionalities for iBwave ibwc and AutoCAD DXF files simplifies and speeds up daily work. The layer that corresponds to the floor where the user is located is visible on the map. The complete integration of the indoor functionality into the R&S®ROMES4 map display allows intuitive operation.

Display of a floor plan in hot spot mode.





# R&S®ROMES4NPA: ANALYSIS AND EVALUATION OF NETWORK PROBLEMS

## Requirements

- ▶ R&S®ROMES4NPA (included in R&S®ROMES4 or standalone)
- ▶ R&S®ROMES4N11
- ▶ R&S®ROMES4N15
- ▶ R&S®ROMES4N17
- ▶ R&S®ROMES4N18
- ▶ R&S®ROMES4N19
- ▶ R&S®ROMES4N20
- ▶ R&S®ROMES4N21
- ▶ R&S®ROMES4N22
- ▶ R&S®ROMES4N23
- ▶ R&S®ROMES4N30
- ▶ R&S®ROMES4N31
- ▶ R&S®ROMES4N34

## Automatic detection, analysis and documentation of trouble spots

The sheer volume of recorded data makes individual and manual analysis impossible. The data (from R&S®ROMES4 or QP files, after conversion in the latter case) is therefore automatically analyzed by the R&S®ROMES4NPA network problem analyzer, which outputs a list of all detected trouble spots and displays them on a map using Google Maps, OpenStreetMap (OSM) or user-defined maps. R&S®ROMES4NPA also provides information about the cause of the problem.

## Sophisticated algorithms to support users

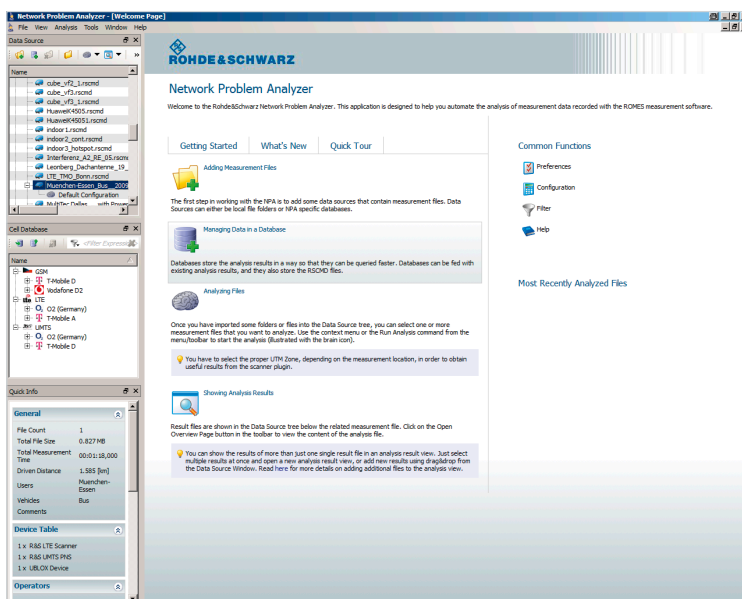
The easy-to-use interface guides the user through the process, from reading in the measured data (from one or more drive tests) and selecting the analysis criteria to retrieving the automatically generated list of trouble spots.

Right-clicking a problem automatically opens R&S®ROMES4 and positions the replay of the measurement file just ahead of the trouble spot in question so that the user can perform a detailed check if required. The result is displayed in HTML in a clear report that can be printed. An export to Excel allows easy data processing.

The measurement data is analyzed according to specific criteria that depend on the modules selected. In all modules, the analysis criteria can be adapted to user-specific limit values and settings.

The R&S®ROMES4NPA base package includes the following modules:

- ▶ NOA (network quality analyzer) for voice calls, base module including KPIs
- ▶ DQA (data quality analyzer) for PS data connections, base module including KPIs



Start screen of R&S®ROMES4NPA.

**Broad range of optional add-on modules for voice quality and data tests as well as coverage and neighborhood analysis**

**R&S®ROMES4N11**

**NQA for GSM/WCDMA/TETRA voice calls, expansion for problem spot detection**

This module enables analysis of voice calls for network problems, which can be selected from more than 140 different problem categories, and delivers a list of the problem spots including the type and cause of problem.

**R&S®ROMES4N15**

**Coverage module with display of coverage data on a raster map**

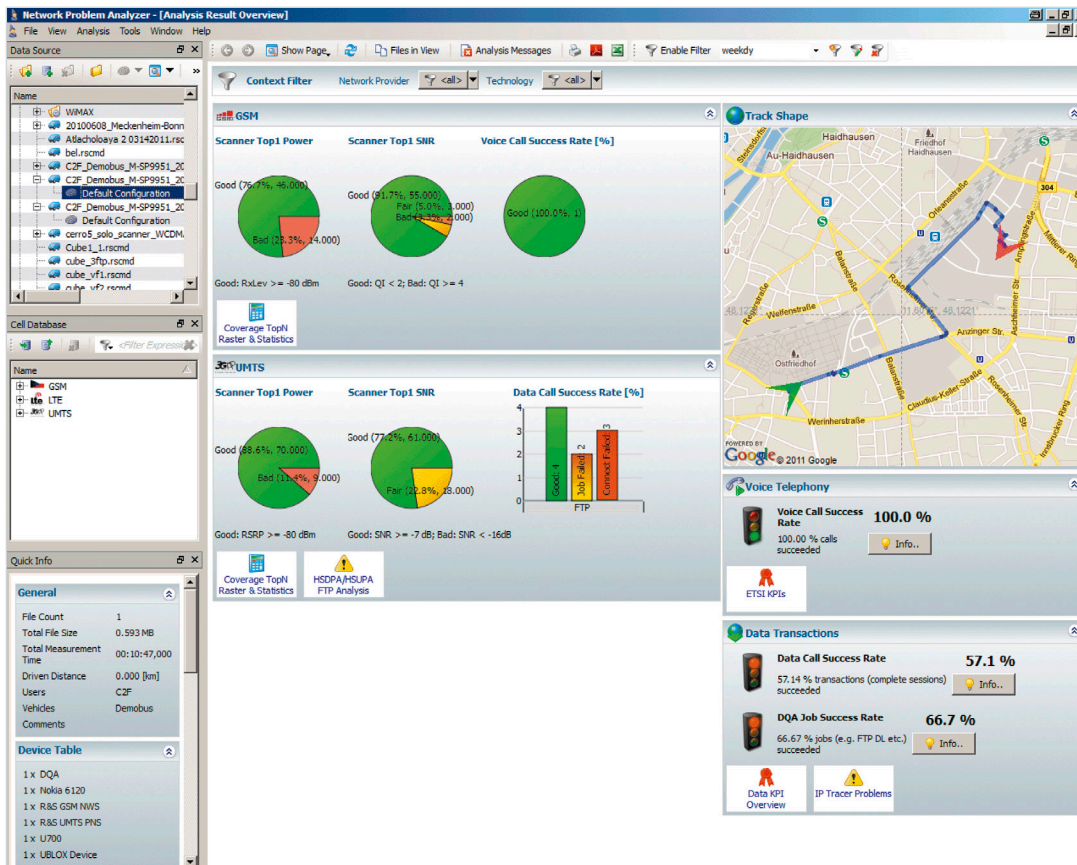
Coverage data (GSM, WCDMA, CDMA2000® 1xEV-DO, TETRA, LTE, LTE-M) measured with Rohde&Schwarz scanners is rasterized and displayed on a map using Google Maps or OpenStreetMap (OSM). This makes it easy to generate coverage plots and create and visualize overshooting problems. Optimizations can be checked using a before-and-after comparison.

**R&S®ROMES4N17**

**Neighborhood analysis module for automatic classification of neighborhood relationships into one of the following categories**

- ▶ (Potentially) missing neighbor: a cell with high signal strength and good quality (both thresholds can be set) has been measured but is not contained in the currently defined neighbors
- ▶ Unused neighbor: a cell is configured as a neighbor but has not been detected during measurement
- ▶ Approved neighbor: a cell has been classified as a (potentially) missing neighbor and is contained in the neighbor list. Analysis of intra-RAT handover in the network problem analyzer (NPA) is available for GSM, UMTS, LTE and TETRA. Inter-RAT handovers are currently limited to GSM and UMTS, but will soon be available for LTE as well.

