Digicel

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06 December 2019

Mr. Charles Punaha
Chief Executive Officer
National Information & Communications Technology Authority
Punaha ICT Haus
Corner of Frangipani & Croton Streets
Hohola
(PO Box 8444 Boroko 111)
National Capital District

By Email & By Hand

Dear Mr. Punaha,

Consultant Paper – 2nd round submission on Draft Rule on Telecommunications Quality of Service Performance Monitoring

Digicel is pleased to review all the responses on the recent NICTA Public Consultation on the "Draft Rule on Telecommunications Quality of Service Performance Monitoring".

Please find enclosed Digicel's 2nd Submission to NICTA in response thereto.

We look forward to the next step in the consultation process. If you require any clarification or further information meantime, please let us know.

Yours faithfully
Digicel (PNG) Limited

Michael Henao
Head of Legal & Regulatory

DIGICEL (PNG) LIMITED

2nd Submission to NICTA

Consultation Paper on "Draft Rule on Telecommunications Quality of Service Performance Monitoring"

Friday, 06th December 2019

Contents

Executive Summary

Digicel welcomes this opportunity to review all the responses to the recent NICTA public consultation on "Draft Rule on Telecommunications Quality of Service Performance Monitoring" and to provide further comments and feedback on the responses from the other respondents.

Digicel is somewhat surprised at the low number of respondents to the public consultation which is very unusual. It is more the norm to have significant levels of response including submissions from commercial and business bodies as well as academic institutions and the like.

Two submissions have been reviewed:

i. the SPEEDCHECKER response, and
ii. the Bmobile response.

Digicel offers the following comments.

The Bmobile response is surprisingly brief and there is in fact little technical comment or details. Instead, bmobile appears to be primarily concerned about data confidentially, data collection techniques, how NICTA will make available its QOS findings to the public and whether its competitors will be able to access the bmobile data. There are also comments that data should be collected by surroundings in Papua New Guinea such as urban, mid-size, rural and Digicel agrees that this type of approach should be adopted.

The SPEEDCHECKER response appears to be a fairly standard sales approach which is tailored or personalised to represent relevant countries and any consultation processes underway in those countries.

SPEEDCHECKER proposes a crowd measurement approach to collecting data on the performance of networks and this data, in turn made, is available to the public via websites and other medium. While there are some merits to this approach, fixed networks are excluded. This crowd approach relies on apps running on smart phones which will be somewhat difficult in Papua New Guinea where just over 50% of subscribers have access to smart phones. Lastly, such crowd-based data collection has little relevance to network analysis and fault finding while it can also give conflicting results where there are significant differences, as there are in Papua New Guinea, between the coverage footprints of the various networks.

In its submission, Digicel proposed the appointment of a NICTA-appointed neutral 3rd party to measure and record the performance of the different ICT networks in Papua New Guinea and, in turn, analyse the findings. Digicel believes that such QOS data should be made publicly available in an appropriate and meaningful format so that existing and potential customers can make informed decisions on their network provider. Digicel would be more than happy to work with NICTA and other operators in Papua

New Guinea to agree a process to collect and analyse QOS data and then to publicly publish this in Papua New Guinea.

1. Introduction

Digicel welcomes this opportunity to review all the responses to the recent NICTA public consultation on "Draft Rule on Telecommunications Quality of Service Performance Monitoring" and to provide further comments and feedback on the responses from the other respondents.

2. Comments on Submissions by Other Respondents

Digicel is somewhat surprised at the low number of respondents to the public consultation which is very unusual. Its more the norm to have significant levels of response including submissions from commercial and business bodies as well as academic institutions etc.

Two submissions have been reviewed: (i) the SPEEDCHECKER Response and (ii) the bmobile response, and Digicel offers the following comments.

2.1 Bmobile

Bmobile have provided comments and feedback in four areas which concern the intended use of the QOS data, how the data is collected, confidentially of the data provided to NICTA and the proposed QOS parameters.

Digicel believes and expects that any data provided to NICTA will be processed and used in a professional and confidential manner. Digicel firmly believes that the results of any QOS exercise should be publicised in an appropriate and meaningful format so that existing and potential customers can make informed decisions on their network provider. Digicel would be more than happy to work with NICTA and other operators in Papua New Guinea to agree a process to collect and analyse QOS data in Papua New Guinea and then to publicly publish this in Papua New Guinea.

Any data provided to NICTA by the operators can be summarised and published in a meaningful and appropriate format.

Digicel proposed in its first submission that NICTA appoint a neutral 3rd party to undertake network trials in Papua New Guinea.

The data collection methodology is to be agreed between NICTA and the Papua New Guinean operators, but there are several well-known and documented methodologies in circulation elsewhere that can be adopted for Papua New Guinea. In its submission, Digicel provided some guidelines based on international best practices that can form the basis of any such discussions.

Bmobile has suggested that any data collection should be on a basis that accommodates the particular data collection environment such as urban areas, semi urban, rural. Digicel fully supports this suggestion. Given the real potential for the unique and challenging local conditions and environment in Papua New Guinea to impact upon network availability, Digicel believes that network availability performance should be collated on at least three separate bases i.e.:

- Urban,
- Semi-Urban, and
- Rural.

2.2 SPEEDCHECKER

The SPEEDCHECKER response promotes the use of crowd-based or crowd sourced network assessment via smartphone-based apps that, either automatically report on phone/user activity, or offer users a dashboard and the option to select responses. It does appear to be a stock or template type response which is personalised or tailored for different countries.

This crowd measurement approach will experience issues in Papua New Guinea as the smartphone penetration in Papua New Guinea is just over 50%. Without the smart phone population to support the measurement app, it is difficult to see how any measurements will be representative of the wider network. There is also the issue that, in Papua New Guinea, the majority of users are pre-paid and not post-paid with large bundled data plans. Within these large post-paid data plans, users are often more than happy to have background apps reporting etc but not with prepaid plans. Given the current data tariffs in Papua New Guinea it would be interesting to understand how users might react to being asked to allow their relatively expensive data packages to be used to provide free assessment of their network performance.

Another issue with crowd-based assessment relates to the actual networks and how similar they are. In Papua New Guinea, Digicel is clearly the market leader and all commentators put their market share at in excess of 90%. Digicel's service footprint is also significantly larger than that of any competitors. Given the Papua New Guinean networks are very dissimilar, crowd-based measurement can give rise to inconsistent results when comparing networks. So just how successful crowd-based assessment would be in Papua New Guinea remains doubtful.

Crowd-based assessment is good at capturing a high-level view of a network and is more associated with publicity, media use and marketing and being able to produce a glimpse of a network. However, this captured data does not lend itself to capturing network critical information needed to support detailed assessment and analysis of network performance. It is also possible that there are many variables or factors involved giving rise to random, unexplained, or unrepeatable results. After all, results are collected at random times, anywhere in the network, indoors, outdoors, in cars, as well as from a mixed population of handsets. There are also issues with crow sourced measurement processes properly collecting voice call data and voice traffic still accounts for significant levels of use on mobile networks.

Digicel does agree with SPEEDCHECKER's comments in section 4 on page 7 about data collection and the need to separate out performance by area or environment type such as Urban, semi Urban and Rural classifications. This was also highlighted in the bmobile submission.

As an alternative to crowd sourced data, controlled surveys using specialised measurement equipment, collecting hundreds of thousands of measurements using an established process or methodology will allow the collection of layer 3 messages as well as other critical network performance data. These measurement regimes are far more relevant to operators; they allow them to carefully monitor performance as well as any expansions and upgrades. These controlled surveys, using specialist measurement equipment, can also be used to capture voice quality data which allows MOS and POLQA analysis as well as voice performance data such as dropped calls, call setup failures etc.

Controlled surveys have a significant cost overhead, but the benefits can outweigh the costs and allow operators and regulators to gain clear insights into network performance. It is also possible to summarise results to support publicity campaigns and subscriber awareness programs.

Digicel would welcome the opportunity to co-operate with NICTA and the other Papua New Guinean operators to further discuss controlled surveys and how they can be used in the country. Perhaps NICTA can sponsor a neutral controlled survey approach using agreed methodologies similar to those outlined in Digicel's first response. Survey locations can be agreed as well as drive routes. In this way, all networks are assessed in a similar way, using the same metrics and processes and definitions giving rise to true comparisons which will in turn educate and inform subscribers in Papua New Guinea.

Should NICTA be interested, a sample of a regulator-published report on network performance using crowd sourced data from the regulator in the United Kingdom, OFCOM, is *attached* herewith.

Also *attached* is a product description for the Rohde and Schwarz Romes suite which is a state-of-the-art RF test and network evaluation platform and used worldwide in many network evaluation programs.

Lastly, a document describing the methodology adopted in the United Kingdom for controlled tests is *attached* for NICTA's information and consideration.

3. Summary

Like Bmobile and SPEEDCHECKER, Digicel agrees that all data should be collected in a way that allows data for urban, semi urban and rural areas is collected separately. This will ensure the unique challenges of providing mobile phone service in Papua New Guinea is properly captured.

Digicel does not believe that crowd sourced data measurement is appropriate for Papua New Guinea at this time due to the limited number of smartphones in the country capable of running crowd apps. The very significant differences in the extent of the various networks in Papua New Guinea may give rise to erroneous results which will be confusing to the people of Papua New Guinea, and issues with subscribers being asked to subsidised the costs of running an app form their data bundles.

Instead, Digicel believes that a regular NICTA sponsored and organised controlled survey, perhaps twice per year be implemented in Papua New Guinea. The various operators should be encouraged to cooperate on the adoption of an agreed Survey methodology to include road tests and static tests covering voice, texts and data and in such a way that the resulting measurements and data can be used by the networks for network optimisation activities. The parties to the controlled test scan then agree on how best to publish summaries of the collected data and its analysis to best give a picture of network performance and quality of service in Papua New Guinea.

Ofcom
making communications work
for everyone

Mobile matters

Researching people's experience of using Android mobile services

Published 10 October 2019

Welsh summary available: Materion symudol

Overview

Ofcom has researched consumers' behaviour and experience of using mobile services in the UK by analysing crowdsourced data collected from Android[1] devices[2]. The dataset was licensed to Ofcom by network benchmarking specialists P3, and contains information relating to mobile end-user experience and the performance of the networks to which people are connected.

In this report we publish findings from data collected between 1 January and 31 March 2019. We report on a range of metrics, including the share of connections across network technologies, data service availability, response time and usage patterns throughout the day, and how these vary by factors such as location, network technology, day of week and time of day.

This research is part of a wider programme of work by Ofcom to research and provide information about mobile quality of service. The data in this report relate to performance when network coverage is available from an operator, while Ofcom's broadband and mobile checker app provides detailed information about mobile coverage from all four mobile networks across the UK.

What we have found

We found that just over two-thirds of the time (69%), people were connected to wifi rather than cellular networks when using their mobile devices. When they were connected to cellular networks (2G, 3G, 4G), 82% of the time was spent connected to 4G. This varied depending on where people were and which mobile network they used. People in urban areas were more likely to be connected using wifi – and in turn 4G – than those in rural areas, which can be attributed to the greater access to wifi in offices and public spaces, and higher availability of 4G networks in urban areas.