Initial overview of scanner measurement content.



## R&S®ROMES4N18

Spectrum analysis module for automatic detection of strong transmitters in a spectrum thought to be empty

- ▶ Easy verification that a purchased spectrum is clear and that no other emitter still occupies part of that band
- ▶ Fast confirmation that part of a spectrum can be used for refarming purposes
- ▶ Reliable observation of power scan measurements, similar to a spectrum analyzer
- ▶ Automated and configurable (bandwidth, duration, power) analysis from potential narrowband and wideband interferers
- ▶ Detailed analysis by drilling down to the corresponding measurement file

## R&S®ROMES4N19

BTS evaluation – summary of key BTS parameters as acceptance criteria

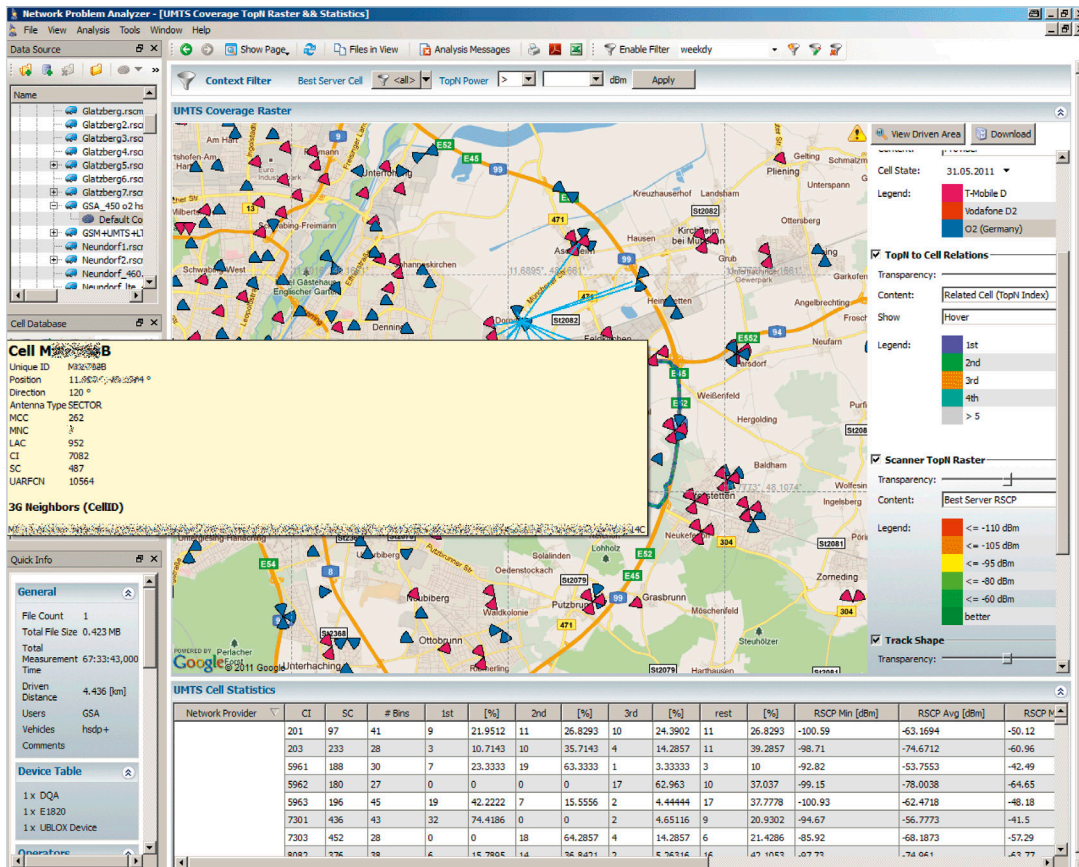
To ensure a consistently high degree of network quality, continual improvements must be made to the mobile network, such as updating the parameters for a mobile base station, replacing hardware or adding new base stations. Each time such improvements are made, the effects on neighboring base stations as well as the mobile network as a whole must be documented and evaluated. The BTS evaluation on the NPA performs these tasks reliably, quickly and cost-effectively.

## R&S®ROMES4N20

Data module for EDGE, HSPA+, LTE and LTE-M data links including problem spot detection

This module offers specific analysis of high-speed data links for achievable data rates and analysis of potential problems as well as an IP data analyzer for analyzing IP-based data traffic and associated problems. When IP-based data services are used, e.g. web browsing or email, this module analyzes the results and shows problem spots and their cause. A comprehensive collection of different analyses specifically designed for LTE is available.

Display of all neighbors of a cell.



## R&S®ROMES4N21

### Carrier aggregation analysis (downlink)

As the use of data is increasing exponentially, mobile networks need to provide higher-speed data links to their customers. When downlink carrier aggregation is used to provide this capability, this module analyzes the results and shows detailed information such as how many carriers are assigned to a mobile phone and its downlink and uplink throughputs. It also provides statistics (RSRP, RSRQ, etc.) for each carrier as well for investigation purposes.

## R&S®ROMES4N22

### VoLTE analysis

LTE is also increasingly used for voice transmission. IP-based telephony via VoLTE places higher demands on network quality because users have less tolerance for poor voice call quality, such as dropped calls, than they do for data calls. This module automatically analyzes SIP and layer 3 messages as well as call setup KPIs and spots problems if there are timing issues at the SIP level.

## R&S®ROMES4N23

### Carrier aggregation analysis (uplink)

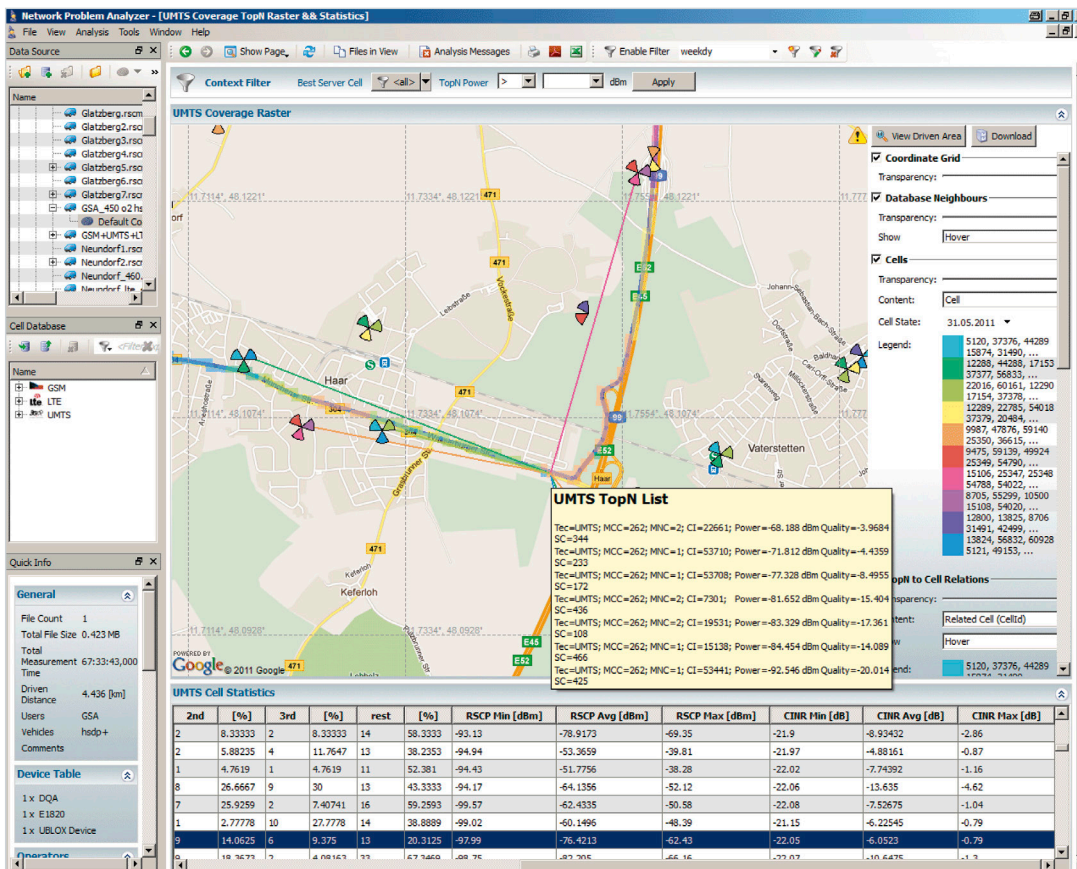
As the use of data is increasing exponentially, mobile networks need to provide higher-speed data links to their customers. When uplink carrier aggregation is used to provide this capability, this module analyzes the results and shows detailed information such as how many carriers a mobile phone uses in uplink as well as the uplink throughput and number of resource blocks used.