But often a connection is not enough: the majority of mobile apps need access to data services in order to provide full functionality. Our analysis shows that when people were connected to 4G networks, they were able to use data services on average 98.8% of the time. This average was lower for 3G connections, which were nearly four times more likely to fail than 4G connections. Throughout the day the proportion of tests that failed on both 3G and 4G remained constant, despite more people connecting to the network during peak times.

One thing that did vary significantly throughout the day was consumers' data use. The proportion of data used on cellular networks peaked between 5 and 6pm, when people were likely to be travelling home from work, while the proportion of wifi use was higher between 6 and 10pm when they were more likely to be at home and have access to wifi.

[1] The operating system used on iPhones (iOS) has restrictions on apps running in the background and being able to access network performance data. Therefore, data collection on iPhone devices is currently not available.
[2] Including mobile phones, tablets and other Android devices with a SIM card.

The amount of data used over wifi was much higher than on mobile technologies; only 10% of people used more than 5GB of mobile data on average each month, compared to 47% on wifi. Just under half of people used less than 500MB of mobile data each month.

Mobile calls remain an important means of communication for many people, with our crowdsourced data showing that only six per cent of people did not make a call during the three-month fieldwork period. For the 94% of panellists who did, almost a third made more than 50 calls per month. However, calls were fairly short on average; over eighty per cent of calls were shorter than five minutes, with the majority of these under ninety seconds, indicating that people are making frequent but relatively short calls.

Contents

Introduction

Purpose of the research

With growing demand for continuous connectivity, people expect to be able to access online services whenever and wherever they are. Seamless movement between wireless networks, the availability of internet services, data and call allowances are all important factors that affect our expectations and experience of using mobile networks. The data analysed in this research give vital information about this experience across the UK, which helps inform Ofcom's policy making.

In May 2018, we published our second Consumer Mobile Experience Report, based on data collected via an Ofcom-branded app installed on around 5,300 Android smartphones. This app was discontinued in July 2018 and we have since licensed a dataset from P3, an independent company specialising in crowdsourced data collection[3] and international network benchmarking. The objectives of discontinuing the app and using this larger dataset were to gain deeper insight into mobile network performance across the UK and how this varies by a number of factors, including geography, time of day and technology used, and also to gain greater insight into consumers' use of Android devices.

Notes on the data included in this report

The upfront metrics in this report – network share and data service availability – are based on tests run while the phone is connected to a network. These tests are run on the highest data network technology at the time, as determined by the device, and recorded as either successful or unsuccessful. We are consequently unable to state whether unsuccessful tests would have succeeded on a lower data network technology, so 3G and 2G data service availability may be underestimated. The metrics do not represent a measure of overall network coverage, as they only reflect data availability when the phone is connected to a network, and because the levels of service quality we use to measure coverage cannot be guaranteed.

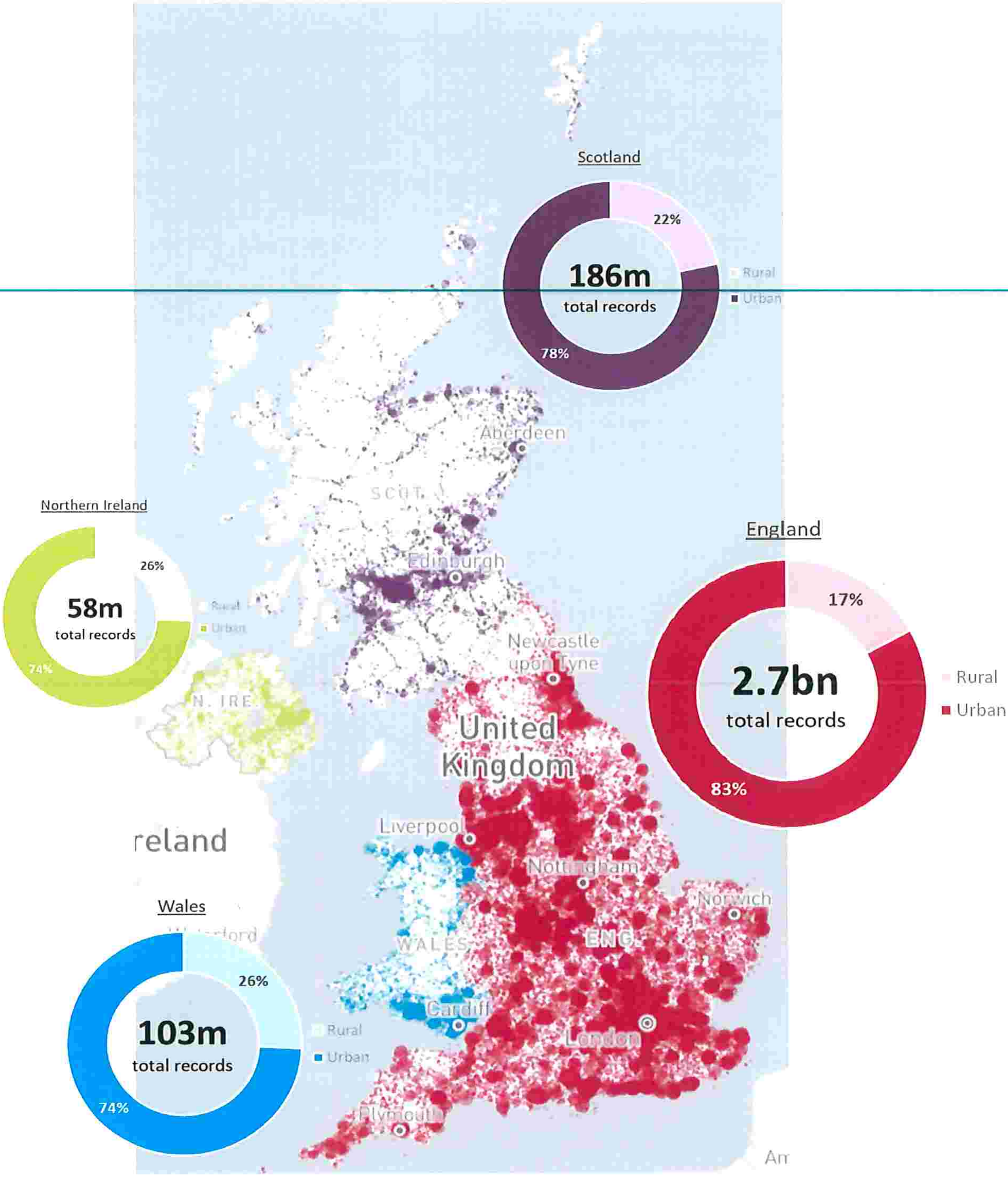
All analysis is conducted at the wholesale mobile network provider (MNO) level. References to the performance of the four MNOs (EE, O2, Three, Vodafone) may also include the performance of panellists who are customers of mobile virtual network operators such as Tesco Mobile, GiffGaff and Virgin Mobile.

The analysed metrics are only some of the factors that people may wish to consider when making decisions about their mobile service. Price, handset type, quality of customer service, coverage and contract terms are other relevant aspects that should be taken into account.

[3] Crowdsourcing is the use of data from a large number of people and, in this particular case, their mobile devices. These data are automatically collected and made available for analysis.

Outline of crowdsourced data

The findings in this report are based on analysis of a dataset containing more than 3 billion records generated from about 150,000 Android device users over a three-month period. The spread of these records across the nations and regions is a good indicator of where mobile users were living, working and travelling in the UK during the data collection period.



For a more detailed description of the data collection and analysis, please see Annex 1: Technical Methodology and Annex 2: Statistical Methodology.

Network share

What is network share?

This metric provides an overall picture of how people are connecting to wireless networks, wherever they are, with their Android mobile devices. More information on how this is measured is available in Annex 1: Technical Methodology, and breakdowns of the data can be found in our interactive report.

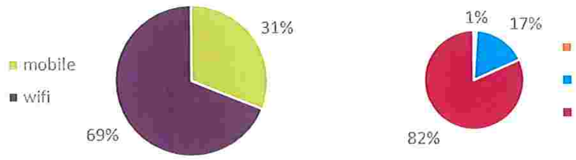
How people connect to networks

Two-thirds of the time, people were connected to wifi rather than to a cellular network (2G, 3G or 4G). This varied significantly by location and network operator. People in urban areas were more likely than those in rural areas to be connected to wifi, which is probably due to greater access to wifi in offices and public spaces. However, the majority of daily wifi use is during the evenings, when people are more likely to be using it at home. Similarly, wifi share was higher at the weekends, when people tend to spend more time at home, than during the week.

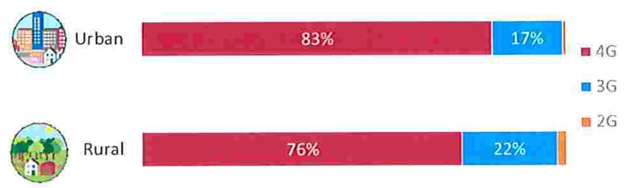
For connections made via cellular networks only, the data show that people were connected to 4G 82% of the time, with most of the rest spent on 3G (17% compared to 1% on 2G[4]). This varied by rurality; people in urban areas were connected to 4G for 83% of the time as opposed to 76% for those in rural areas.

Panellists using the EE network spent the highest proportion of time connected to 4G (90%), while those using the Three network spent less time on 4G (78%) and more time connected to 3G (22%) than those using either EE, O2 or Vodafone. This is likely to be related to a combination of 4G network coverage and network management. For many activities, such as reading the news or browsing social media, the performance of a 3G connection can be as good as a 4G connection, and operators may revert consumers to a 3G connection in weaker signal areas to provide a better connection or to more efficiently manage their network and ensure a good connection experience for as many people as possible.