## R&S®ROMES4N30

### Delta and comparative analysis of R&S®ROMES4 measurement data

This add-on module enables quick comparison of measurement data, for example for visualizing the effects of an implemented network optimization. Measurement data from different cells, UEs or operators can also be compared for benchmarking.

Display of the cells providing coverage on the map.



## R&S®ROMES4N31

### LTE MIMO and downlink allocation analyzer

LTE MIMO analysis is performed based on the condition number (CN) and rank indicator (RI) values measured by the scanner. If mobile device data is available for the analysis, the efficiency per Hz or resource block is also included in the analysis. Any inconsistencies in the condition number, efficiency per resource block or condition number matrix are displayed as problem spots on the map and designated in tables.

The result analysis from the downlink allocation analyzer lists the cell throughput per TTI and operator as well as maximum and average cell throughput in a table and graphically.

## R&S®ROMES4N34

### NB-IoT analyzer

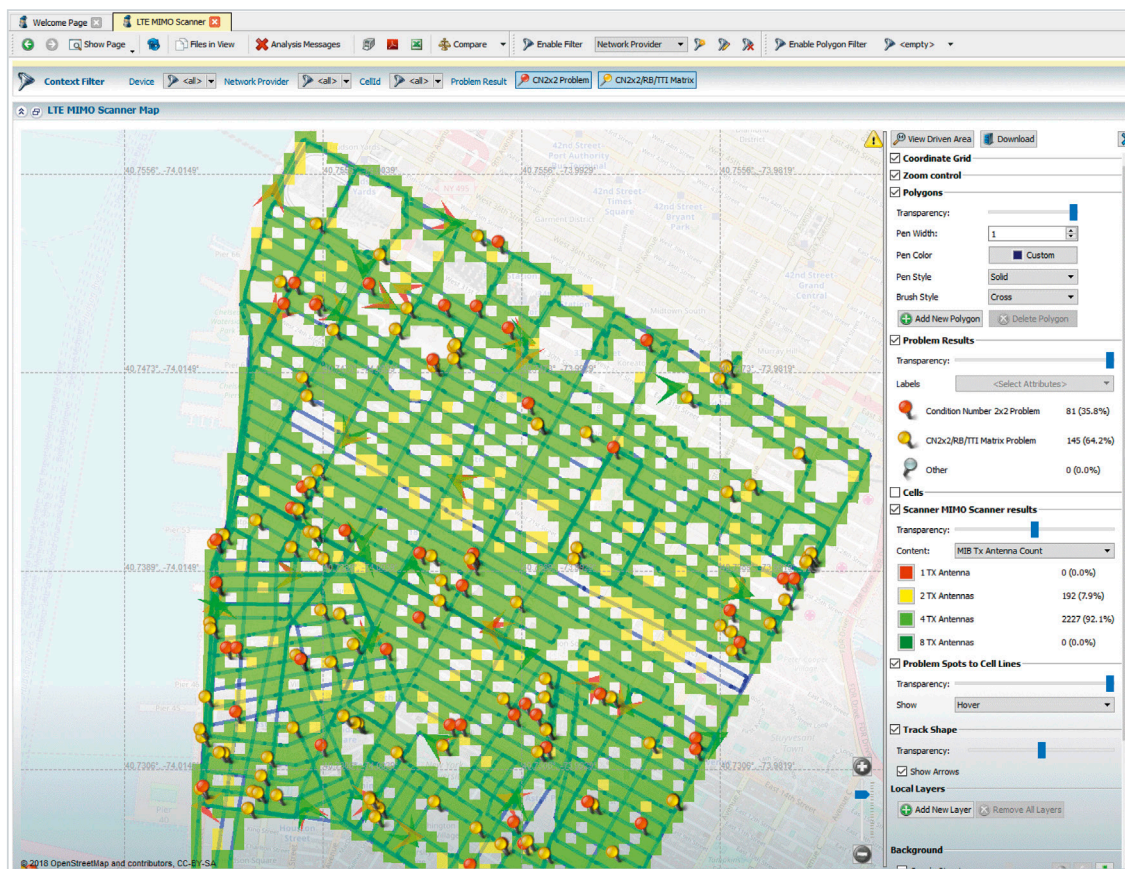
This module delivers dedicated coverage and problem spot reporting as well as cell statistics for NB-IoT analysis based on scanner measurements.

## R&S®ROMES4N35

### NB-IoT UE analyzer

This module delivers dedicated coverage and problem spot reporting as well as cell statistics for NB-IoT analysis based on UE measurements.

NPA analysis identifies LTE MIMO problems based on scanner and smartphone measurements.



### Comprehensive set of reporting functions

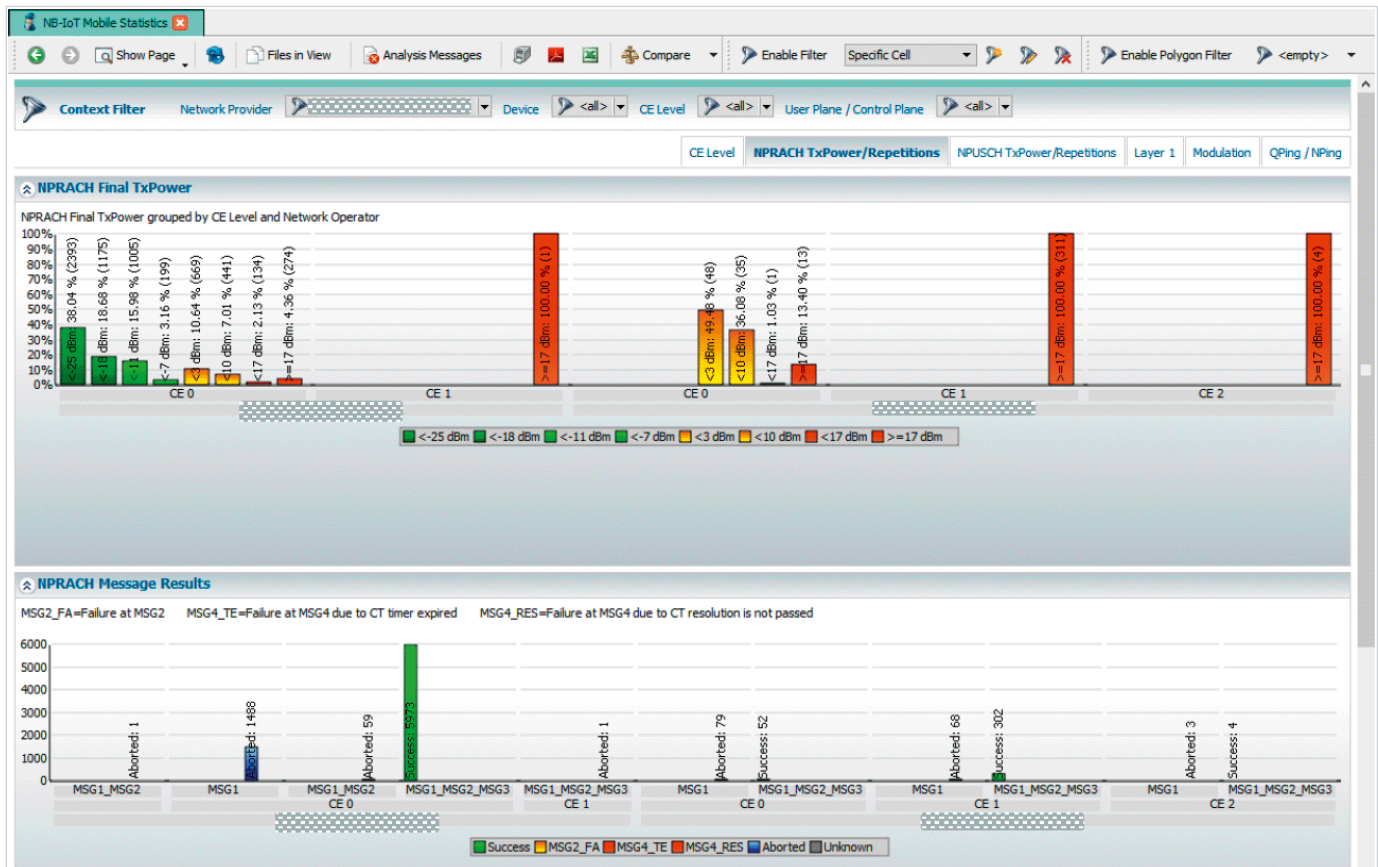
If multiple drive tests are selected, the user can draw statistical conclusions about quality in the measured areas. A comparison between various network operators in the same area is also possible (benchmarking).

A further way to evaluate analysis results in greater detail is to use sophisticated filter algorithms (e.g. for examining only one operator/one cell or only specific times or days of the week). The dynamic context filter algorithm makes this even easier and faster. For analyzing dedicated geographical areas, polygon filters can easily be drawn on the map. The result analysis and statistics are automatically tuned to the active filters.

Automated analysis with R&S®ROMES4NPA considerably saves time and reduces costs. Optimizing the results no longer requires time-consuming manual checks and analysis of data that may not even contain any problems.

R&S®ROMES4NPA uses sophisticated algorithms to help users find problem causes. More in-depth analyses can be performed at any time. A large amount of measured data can be automatically and quickly processed; reports (for management and for general documentation) are generated without requiring user interaction.

Random access statistics distributed on CE level as part of the analysis enabled by the NB-IoT analyzer.



LTE neighborhood analysis: map, list of the actual, possible and unused neighbors of several cells.

**Network Problem Analyzer - [LTE Neighbourhood Analysis]**

**Problem Spot Map**

**LTE TopN List**

Tec=LTE; MCC=262; MNC=3; CI=8962048; Physical CI=96 Power=-73.305 dBm Quality=-14.084  
 Tec=LTE; MCC=262; MNC=3; CI=8962049; Physical CI=97 Power=-92.181 dBm Quality=-28.391  
 Tec=LTE; MCC=262; MNC=3; CI=8962050; Physical CI=98 Power=-94.49 dBm Quality=-31.86

**Unused Neighbor**

Title: Configured Neighbor Tec=LTE; MCC=262; MNC=3; Physical CI=283 not measured  
 Description: Neighbor with ID Tec=LTE; MCC=262; MNC=3; Physical CI=283 was reported from the network as neighbor from cell Tec=LTE; MCC=262; MNC=3; CI=8962048, but has not been measured in the drivetest.  
 If a big area has been covered, this might indicate an superfluous neighbor relation. InCell Database Information:  
 \* Neighbor Cell Identification: Tec=LTE; MCC=262; MNC=3; CI=20712193  
 \* Distance between cell and neighbor is 15.5718 kilometers.

**Unused Neighbor**

Title: Configured Neighbor Tec=LTE; MCC=262; MNC=3; Physical CI=282 not measured  
 Description: Neighbor with ID Tec=LTE; MCC=262; MNC=3; Physical CI=282 was reported from the network as neighbor from cell Tec=LTE; MCC=262; MNC=3; CI=8962048, but has not been measured in the drivetest.  
 If a big area has been covered, this might indicate an superfluous neighbor relation. InCell Database Information:  
 \* Neighbor Cell Identification: Tec=LTE; MCC=262; MNC=3; CI=20712192  
 \* Distance between cell and neighbor is 15.5718 kilometers.

**Neighbourhood Overview**

Network Provider	Cell Identity	Cell Name	Nb CI	Nb Name	0	1	2	100.0 %	0	0	Result	
8962050	n/a	n/a	n/a	n/a	0	0	2	100.0 %	0	0	Not enough measurement data for this serving cell.	
					0	1	13	100.0 %	-76.701	-12.264	Green	SIB Neighbor - confirmed
					0	2	1	7.7 %	-84.088	-12.75	Green	SIB Neighbor - confirmed
					0	0	0	0.0 %			Blue	SIB Neighbor - but never measured
8962048	n/a	n/a	n/a	n/a	0	0	0	0.0 %			Blue	SIB Neighbor - but never measured
					0	0	0	0.0 %			Blue	SIB Neighbor - but never measured
					0	0	0	0.0 %			Blue	SIB Neighbor - but never measured

LTE handover analysis: map, KPIs and detailed list.

**Network Problem Analyzer - [LTE Handover Analysis]**

**Handover Statistics**

**Handover Success Rate** 100.0 %

100.00 % handovers completed

**Handover Setup Time Rate** 90.0 %

90.00 % handovers completed within 1s

**Handover List**

Network Provider	HO Type	HO Result	HO Duration [ms]	Source Cell Name	Source CI	Source PhyCI	Target Cell Name	Target CI	Target PhyCI	Start Time	End Time	Dis
Unknown		Complete	3281							10:40:55.095	10:40:58.376	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	48		8962048	96		8962050	96	10:40:59.580	10:40:59.628	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	15		8962050	98		8962048	96	10:41:01.252	10:41:01.267	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	48		8962048	96		8962050	96	10:41:02.393	10:41:02.441	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	46		8962050	98		8962048	96	10:41:04.143	10:41:04.189	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	49		8962048	96		8962050	98	10:41:05.392	10:41:05.441	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	2		8962050	98		8962048	96	10:41:07.142	10:41:07.144	0.00
Vodafone D2 (262; 2)	LTE->LTE	Complete	63		8962048	96		8962050	98	10:41:08.549	10:41:08.612	0.00

# SYSTEM CONFIGURATION FOR VARIOUS APPLICATION SCENARIOS

## R&S®FR4 Freerider 4 backpack

The R&S®FR4 Freerider 4 backpack is a compact, light-weight backpack for walk test and drive test campaigns. Supporting for up to 12 test mobile phones and high-performance scanner measurements (including 5G mmWave and LTE 4x4 MIMO), it is ideal for network optimization, benchmarking and cellular network analysis. Its benefits include the following:

### Well thought-out product design

#### Flexible design

The backpack can be operated from a tablet or laptop via Wi-Fi to control the measurement application running on a built-in PC (R&S®NCM2) or an R&S®TSMA6 scanner. A cabled LAN or USB connection is also possible via the integrated LAN switch or optional USB hub. With the R&S®FR4 Freerider 4, a complete and compact drive test system can be temporarily installed in a rental car, significantly reducing the setup time for measurement campaigns. The sturdy construction is shock and vibration proof in line with automotive standards and can be used in any vehicle type.

R&S®FR4-CORE with mounted mobile phones and scanner.



User-specific cabling.



## Maximum flexibility and future readiness

### Extensive test mobile support

The R&S®FR4 Freerider4 supports up to 12 test mobile phones, which can be charged via the optional, integrated USB hub.