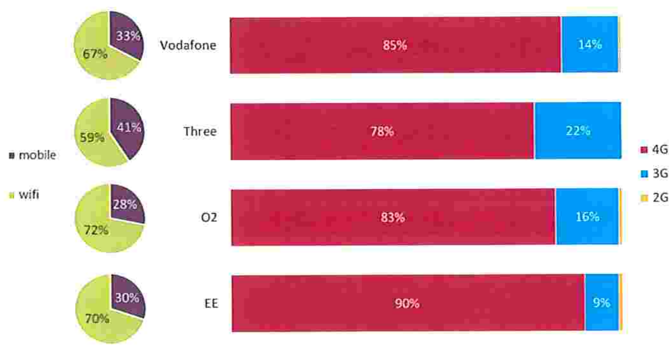
Average network share by network technology



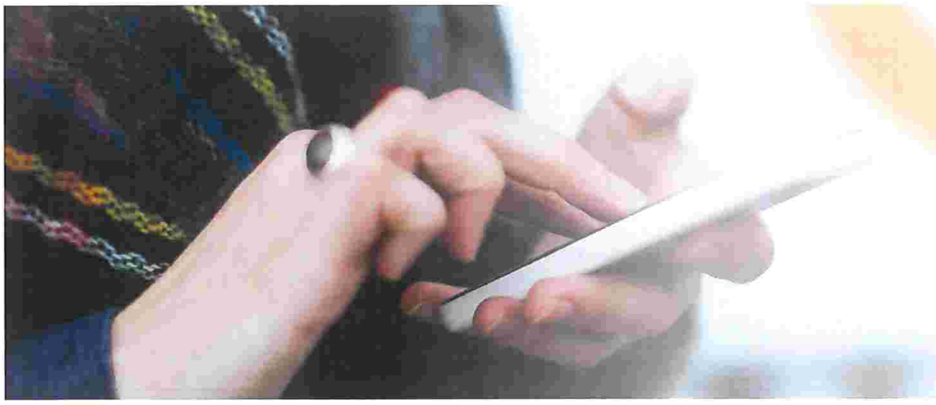
Average mobile network share by rurality



Average network share by mobile network



[4] Figures rounded to nearest whole percentage

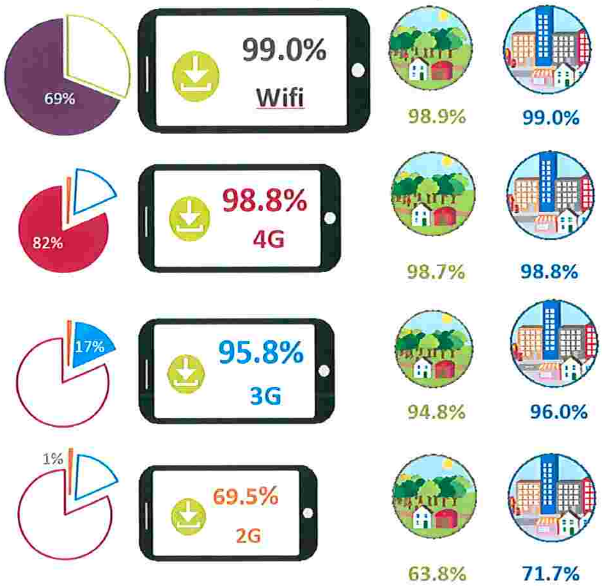


Data service availability

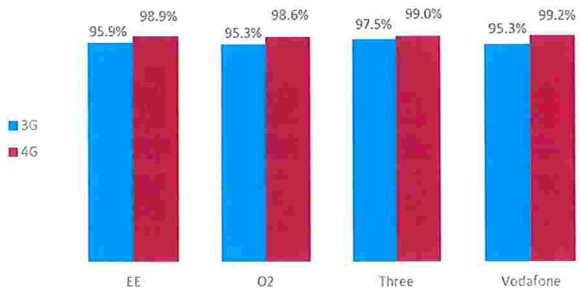
What is data service availability?

With mobile phones increasingly important for everyday tasks like checking emails, reading the news and paying for groceries, people rely on being able to connect to data services wherever they are. This metric shows the proportion of times people successfully access data services while connected to a network. It is not a measure of coverage, but shows how well demand for data services was satisfied when a network was available. More information on how this is measured is available in Annex 1: Technical Methodology, and breakdowns of the data can be found in our interactive report.

Average data service availability, by technology and rurality



Average data service availability, by mobile technology and mobile network



When people can use data services

The data collected reveals how often people could access data services when they were using their Android mobile devices and connected to a network. On average, people could use data services on 4G networks 98.8% of the time, with no significant difference by nation or rurality. This was almost identical to the 99.0% average success rate for wifi connections.

Success rate was lower on average for 3G connections, with consumers able to access data services on average 95.8% of the time. However, it is important to note that these connections are more likely to be at the 'edge' of a network where a reliable 4G connection is not available. The same is true of 2G connections, which represented less than 1% of the total mobile records.

There were no significant differences in 4G data service availability by mobile network, but 3G connections on the Three network were more likely to succeed than those on other mobile networks.

Response time

What is response time?

Response time, referred to technically as latency, is a measure of how quickly a request for data is processed and the information sent back to the user. A connection with low latency will 'feel' more responsive and give a better experience for certain mobile activities, such as web browsing or video calling. Full breakdowns of the data can be found in our interactive report.

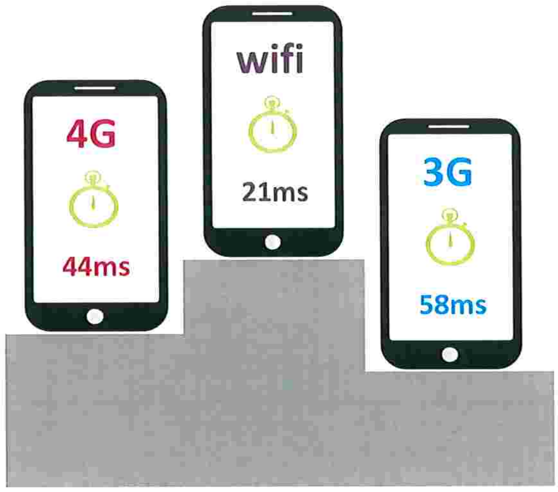
How quickly networks respond to data requests

Measured in milliseconds, the time it takes the network to respond to data requests – for example to load a web page or stream a video – can have a noticeable impact on user experience. In general, most mobile activities need a network response time under 100ms to provide a good experience, although some will perform satisfactorily with a slower response time.

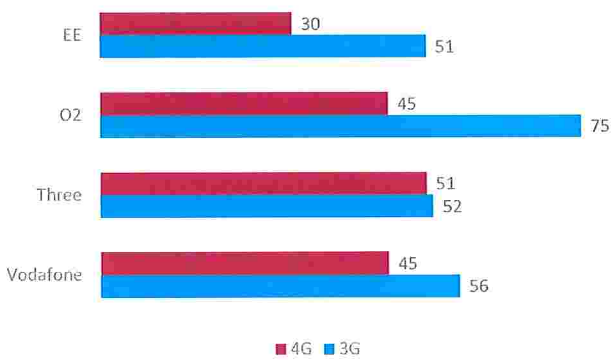
On average, wifi connections were more than twice as responsive as 4G connections, with no significant differences by rurality. Average response time on 3G networks were higher, with significant differences by rurality (62ms in rural vs. 57ms in urban areas). Looking at the data by nation, connections in England were the most responsive, while those in Northern Ireland were the least, on both 4G and 3G networks.

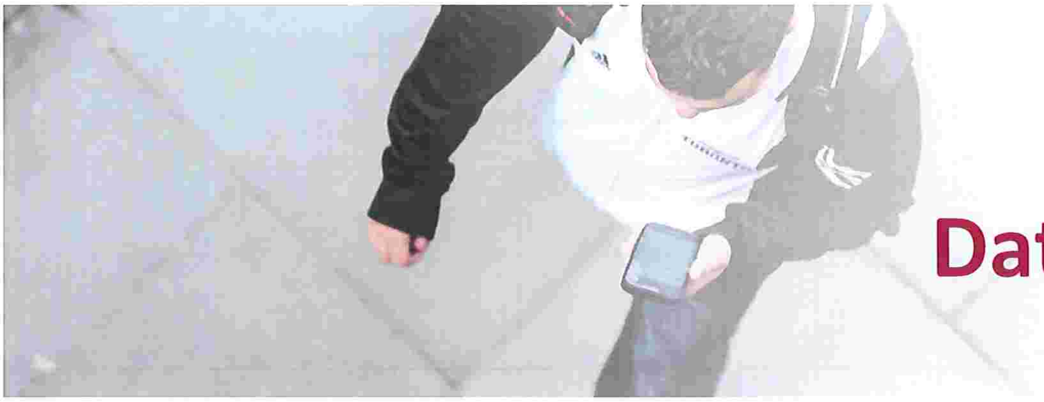
4G connections were fastest on the EE network and slowest on the Three network, while 3G connections were the least responsive on the O2 network.

Average response time (ms) by technology



Average response time (ms) by mobile network and network technology





Data use

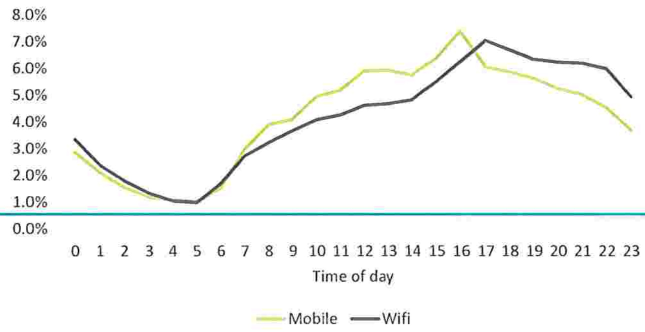
How people are using data

Our research shows that data use on mobile and wifi technologies increased steadily through the day from around 6am. The proportion of data used on cellular networks peaked between 5 and 6pm, when people were likely to be travelling home from work, while the proportion of wifi use was higher between 6 and 10pm when people were connected at home.

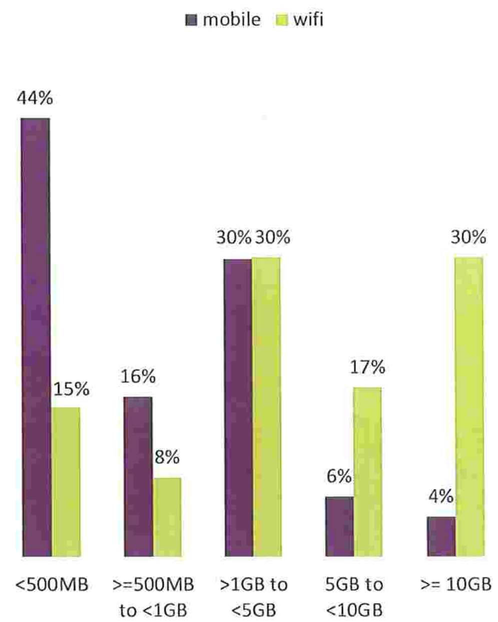
Average monthly data consumption varied significantly between panellists. Forty-four per cent of people used less than 500MB of mobile data per month, while only 10% of people used 5GB or more.

As expected, given our data on the time spent on different networks, average data use on wifi was much higher than on mobile technologies. People may also do their more data-heavy mobile activities on wifi due to their limited mobile data allowance, or lack of information on how much data certain activities use. The proportion of people with monthly data use over 5GB was almost five times higher on wifi than on mobile technologies, while the proportion of those using less than 500MB dropped by two-thirds to just 15% on wifi.

Proportion of data traffic by time of day and network technology

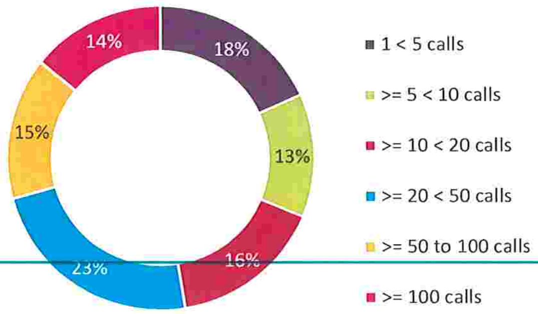


Proportion of average monthly data use per person by network technology

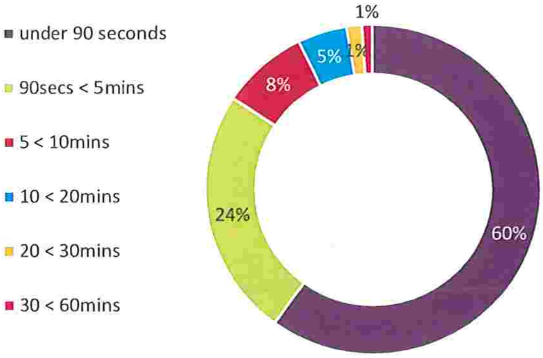


Voice call use

Proportion of average monthly calls made per person



Proportion of calls by average call length



Average call duration by city (mins:secs)

How people are using voice calls

Mobile voice calls remain an important means of communication for most consumers. Our crowdsourced data showed that 94% of panellists made a call during the three months of the fieldwork period, and 96% of panellists made or received a call.