### Scanner and technology support

The R&S®FR4 fully supports the R&S®TSMx scanner family as well as GSM, WCDMA, CDMA2000® 1xEV-DO, WiMAX™, LTE, NB-IoT, LTE-M, PowerScan RF, CW channel power scan and 5G NR. For the 5G NR mmWave bands, it offers a measurement bandwidth of up to 100 MHz. LTE MIMO measurements support up to 4x4 MIMO.

## Designed for the toughest environmental conditions

The system has been designed for indoor and outdoor use. Active ventilation with silent fans allows operation in hot climates. The coating protects the backpack against splash water ingress in rainy conditions, and the light color of the coating minimizes the impact of solar radiation.

### R&S®ROMES4 configurations

R&S®ROMES4 and the connected measuring equipment (test mobile phones, R&S®TSMx scanners, etc.) can also be used and delivered in the following configurations on request:

- ▶ User-specific cabling
- ▶ As a test suitcase
- ▶ As a turnkey test vehicle
- ▶ As a TETRA backpack solution based on the R&S®MNT-CORE2.



R&S®FR4-BP backpack.



Turnkey test vehicle.

## R&S®FR4 Freerider 4 specifications in brief

Environmental conditions		
Temperature	operating temperature range	0°C to +50°C
	permissible temperature range	-10°C to +55°C <sup>1)</sup>
	storage temperature range	-40°C to +55°C
Damp heat		+25°C/+55°C, < 95% relative humidity, cyclic, non-condensing, in line with EN60068-2-14
Connectors		<ul style="list-style-type: none"> <li>▶ power in</li> <li>▶ 5 × LAN</li> <li>▶ 16 × USB (optional)</li> </ul>
Power rating		
Supply voltage, DC		10 V to 19 V
Power consumption during operation	equipped with R&S®NCM2; 2 R&S®TSME6, 8 UEs performing a real measuring task	90 W (typ.)
Maximum inrush current		11 A at 19 V
Product conformity		
Electromagnetic compatibility	EU: in line with EMC directive 2004/108/EC	applied harmonized standards: <ul style="list-style-type: none"> <li>▶ EN 55032: 2012/EN 61326-1: 2006 (home location, class B)</li> <li>▶ EN 55024: 2010</li> <li>▶ EN 61000-6-2: 2005/EN 61326 (industrial location, class B)</li> </ul>
Electrical safety	EU: in line with directive 2014/35/EU	EN 61010-1
	USA	UL 61010-1
Dimensions	R&S®FR4-CORE (layer 1 and 2)	485 mm × 356 mm × 146 mm (19.1 in × 14.0 in × 5.7 in)
	R&S®FR4-CORE plus R&S®FR4-EXTEND (layer 1 to 3)	485 mm × 356 mm × 191 mm (19.1 in × 14.0 in × 7.5 in)
Weight	depends on installed devices	
	without devices/batteries, layer 1 and 2	approx. 3.2 kg (7.1 lb)
	without devices/batteries, layer 1 to 3	approx. 4.0 kg (8.8 lb)
	typical weight (1 × R&S®TSMA6 and 4 × test mobiles)	7.9 kg (17.4 lb)
R&S®FR4 Freerider 4 is optimized for the software applications R&S®ROMES4, SmartBenchmarker and R&S®NESTOR. Only one of them can be installed.		

<sup>1)</sup> The maximum operating temperature may be lowered by the maximum stable operating temperature of the installed UEs and devices.

# SYSTEM COMPONENTS

Technology	GSM driver	Qualcomm CDMA2000® 1xEV-DO driver	Exynos (Samsung) driver, Qualcomm driver	TETRA driver	Qualcomm/Samsung Exynos 5G UE drivers	Qualcomm IoT driver, Neul IoT driver	R&S®TSMIA driver, R&S®TSMIE driver, R&S®TSMIW driver	R&S®TSMIA6 driver, R&S®TSMIE6 driver
GSM/GPRS	•		•				•	•
EDGE	•		•				•	•
WCDMA Rel. 99			•				•	•
HSPA+			•				•	•
CDMA2000® 1xEV-DO		•					•	•
WiMAX™ IEEE802.16e							•	•
LTE			•				•	•
Spectrum							•	•
TETRA				•			•	•
NB-IoT						•	•	•
5G					•			•

A list of test mobile phones supported by R&S®ROMES4 is available separately.

# SYSTEM REQUIREMENTS

## Recommended

- ▶ Intel Core i7
- ▶ 16 Gbyte RAM for Windows 10, 64 bit
- ▶ 512 Gbyte SSD
- ▶ USB 3.0 and LAN ports
- ▶ Windows 10, 64 bit

# APPLICATION: TETRA

## Requirements

- ▶ R&S®TSMW or R&S®TSME/R&S®TSME6 or R&S®TSM/ R&S®TSM A6 scanner
- ▶ R&S®TSMW-K26 TETRA option for scanner
- ▶ R&S®ROMES4
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver
- ▶ R&S®ROMES4TET

R&S®ROMES4 is the software platform for measurements on the TETRA air interface. Statistics, analyses, troubleshooting for coverage, quality of service and handover behavior give network operators a complete overview of the network state and help them keep it in the best possible state.

The R&S®TSMW scanner, TETRA radios and other accessories are controlled by R&S®ROMES4. For such tasks, the following capabilities are indispensable:

- ▶ Mobility and speed – use in vehicles, helicopters and on foot
- ▶ Highly accurate coverage measurements on TETRA networks using a passive RF scanner
- ▶ Spectrum analysis for identifying interferers
- ▶ Measurement and identification of TETRA base stations
- ▶ Subsequent problem analysis – uncovers problems in the TETRA network and analyzes them based on the test data obtained with R&S®ROMES4

The R&S®TSME scanner, TETRA radios and other accessories controlled by R&S®ROMES4 in a backpack. The sound drivers are ASIO compatible.



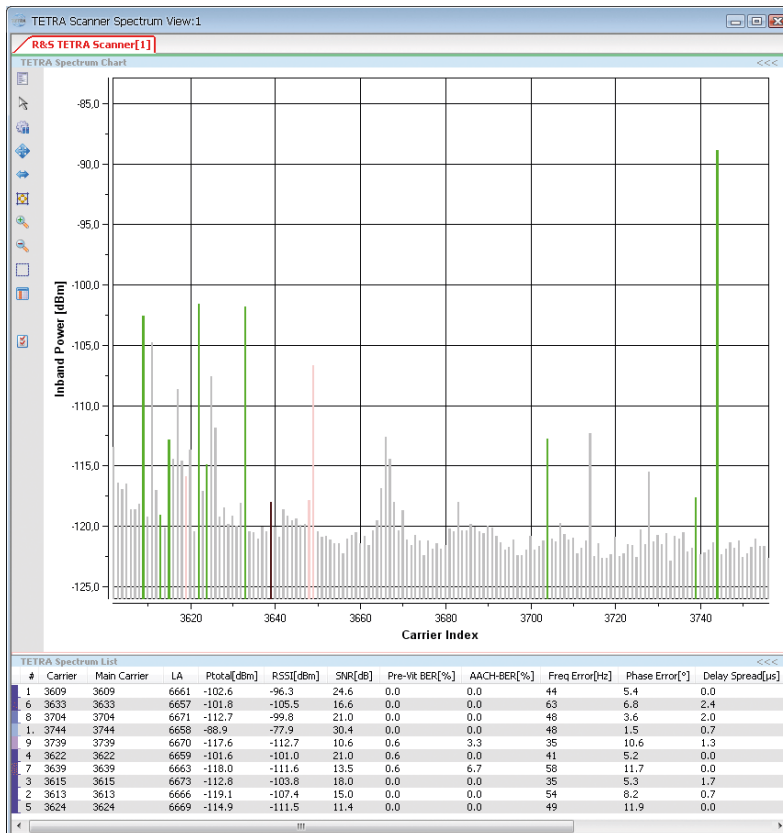
In the downlink, measurements performed using the R&S®TSMW in the D-CT and D-CTT operating modes include the following:

- ▶ 100 MHz to 1000 MHz frequency range, with parallel measurements of all channels in a 10 MHz block
- ▶ 25 kHz channel resolution (with QPSK)
- ▶ Automatic detection of the broadcast synchronization channel (BSCH)
- ▶ Up to 20 Hz measurement rate for carrier measurements of up to 2 × 600 channels simultaneously (10 MHz block, QPSK) with:
  - Channel number and frequency
  - Power of each base station
  - MCC, MNC, TN, FN, MFN
  - BER before Viterbi
  - AACH BER
  - Frequency error and phase error
  - SNR
  - Delay spread
  - In-band spectrum
  - Constellation diagram
  - BCH demodulation, incl. decoding of neighboring cells
  - Measurement of co-channel interference
  - Channel impulse response (channel sounder)

The R&S®ROMES4TET software option controls Sepura (latest Sepura SC20 also supported), EADS and Motorola radios via the standardized PEI interface to control calls and transfer data in order to emulate user behavior in the network and provide additional status information. This software option also provides layer 3 information for calculating KPIs of QoS measurements, including handover and neighborhood analysis.