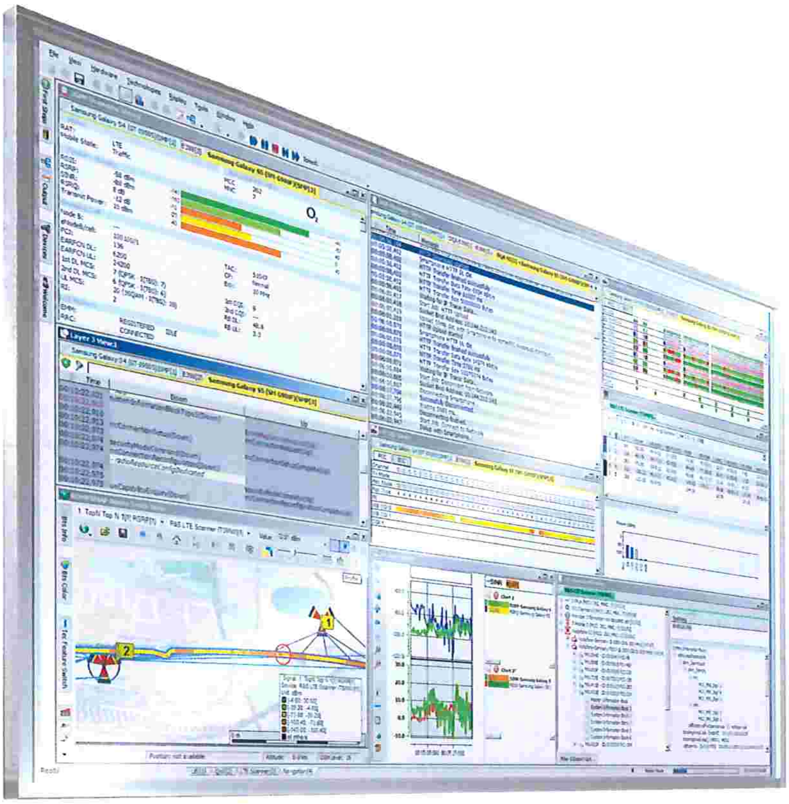
The average number of outgoing calls each month varied greatly from person to person. Of those who made calls, just under a fifth made between one and five calls on average each month, meaning 24% made five or fewer calls a month. In contrast, almost a third of those who made calls made more than 50 calls per month.

However, looking at the length of these calls shows a very different picture. More than 80% of calls were shorter than five minutes, with 60% under ninety seconds, suggesting that mobile users are making frequent but relatively short calls.

The average outgoing call lasted just over four and a half minutes, with significant differences by nation, rurality and day of week. People in rural Scotland spent longer on calls than those in other rural areas, while those rural Northern Ireland had the shortest average call length overall at just over three minutes. Calls in Liverpool lasted longer than those in other cities in the dataset, at an average of just under seven minutes. Weekend calls were slightly longer on average than weekday calls, at just under five minutes compared to four and a half minutes.

R&S®ROMES4 Drive Test Software

Mobile coverage and QoS measurements in mobile networks



Product Brochure | Version 18.00

ROHDE&SCHWARZ
Mobile Network Testing

R&S®ROMES4 Drive Test Software

At a glance

The R&S®ROMES4 drive test software, the unique scanner and network problem analyzer (NPA) tool from Rohde & Schwarz, provides an all-in-one solution for network analysis and optimization.

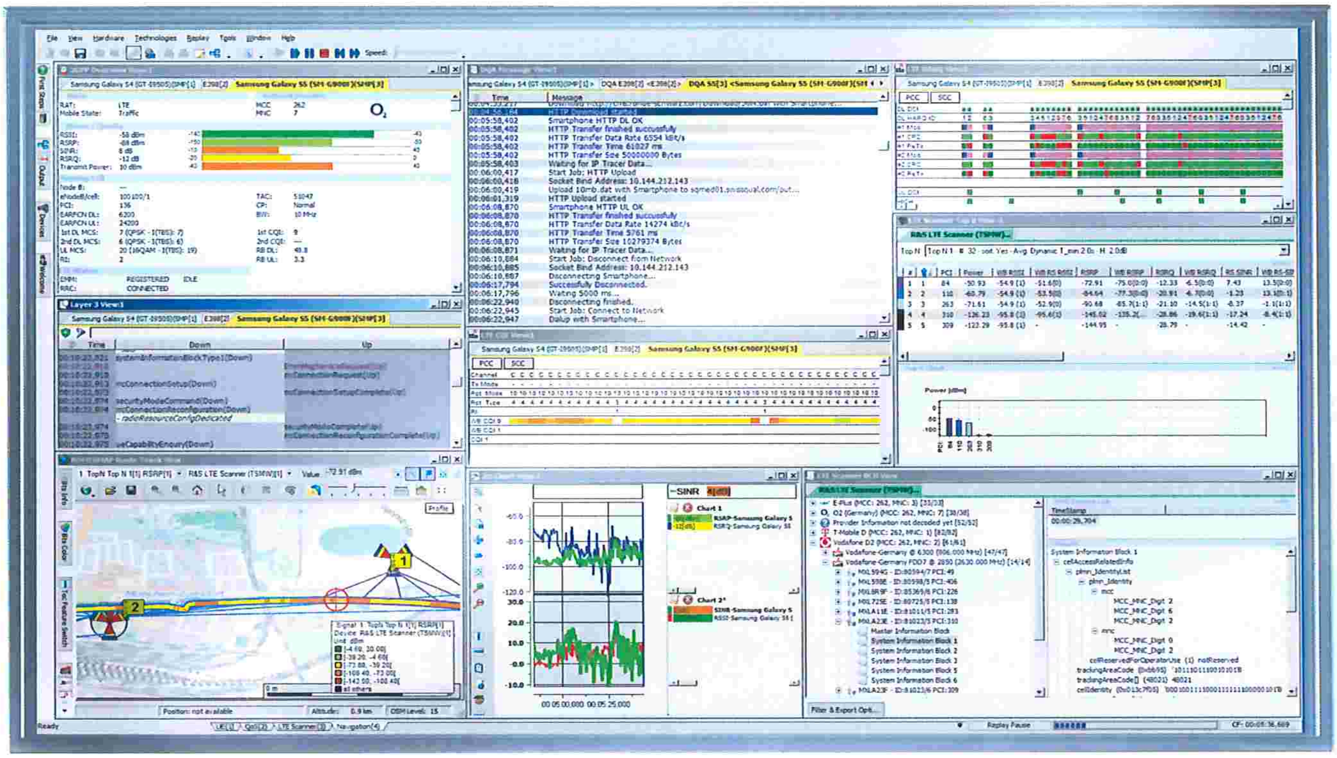
Universal software platform

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 7/10 (64 bit) PC.

Straightforward R&S®ROMES4 drive test software user interface



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.

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

R&S®ROMES4 Drive Test Software Benefits and key features

Easy operation and high flexibility
- Easy-to-use interface that adapts to the user's level of knowledge
- Ready to use in no time thanks to workspaces and projects
- Easy system configuration with device manager and wizards
- Fast setup due to automatic channel detection
- Support of numerous map data formats
- Powerful analysis tools

▷ page 6

5G NR network testing
- Analysis of R&S®TSME6 and R&S®TSMA6 scanner measurements on 5G NR synchronization signal blocks (SSB)
- Analysis of 5G NR UE measurements

▷ page 8

Numerous application tests
- Creation of different application jobs
  - Data throughput measurement on a PC
  - Innovative on-device testing with commercial smartphones
- Output of KPIs and the most important network parameters in a report

▷ page 10

R&S®ROMES4 with test devices

Automatic handover and neighborhood analysis

- Automatic detection of missing neighboring cells during drive testing
- Improvement of network coverage

▷ page 12

Testing of voice quality – incl. VoLTE

- User-friendly configuration for checking voice quality
- Complete end-to-end measurement from the user perspective
- Based on POLQA standard

▷ page 13

LTE broadcast (eMBMS) network optimization

- R&S®ROMES4 in combination with a Rohde & Schwarz LTE scanner and an LTE eMBMS test mobile
- Network planning
- Network rollout
- Intersymbol interference detection
- Network configuration check
- Network performance validation

▷ page 14

LTE downlink allocation analyzer (DLAA) and uplink allocation analyzer (ULAA)

- Allocation analysis of strongest eNodeB in downlink and uplink
- Wide range of applications

▷ page 16

NB-IoT/Cat NB1 and LTE-M measurements

- Combination with a Rohde & Schwarz scanner
- Support of all operating modes defined in NB-IoT/Cat NB1
- Simultaneous measurements of NB-IoT and other technologies
- Layer 3 decoding
- Combination with an NB-IoT UE
- LTE-M (Cat M1/eMTC) support

▷ page 18

Full overview of layer 1 and layer 3

- Display of mobile phone activities in layer 3
- Fast analysis of interrupted connections

▷ page 21

Parallel spectrum measurement

- Broadband spectrum measurement
- Detection of broadband interferers, neighborhood interference and uplink activities

▷ page 22

Location estimation of 2G/3G/LTE and NB-IoT base stations

- Creation of a base station list during a drive test
- Requires only scanners and GPS

▷ page 23

GSM interference analysis with automatic interferer identification

- Automatic measurement and identification of interferers from own GSM mobile network
- Evaluation of BCCH and TCH channels allows full-featured analysis
- Detection of adjacent-channel and co-channel interferers

▷ page 24

Indoor measurements

- Stationary or moving measurements indoors without a GPS signal
- Combined indoor/outdoor measurements

▷ page 26

R&S®ROMES4NPA: analysis and evaluation of network problems

- Automatic detection, analysis and documentation of trouble spots
- Sophisticated algorithms to support users
- Broad range of optional add-on modules for voice quality and data tests as well as coverage and neighborhood analysis
- Comprehensive set of reporting functions

▷ page 27

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 workspaces and projects

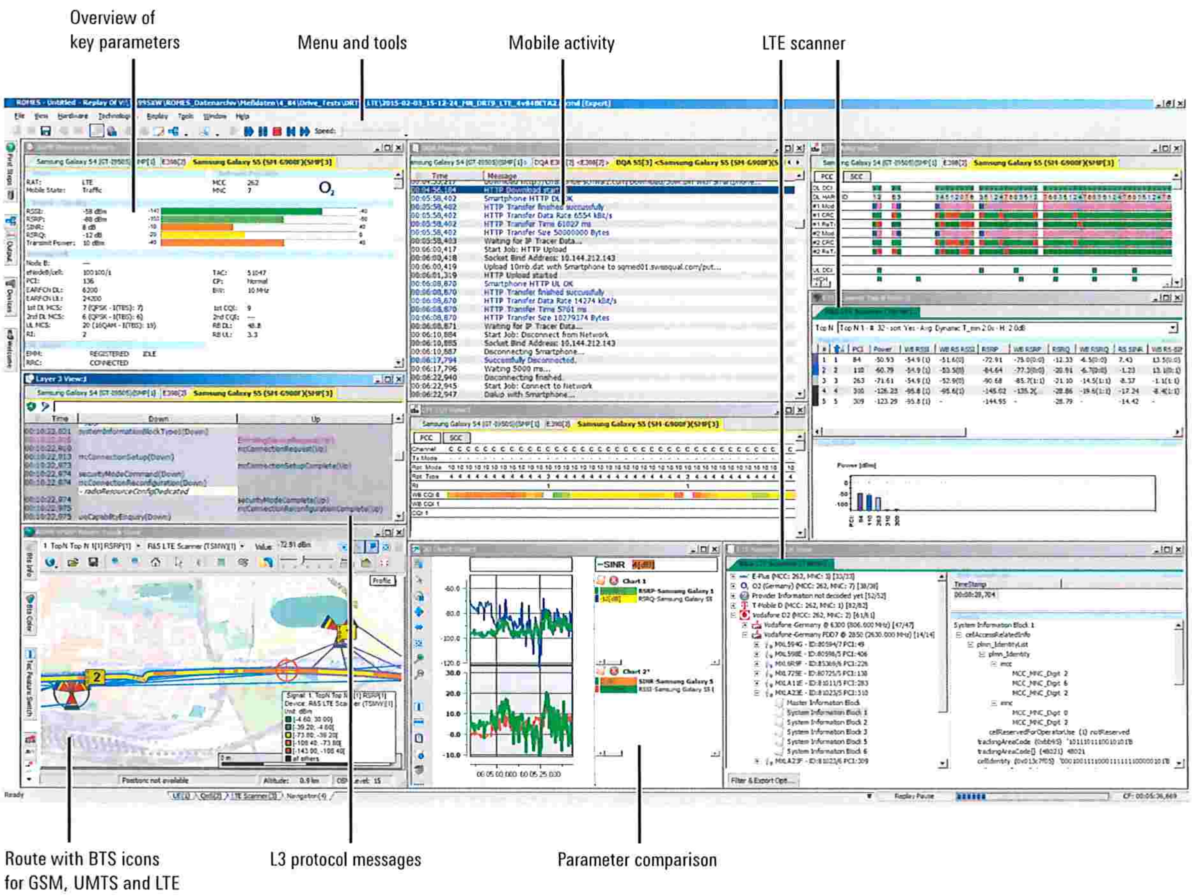
Users can create a workspace in which to store all settings and loaded drivers. At the start of a new drive test, all they need to do is load this workspace and the test system is immediately ready to use.

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.

Overview of the R&S®ROMES4 graphical user interface



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 40 for more details).

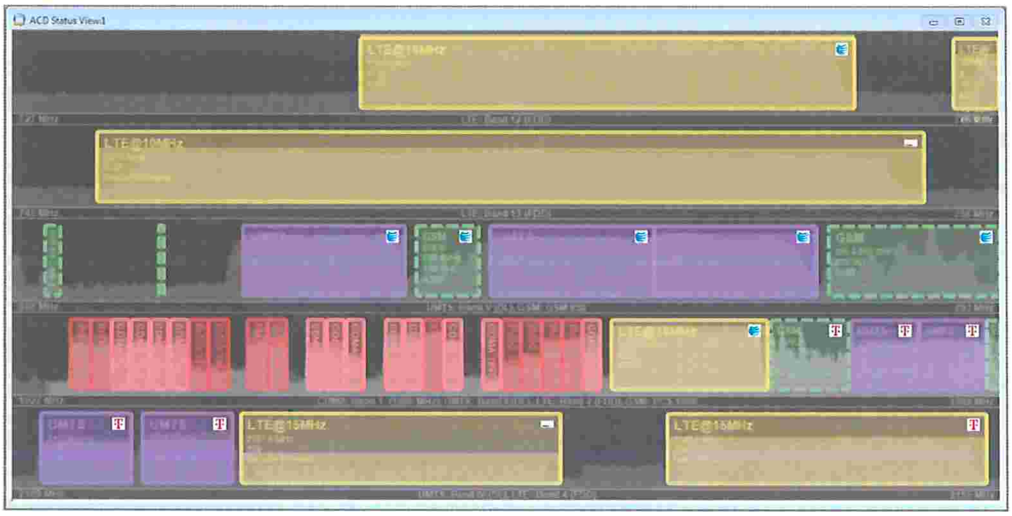
OpenStreetMap

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.

Quick overview thanks to automatic channel detection



5G NR network testing

Requirements
- R&S®ROMES4
- R&S®TSME6 or R&S®TSMA6 scanner with R&S®TSME6-K50/R&S®TSMA6-K50 option
- R&S®ROMES4T1E
  - for mmWave: R&S®TSME30DC ultracompact downconverter and R&S®ROMES4T30D downconverter driver
- 5G UE Qualcomm support:
  - 5G device (Qualcomm chipset)
  - R&S®ROMES4QC
  - R&S®ROMES4NRQ
- 5G UE Samsung support:
  - 5G device (Exynos chipset)
  - R&S®ROMES4SAM
  - R&S®ROMES4NRS

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 R&S®TSME6 and R&S®TSMA6 scanner measurements on 5G NR synchronization signal blocks (SSB)

With the R&S®TSME6-K50 or R&S®TSMA6-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 and mmWave up to 30 GHz, for which an R&S®TSME30DC ultracompact downconverter is needed in addition to the scanner.

5G NR UE measurements

With UE specific options (R&S®ROMES4QC and R&S®ROMES4NRQ for Qualcomm based UEs or R&S®ROMES4SAM and R&S®ROMES4NRS for Samsung based UEs) users are able to perform dual-port recording for non-standalone (NSA) mode. 5G NR UE 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, and L3 signaling together with services testing data.

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

Numerous application tests

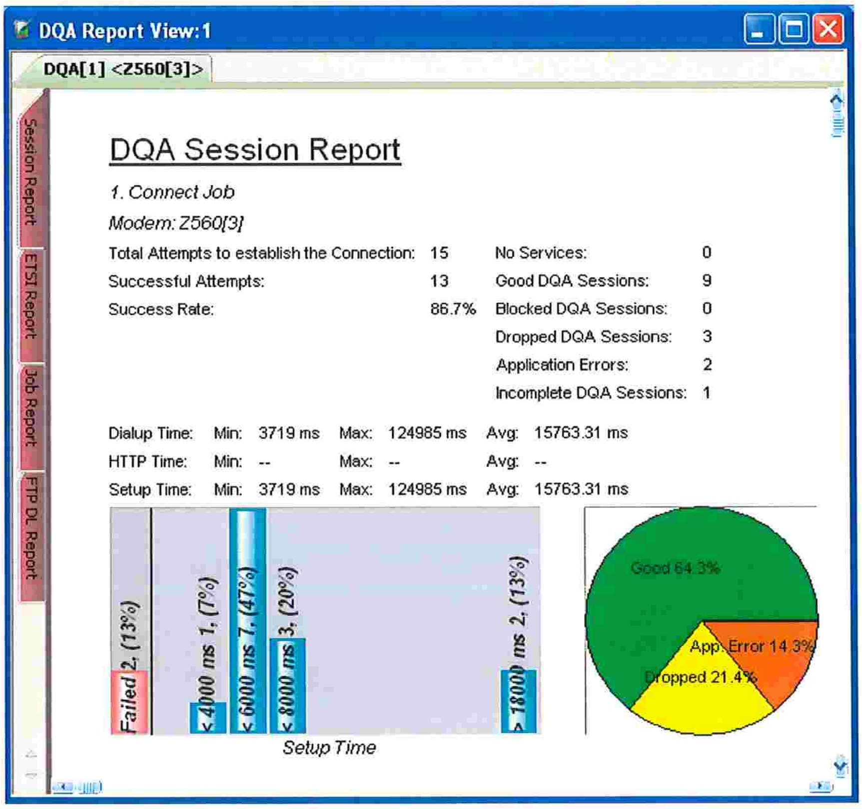
Requirements
- R&S®ROMES4
- Test mobile phone
- R&S®ROMES4QC (Qualcomm driver) or R&S®ROMES4SAM (Samsung driver)
- R&S®ROMES4QP (QualiPoc driver)
- Optional:
  - R&S®ROMES4CA or R&S®ROMES4CAU (carrier aggregation drivers for DL or UL, Qualcomm)
  - R&S®ROMES4LAA (licensed assisted access, Qualcomm, requires R&S®ROMES4CA)

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 DQA report of a drive test quickly reveals trouble spots

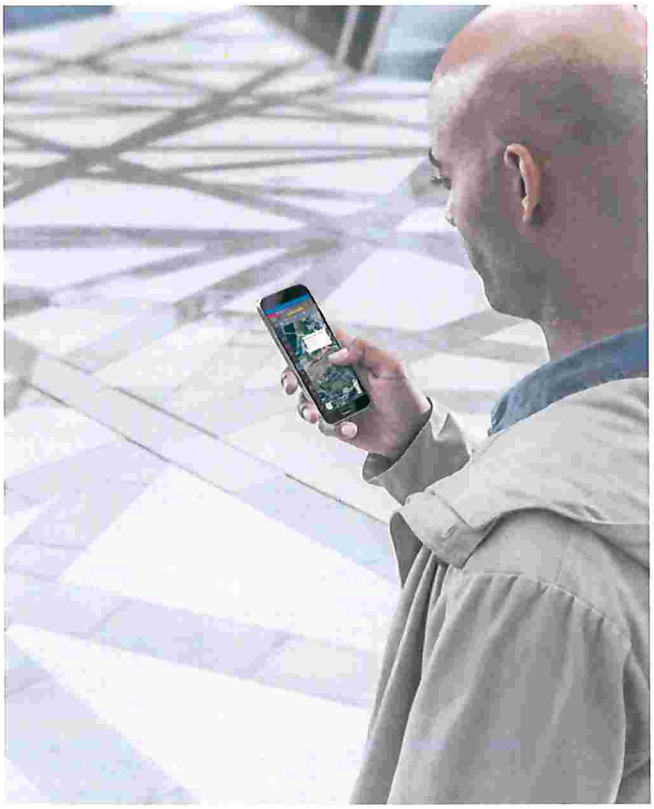
Innovative on-device testing with a smartphone
When used together with a suitable QualiPoc Android phone, the R&S®ROMES4QP smartphone option sends all of the messages and analyses directly to the smartphone. This ensures an almost exact simulation of user behavior. R&S®ROMES4 GUI makes configuration 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 also can be assigned to a job list: email, ping, FTP, HTTP, HTTP capacity test, Call2AnyNumber, double-ended voice quality, MOC DL voice quality, network performance tests and application testing such as YouTube, Ookla, Facebook or WhatsApp.