The R&S®ROMES4NPA network problem analyzer completely supports analysis of TETRA QoS using R&S®ROMES4N11 and R&S®ROMES4N15 for coverage and interference and R&S®ROMES4N17 for handover and neighborhoods.

The TETRA spectrum scan displays all channels in a 10 MHz band.



# APPLICATION: LTE

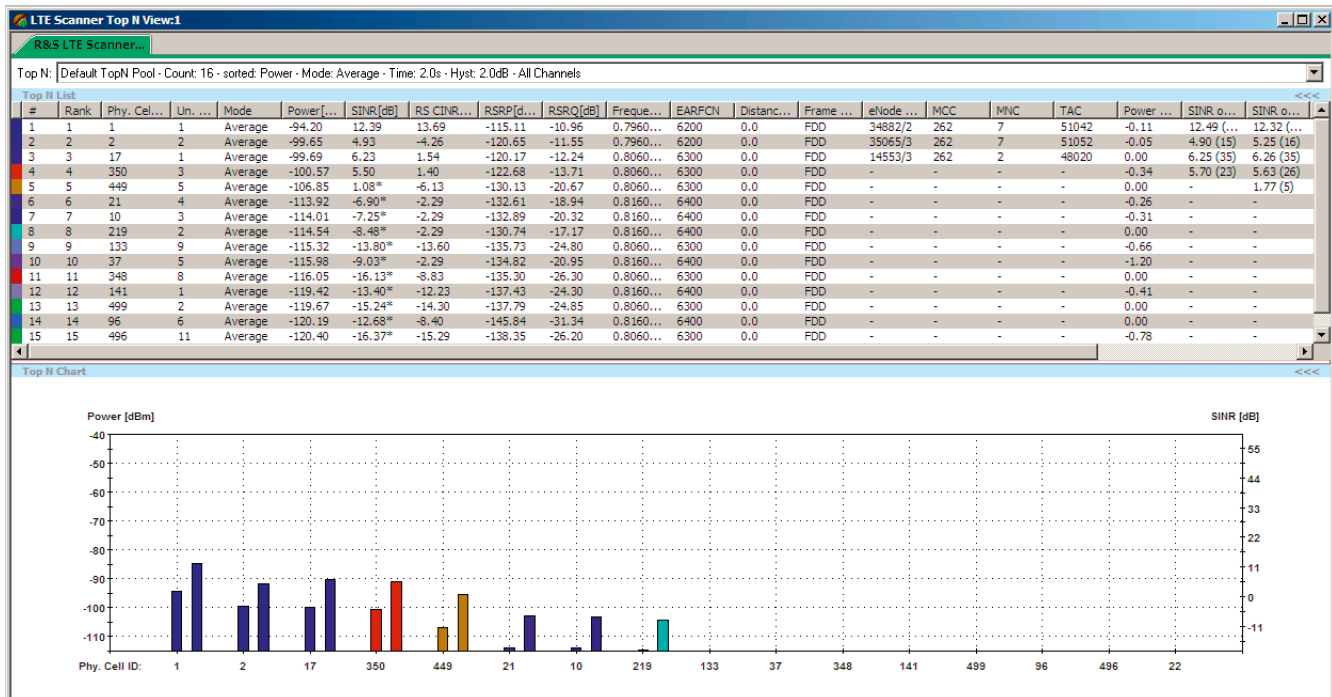
## Requirements

- ▶ R&S®ROMES4
- ▶ Chipset driver for connecting devices to R&S®ROMES4
- ▶ R&S®TSMW or R&S®TSME or R&S®TSMA scanner
- ▶ R&S®ROMES4T1W or R&S®ROMES4T1E scanner driver

## Coverage analysis with Rohde & Schwarz scanners

This essential analysis determines whether an LTE signal of sufficient strength is available at the test site. R&S®ROMES4 and TopN View can be used to clearly display the results and plot them on a map. For signal strength, the R&S®TSMW, R&S®TSME and R&S®TSMA scanners deliver the RSRP value or the power of the P-SYNC/S-SYNC signals. In addition to signal strength, the reference signal received quality (RSRQ) and the signal to interference plus noise ratio (RS-SINR) for each cell as well as the SINR for the SYNC signals are displayed. If one of these values is too low, this indicates interference, intermodulation or other types of disturbance. In this case, the R&S®TSMW/R&S®TSME/R&S®TSMA and R&S®ROMES4 offer a more detailed cause analysis.

TopN View shows eNodeB signals sorted by strength.



## Data throughput measurements with an LTE test mobile phone

R&S®ROMES4 collects scanner data and measurement data from a Qualcomm or Samsung LTE test mobile phone. One of the most important parameters is data throughput. If it is too low, the cause may be a low-order modulation format such as QPSK or the use of SISO rather than MIMO. A comparison with the scanner data permits further conclusions about possible causes. Interference, multipath propagation, handover failures or even weak network coverage might be the cause of error.

In addition to measuring data throughput, measurement data of layer 1 and layer 3 messages is recorded. Qualcomm or Samsung chipset based LTE mobile phones or data sticks display detailed information about individual data packages so that often a quick glance is enough to detect possible causes of error.

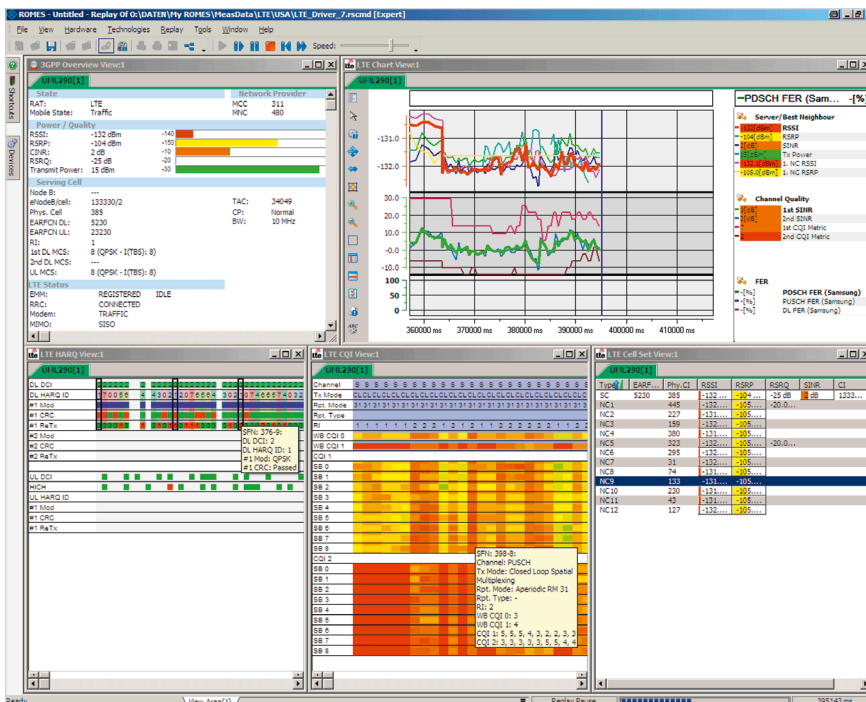
## VoLTE measurements

LTE is also increasingly used for voice transmission. IP-based telephony via VoLTE places higher demands on network quality because users have less tolerance for poor voice call quality, such as dropped calls, than they do for data calls. In addition to the normal chipset trace data, R&S®ROMES4 also supports output of the SIP signaling used for VoLTE. This makes it possible to collect voice KPIs for VoLTE and identify the cause of errors.