The QualiPoc Android phone can also be used as a standalone 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 precommercial 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. higher-order carrier aggregation [1]), licensed-assisted access (LAA) and MIMO 4x4) in the lab or field. The R&S®ROMES4 data quality analyzer supports on-device testing in both ADB mode for FTP, HTTP and capacity tests and QualiPoc unrooted mode, where R&S®ROMES4 executes a QualiPoc installation on the connected commercial smartphone, delivering DQA tests (Wi-Fi, VoLTE, ping, messaging and POLQA call tests) in addition to those provided in ADB mode.

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.

1) Currently up to five carriers in downlink (DL) and two in uplink (UL).



The QualiPoc Android phone can also be used as a standalone device, for instance for indoor measurements

Automatic handover and neighborhood analysis

Requirements
- R&S®ROMES4
- R&S®ROMES4HOA
- R&S®ROMES4T1W or R&S®ROMES4T1E
- R&S®TSMW, R&S®TSME or R&S®TSMA scanner
- R&S®TSMx GSM/UMTS scanner
- Test mobile phone
- R&S®ROMES4QC (Qualcomm driver) or R&S®ROMES4SAM (Samsung driver)

Automatic detection of missing neighboring cells during drive testing

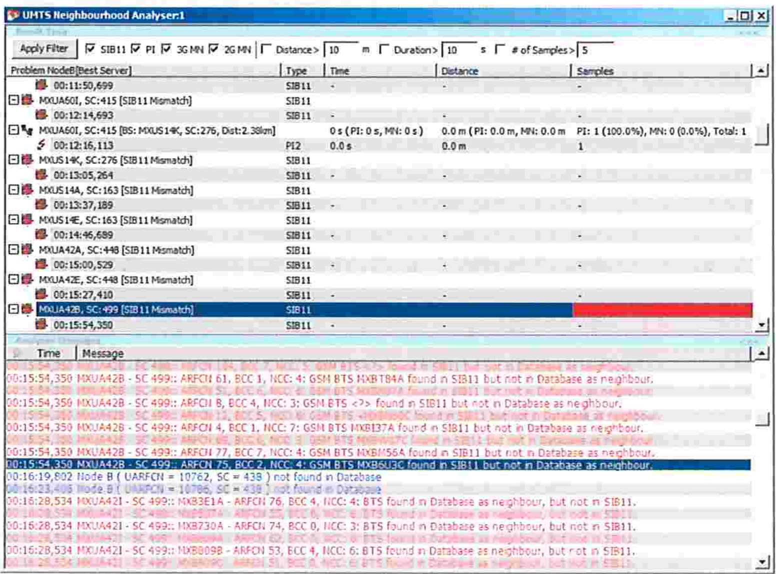
Automatic neighborhood analysis is based on a base station list and the base stations' broadcast signals that are decoded by the R&S®TSMx scanners. These system information blocks (UMTS and LTE) or system information types (GSM) include information that is normally used by test mobile phones to identify 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.

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.

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 27).

Detecting a missing neighborhood at a glance



Testing of voice quality – incl. VoLTE

Requirements
- R&S®ROMES4
- R&S®ROMES4QP
- QualiPoc Android QA test mobile phone
- R&S®ROMES4QC (Qualcomm driver)
- R&S®ROMES4SAM (Samsung driver)
- Optional: R&S®ROMES4VO (VoLTE driver)

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

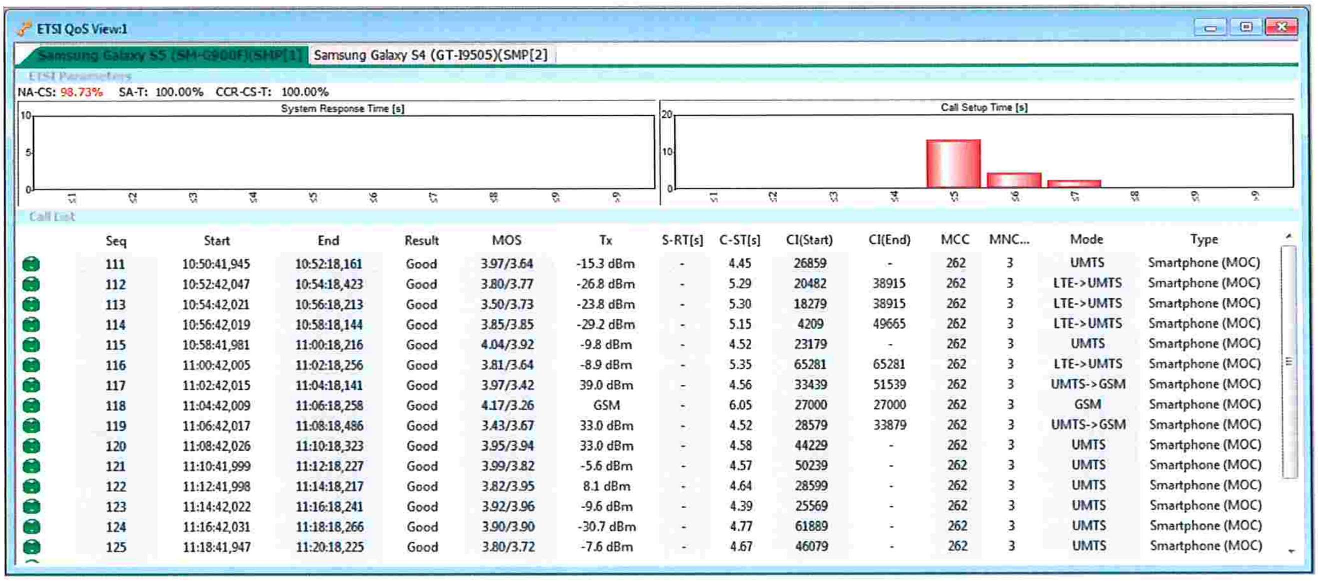
The measurements can be performed using a fixed-network station, usually a voice-quality server, or another mobile phone. The mobile phone reflects the quality as experienced by a mobile user and also permits HD voice measurements. In contrast, a fixed-network station serves as a reference, enabling 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) with a Samsung Galaxy S5



Seq	Start	End	Result	MOS	Tx	S-RT[s]	C-ST[s]	CI(Start)	CI(End)	MCC	MNC...	Mode	Type
111	10:50:41,945	10:52:18,161	Good	3.97/3.64	-15.3 dBm	-	4.45	26859	-	262	3	UMTS	Smartphone (MOC)
112	10:52:42,047	10:54:18,423	Good	3.80/3.77	-26.8 dBm	-	5.29	20482	38915	262	3	LTE->UMTS	Smartphone (MOC)
113	10:54:42,021	10:56:18,213	Good	3.50/3.73	-23.8 dBm	-	5.30	18279	38915	262	3	LTE->UMTS	Smartphone (MOC)
114	10:56:42,019	10:58:18,144	Good	3.85/3.85	-29.2 dBm	-	5.15	4209	49665	262	3	LTE->UMTS	Smartphone (MOC)
115	10:58:41,981	11:00:18,216	Good	4.04/3.92	-9.8 dBm	-	4.52	23179	-	262	3	UMTS	Smartphone (MOC)
116	11:00:42,005	11:02:18,256	Good	3.81/3.64	-8.9 dBm	-	5.35	65281	65281	262	3	LTE->UMTS	Smartphone (MOC)
117	11:02:42,015	11:04:18,141	Good	3.97/3.42	39.0 dBm	-	4.56	33439	51539	262	3	UMTS->GSM	Smartphone (MOC)
118	11:04:42,009	11:06:18,258	Good	4.17/3.26	GSM	-	6.05	27000	27000	262	3	GSM	Smartphone (MOC)
119	11:06:42,017	11:08:18,486	Good	3.43/3.67	33.0 dBm	-	4.52	28579	33879	262	3	UMTS->GSM	Smartphone (MOC)
120	11:08:42,026	11:10:18,323	Good	3.95/3.94	33.0 dBm	-	4.58	44229	-	262	3	UMTS	Smartphone (MOC)
121	11:10:41,999	11:12:18,227	Good	3.99/3.82	-5.6 dBm	-	4.57	50239	-	262	3	UMTS	Smartphone (MOC)
122	11:12:41,998	11:14:18,217	Good	3.82/3.95	8.1 dBm	-	4.64	28599	-	262	3	UMTS	Smartphone (MOC)
123	11:14:42,022	11:16:18,241	Good	3.92/3.96	-9.6 dBm	-	4.39	25569	-	262	3	UMTS	Smartphone (MOC)
124	11:16:42,031	11:18:18,266	Good	3.90/3.90	-30.7 dBm	-	4.77	61889	-	262	3	UMTS	Smartphone (MOC)
125	11:18:41,947	11:20:18,225	Good	3.80/3.72	-7.6 dBm	-	4.67	46079	-	262	3	UMTS	Smartphone (MOC)

LTE broadcast (eMBMS) network optimization

Requirements
- R&S®ROMES4
- R&S®ROMES4T1W or R&S®ROMES4T1E
- 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
- Optional for test mobile support: R&S®ROMES4QC and R&S®ROMES4EMQ

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.