## Interference analysis

LTE is a single frequency network (SFN) that is identified by a reuse factor of 1. This means that neighboring cells use the same frequency ranges. Interference is therefore especially frequent and must be analyzed to the greatest possible extent to avoid capacity losses. This is a special challenge for T&M equipment because the interference can also affect the T&M equipment itself. The R&S®TSMW was developed specially for this task and features an impressive C/I value of  $-20$  dB. Even signals that are 20 dB weaker than the strongest noise can be measured, making it possible to identify interferers and reduce interference. The R&S®TSMW can also distinguish between signals that have the same physical cell ID but come from different eNodeBs. It makes no difference whether the measurement is performed in the FDD mode or in the TDD mode.

Display of measurement data from a Qualcomm chipset based LTE data stick.



## Cyclic prefix analysis

A special feature of the Rohde & Schwarz LTE drive test solution based on the R&S®TSMW, R&S®TSME and R&S®TSMA is the channel impulse response (CIR) measurement. This involves a channel measurement performed over a period of time. R&S®ROMES4 displays the multipath propagation of the signals – also referred to as echoes – in a power versus time diagram. As an OFDM standard, LTE has a defined frame length and a fixed guard interval, also referred to as a cyclic prefix. This value is necessary in order to wait for echoes in the receiver. A cyclic prefix that is too short or an echo that is too long can cause problems in the subsequent frames. This is referred to as intersymbol interference (ISI). The effect manifests itself in a low SINR. R&S®ROMES4 can measure the length of the cyclic prefix and match it against the multipath propagation. This enables the user to draw conclusions about how often multipath propagation disturbs the subsequent symbol, whether a longer cyclic prefix would be better and whether the network needs to be optimized, e.g. by adding eNodeBs.

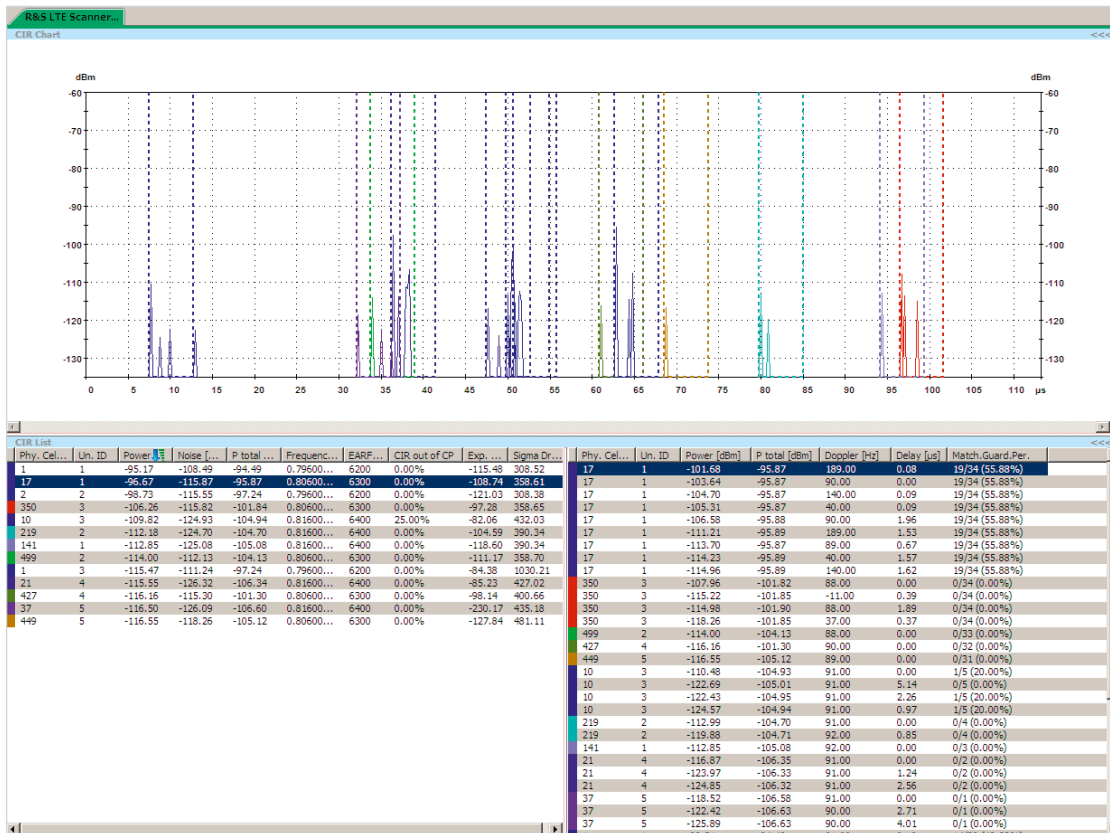
## Demodulation of eNodeB broadcast information

The R&S®TSMW, R&S®TSME and R&S®TSMA can scan LTE signals and demodulate broadcast signals. The broadcast information from previously detected eNodeBs is demodulated (MIB and SIBs) to learn more about the base station. Based on this information, the user knows the country, the network and the cell from which the received signal originates. Neighborhood relationships (intra-RAT and inter-RAT) and handover thresholds are also visible. All these values make it easier to classify the signals and detect problem spots.

## Subband measurements

The LTE wireless communications standard permits channel bandwidths of 1.4 MHz to 20 GHz. While the synchronization and broadcast information is contained within a bandwidth of approximately 1 MHz in the center of the LTE carrier, useful data is transmitted over the entire bandwidth. Narrowband interference outside the center of the carrier can be detected through subband measurements performed on the LTE scanner. The SINR of the reference signals is determined for every resource block (12 subcarriers corresponding to 180 kHz). R&S®ROMES4 graphically displays these values in a waterfall diagram. Interferers are visible as vertical lines in the diagram.

CIR View shows the channel impulse response (CIR) and all parts of the multipath propagation (echoes) together with a cell's cyclic prefix.

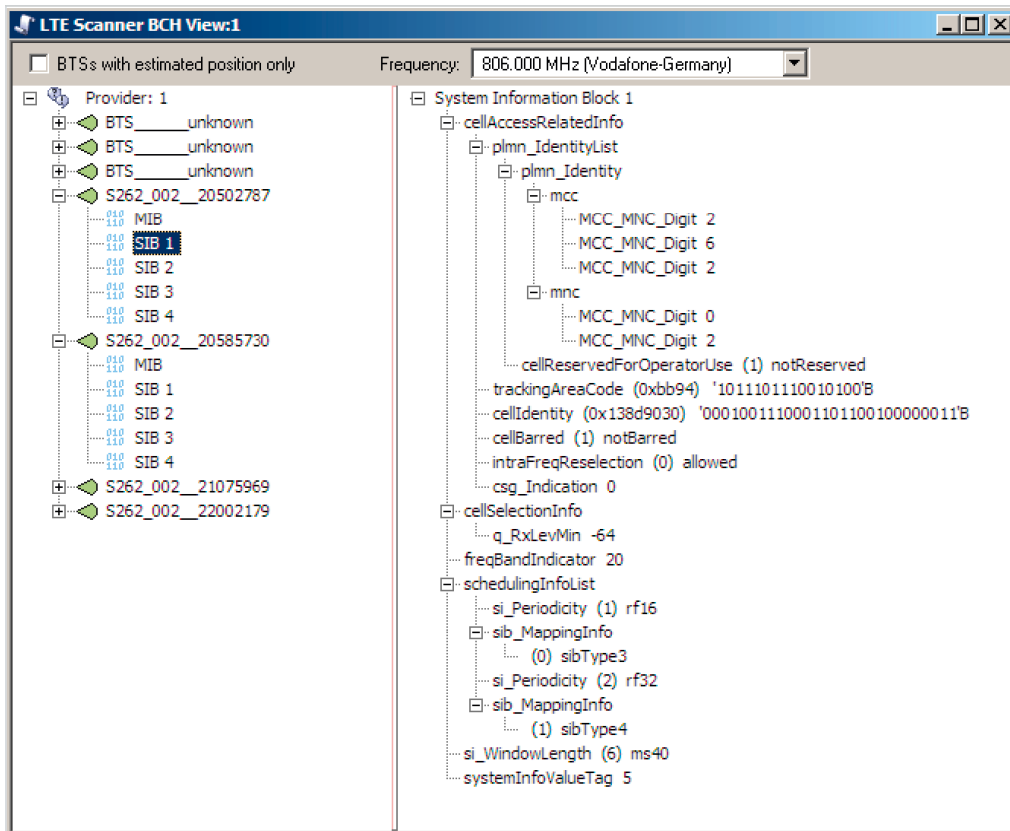




## MIMO measurements

MIMO plays an essential role in achieving high data rates in LTE networks. Ideally, using MIMO 2x2 will double the data rate and MIMO 4x4 will quadruple the data rate. Whether this is possible in each specific case depends on the characteristics of the radio channel. The characteristics can be measured using the R&S®TSMW for MIMO 2x2 or a set of R&S®TSMW for MIMO 2x2 and 4x4 together with the R&S®TSMW-K30 MIMO option. The scanner receives the eNodeB reference signals from all transmit antennas at its independent frontends. These signals are then used to determine the transmission matrix for the radio channel and the condition number. The condition number describes how effectively MIMO can be used. If the condition number is low, the radio channel is suited for MIMO. The MIMO and SINR measurements can be used to explain the data rates achieved with the test mobile phone.

Decoding LTE BCH information with the R&S®TSMW LTE scanner.



# RELATED PRODUCTS

## MOBILE NETWORK SCANNERS



- ▶ No limitation in 3GPP frequency bands up to 6 GHz (e.g. 5G NR, LTE, WCDMA, GSM, NB-IoT), including a multi-GNSS receiver for uninterrupted location tracking
- ▶ Integrated high-performance Intel i7 CPU based PC



- ▶ Multiband support from 350 MHz to 6 GHz
- ▶ GSM, WCDMA, LTE FDD, LTE TDD, CDMA2000® 1xEV-DO, TETRA, WiMAX™ and spectrum analysis simultaneously in one scanner



Parallel mmWave and sub-6 GHz measurements with a single scanner

### R&S®TSMA6 ultracompact drive test scanner

Combination of the technology of the R&S®TSME6 multitechnology network scanner with a high-performance Intel CPU based PC

The R&S®TSMA6 scanner supports the measurements of all supported technologies from 350 MHz to 6 GHz simultaneously. The future-proof architecture and in-field upgradability for both hardware and software allows up to MIMO 4x4 measurements and supports 5G NR technology requirements.

### R&S®TSME6 ultracompact drive test scanner

All bands, all technologies simultaneously, ready for the 5G NR standard

The R&S®TSME6 is designed for efficient drive and walk testing with a maximum degree of freedom and upgradability. With its ultracompact design, multiband and multitechnology support and readiness for the future 5G NR standard, the R&S®TSME6 is a state-of-the-art T&M instrument.

### R&S®TSME30DC and R&S®TSME44DC ultracompact downconverters

Ultra broadband RF frequency range for downconversion

(R&S®TSME30DC: 24 GHz to 30 GHz, R&S®TSME44DC: 24 GHz to 44 GHz)

The R&S®TSME30DC and R&S®TSME44DC are designed to easily upgrade the R&S®TSMx6 scanners to measure 5G NR signals in the mmWave frequency range. They perfectly extend the latest generation mobile network scanner family and provide all the features required for easy drive and walk testing. They are fully controlled by the R&S®TSMx6 and the corresponding software layers, which allows seamless, unattended operation.



- ▶ Multiband support from 350 MHz to 4.4 GHz
- ▶ Parallel GSM, WCDMA, LTE FDD, LTE TDD, CDMA2000® 1xEV-DO, TETRA, WiMAX™ measurements and spectrum analysis in one scanner
- ▶ Connects to Windows PC, Android UE or tablet

### R&S®TSMA autonomous mobile network scanner

Walk and drive testing with flexible connectivity

The compact R&S®TSMA autonomous mobile network scanner offers all the features required for drive and walk testing. WLAN or Bluetooth® connects the smartphones/tablets used for data collection. The autonomous mobile network scanner can also run comprehensive drive test software, such as R&S®ROMES4, on its built-in i5 processor. Multitechnology and multiband measurements provide full flexibility.



- ▶ Multiband support from 350 MHz to 4.4 GHz
- ▶ Parallel measurements of up to eight technologies in one scanner
- ▶ Compact, lightweight design

### R&S®TSME ultracompact drive test scanner

All bands, all technologies, simultaneously

The extremely compact R&S®TSME offers all the features required for mobile use. Multitechnology measurements and multiband support provide full flexibility and an optimal price/performance ratio for drive and walk tests.

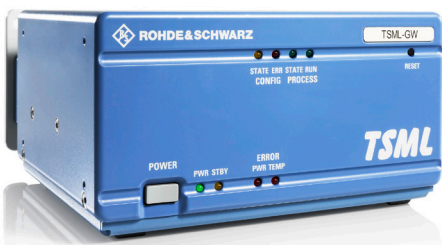


- ▶ User-definable input frequency range from 30 MHz to 6 GHz
- ▶ Parallel measurements in GSM, WCDMA, LTE, CDMA2000® 1xEV-DO, TETRA and WiMAX™ networks with the R&S®ROMES4 drive test software

### R&S®TSMW universal radio network analyzer

Scanner for drive tests and I/Q streaming

The R&S®TSMW universal radio network analyzer is a platform for optimizing all conventional wireless communications networks. Two frontends for any input frequency from 30 MHz to 6 GHz, pre-selection and software-defined architecture offer unsurpassed performance while providing maximum flexibility. In addition to functioning as a scanner for wireless communications networks, the R&S®TSMW is also an ideal digital I/Q baseband receiver.



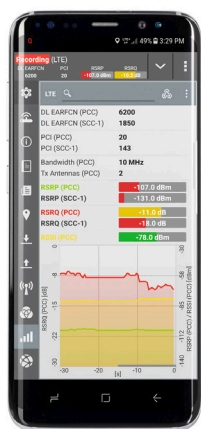
- ▶ Wideband receiver (80 MHz to 6 GHz)
- ▶ Support of distance triggered CW measurements

### R&S®TSML-CW radio network analyzer

Drive test scanner for CW measurements

The R&S®TSML-CW radio network analyzer is ideal for distance triggered CW measurements.

## TEST MOBILE



Rich set of service tests for voice quality, data, messaging and video quality to reflect the real end user experience.

### QualiPoc Android

Smartphone based product for optimizing mobile networks

QualiPoc Android is based on the latest commercial Android smartphones. It supports all mobile network technologies used worldwide, and covers multiple protocol layers as well as the IP stack in realtime. QualiPoc Android provides extensive test functions for voice, including MOS, data, video streaming and messaging tests to assess and reflect the real end user experience (QoS/QoE) within a mobile network.

## 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](http://www.rohde-schwarz.com)

## Mobile network testing

The company's broad and diverse product portfolio for mobile network testing addresses every test scenario in the network lifecycle – from base station installation to network acceptance and network benchmarking, from optimization and troubleshooting to interference hunting and spectrum analysis, from IP application awareness to QoS and QoE of voice, data, video and app based services.

[www.rohde-schwarz.com/mnt](http://www.rohde-schwarz.com/mnt)

## Rohde & Schwarz customer support

[www.rohde-schwarz.com/support](http://www.rohde-schwarz.com/support)