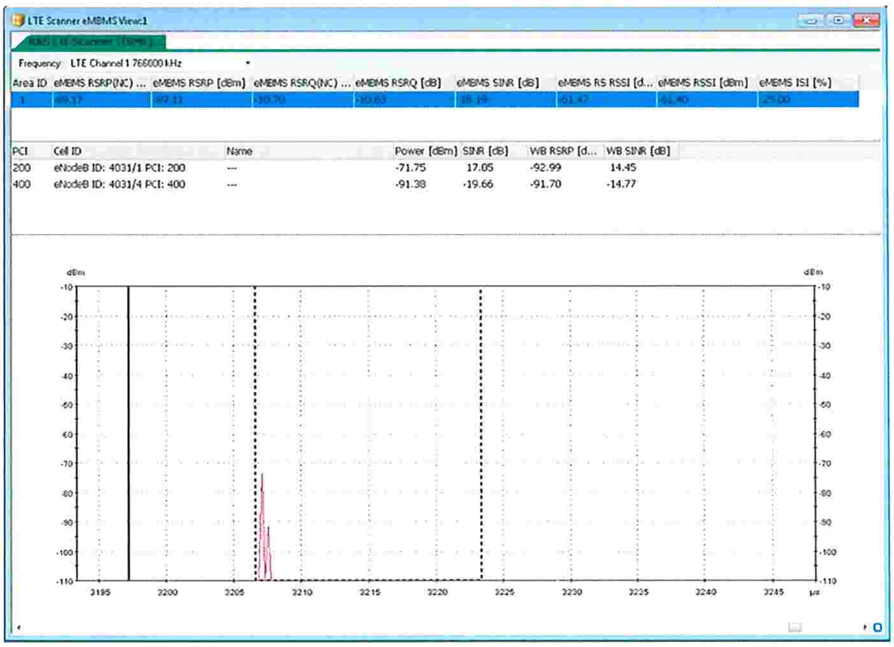
Network configuration check

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

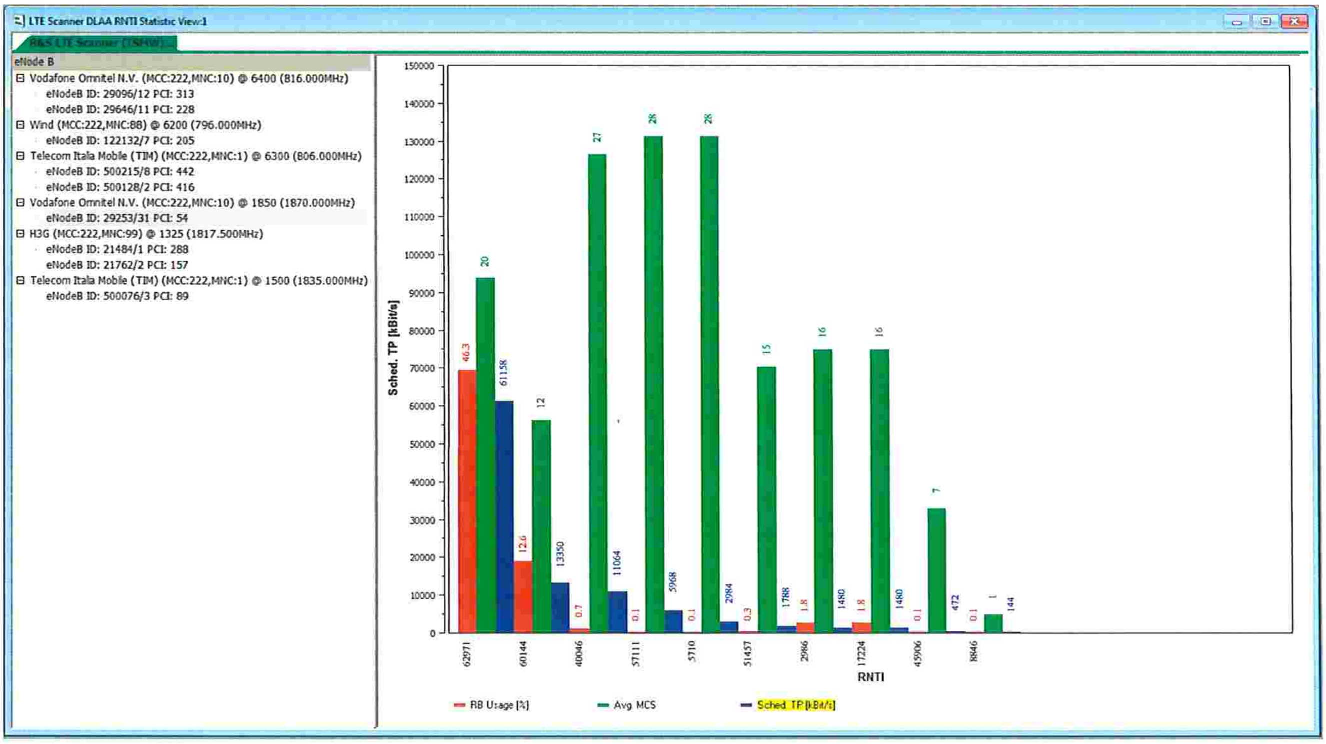
While the scanner allows optimization of the RF environment, it is also crucial to validate the network performance with a test mobile. R&S®ROMES4 supports eMBMS test mobiles with a Qualcomm chipset, so the engineer can test the connection to the eMBMS network, view layer 3 and flute messages, capture 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



LTE downlink allocation analyzer (DLAA) and uplink allocation analyzer (ULAA)

Requirements
- R&S®ROMES4
- R&S®ROMES4T1W or R&S®ROMES4T1E
- For DLAA
  - R&S®TSMW scanner with R&S®TSMW-K29 and R&S®TSMW-K31 or R&S®TSME scanner with R&S®TSME-K29 and R&S®TSME-K31 or R&S®TSMA scanner with R&S®TSMA-K29 and R&S®TSME-K31
- For ULAA
  - R&S®TSMW scanner with R&S®TSMW-K29 and R&S®TSMW-K33 or R&S®TSME scanner with R&S®TSME-K29 and R&S®TSME-K33 or R&S®TSMA scanner with R&S®TSMA-K29 and R&S®TSME-K33
- Optional: R&S®TSMW-K27/R&S®TSME-K27/ R&S®TSMA-K27 RF power scan



Fast overview of resource block allocation, average MCS and target throughput of various RNTIs

Allocation analysis of strongest eNodeB in downlink and uplink

In combination with an R&S®TSMW, R&S®TSME or R&S®TSMA scanner, R&S®ROMES4 offers a unique feature that allows analysis of the downlink and uplink allocations (up to Release 12) of the strongest eNodeB during measurements. The following information is included:

- Number of RNTIs (UEs) scheduled by the eNodeB for data reception
- Modulation and coding scheme (MCS) and throughput for each detected UE
- Cell allocation

Information is provided per TTI and per resource block. Data can be statistically evaluated to estimate the overall cell load based on throughput and number of users. This information is important during network optimization and troubleshooting as it helps users acquire network data without special maintenance tools such as base station counters.

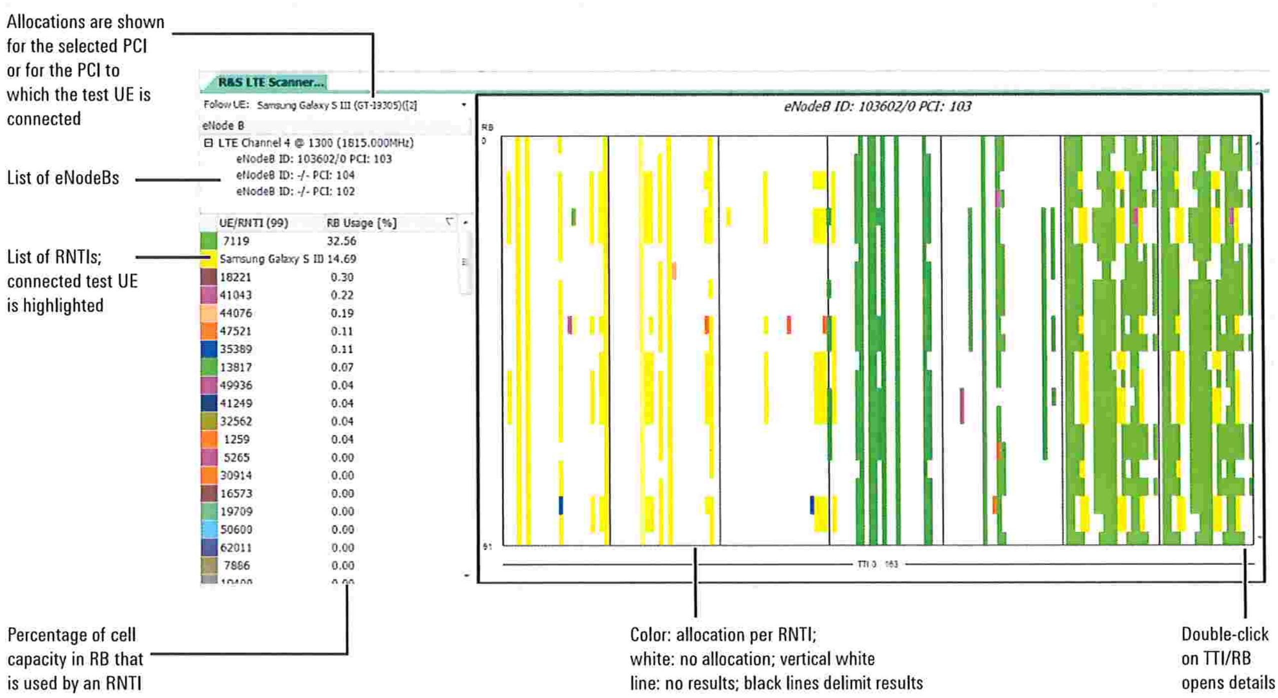
Wide range of applications

The analysis results for LTE downlink and uplink allocations, for example, can explain the limited throughput of a test mobile phone if the scanner shows that the cell load is high and that there are not enough resources available for the phone.

In a benchmarking environment, this feature provides deep insight into networks, allowing comparison of traffic load and available capacity for different operators.

Other applications include a network probe to measure the cell load in stationary operation, for example when a base station site owner wants to know the importance of a certain base station before renewing the lease with the network operator.

DLAA: RNTI allocation overview



NB-IoT/Cat NB1 and LTE-M measurements

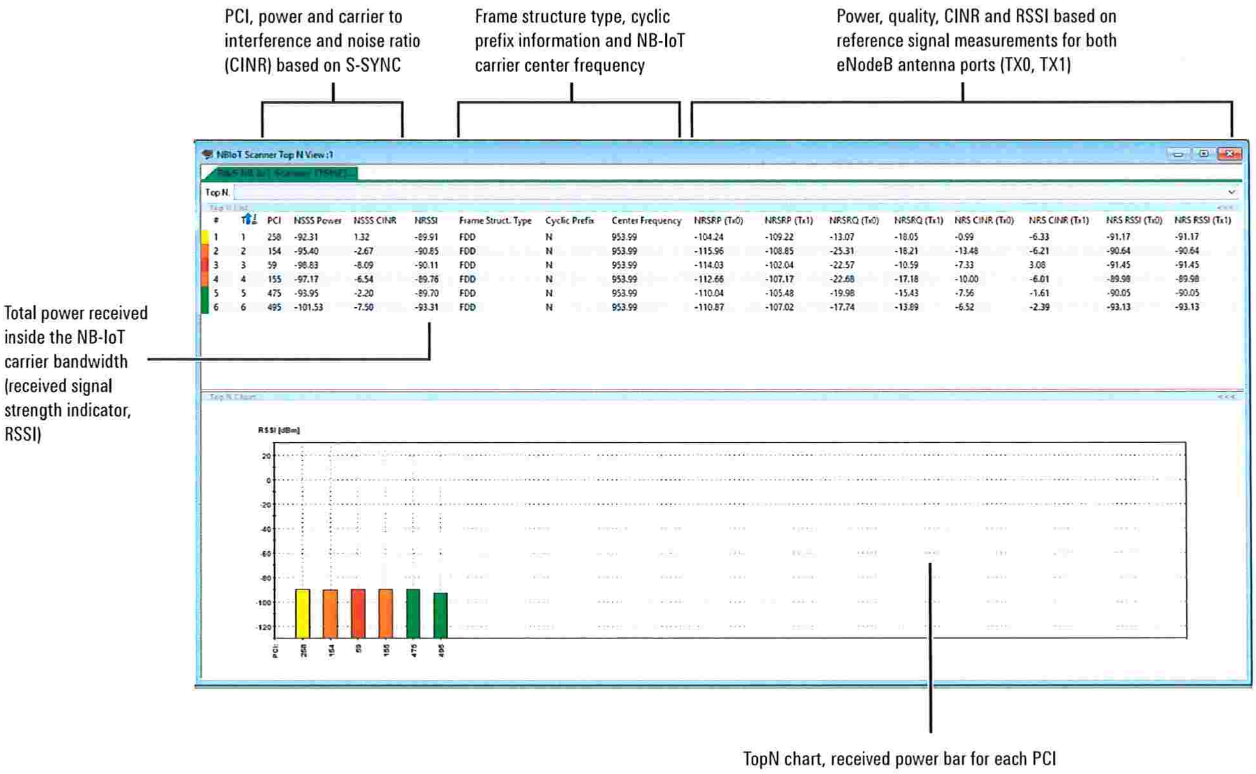
Requirements
- R&S®ROMES4
- R&S®ROMES4T1W or R&S®ROMES4T1E
- R&S®TSMW scanner with R&S®TSMW-K29 and R&S®TSMW-K34/R&S®TSMW-K35 or R&S®TSME scanner with R&S®TSME-K29 and R&S®TSME-K34/R&S®TSME-K35 or R&S®TSMA scanner with R&S®TSMA-K29 and R&S®TSMA-K34/R&S®TSME-K35
- R&S®ROMES4QC and R&S®ROMES4NBQ for Qualcomm NB-IoT support
- R&S®ROMES4NBN for Neul NB-IoT UE support
- R&S®ROMES4QC for Qualcomm LTE-M support

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. 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.

NB-IoT scanner TopN view



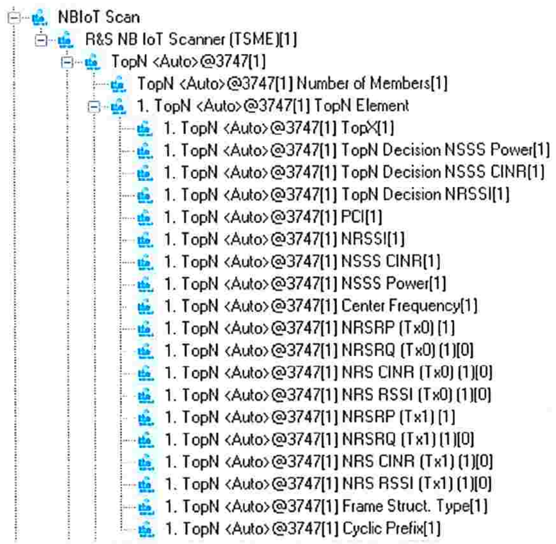
Support of all operating modes defined in NB-IoT/Cat NB1

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.

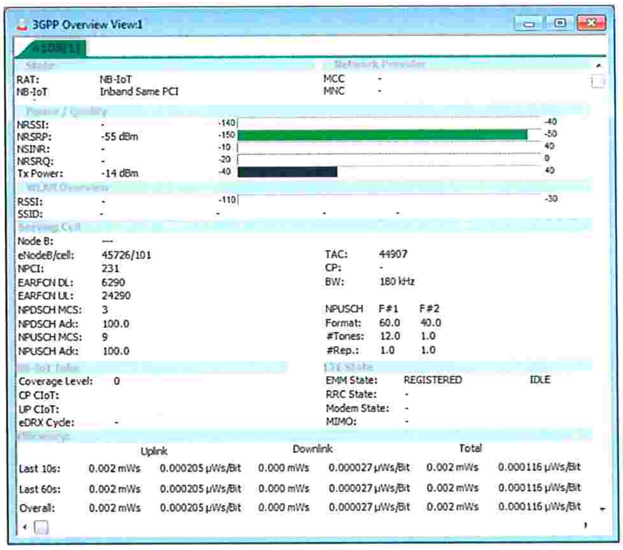
Simultaneous measurements of NB-IoT and other technologies

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.

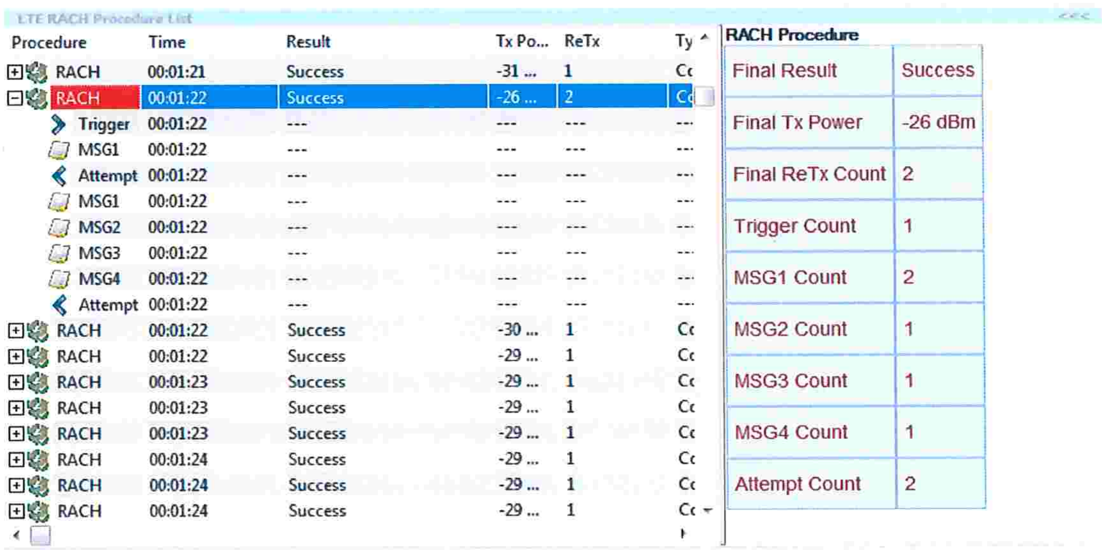
NB-IoT scanner TopN signals



NB-IoT UE overview view



NB-IoT RACH retransmission



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) and the random access channel (RACH) procedure.

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

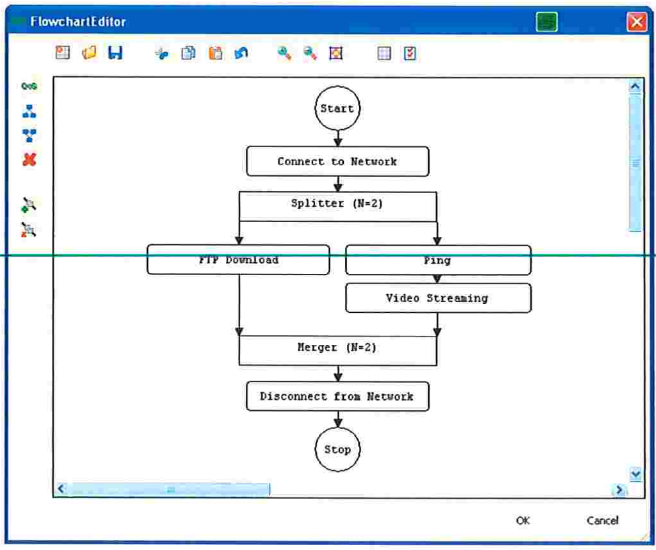
LTE-M is fully compatible with existing LTE networks. R&S®ROMES4 supports LTE-M measurements in combination with both a scanner and an LTE-M device. LTE-M is standardized for the LTE in-band mode only. By performing subband measurements with a Rohde & Schwarz scanner, it is possible to evaluate the RF 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®TSMA autonomous mobile network scanner

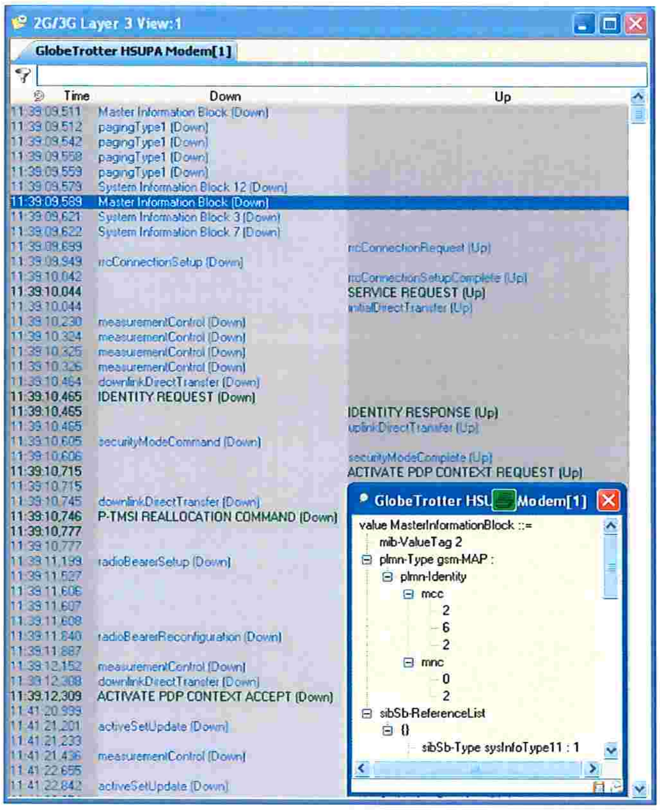
Full overview of layer 1 and layer 3

Requirements
- R&S®ROMES4
- Test mobile phone
- R&S®ROMES4GSM (GSM driver) or
  R&S®ROMES4QC (Qualcomm driver) or
  R&S®ROMES4SAM (Samsung driver) or
  R&S®ROMES4QP (QualiPoc driver) or
  R&S®ROMES4TET (Sepura TETRA driver)

Parallel jobs are configured with simple graphics



Layer 3 protocol messages for uplink and downlink



Display of mobile phone activities in layer 3

The basic functionality of R&S®ROMES4 in combination with the drivers for test mobile phones provides a large amount of information from layers 1 and 3. Users can see the radio conditions (GSM or WCDMA, channel, voice codec, etc.) for phone calls at a glance.

If measurements are also taken by a scanner, the scanner's measured data is displayed in the same window, allowing a direct comparison.

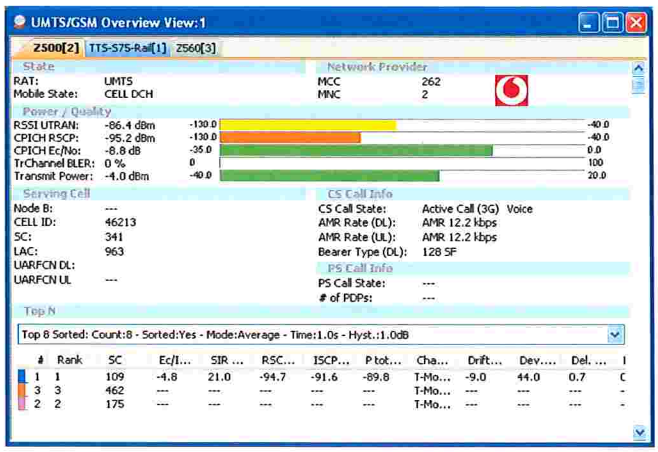
Layer 3 View displays all the messages, sorted by uplink and downlink. Each message is decoded and can be opened if necessary.

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.

Overview of all important network parameters



Parallel spectrum measurement

Requirements
- R&S®ROMES4
- R&S®ROMES4T1W or R&S®ROMES4T1E
- R&S®TSMx scanner with R&S®TSMU-K17 RF power scan
- 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

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.

Detection of broadband interferers, neighborhood interference and uplink activities

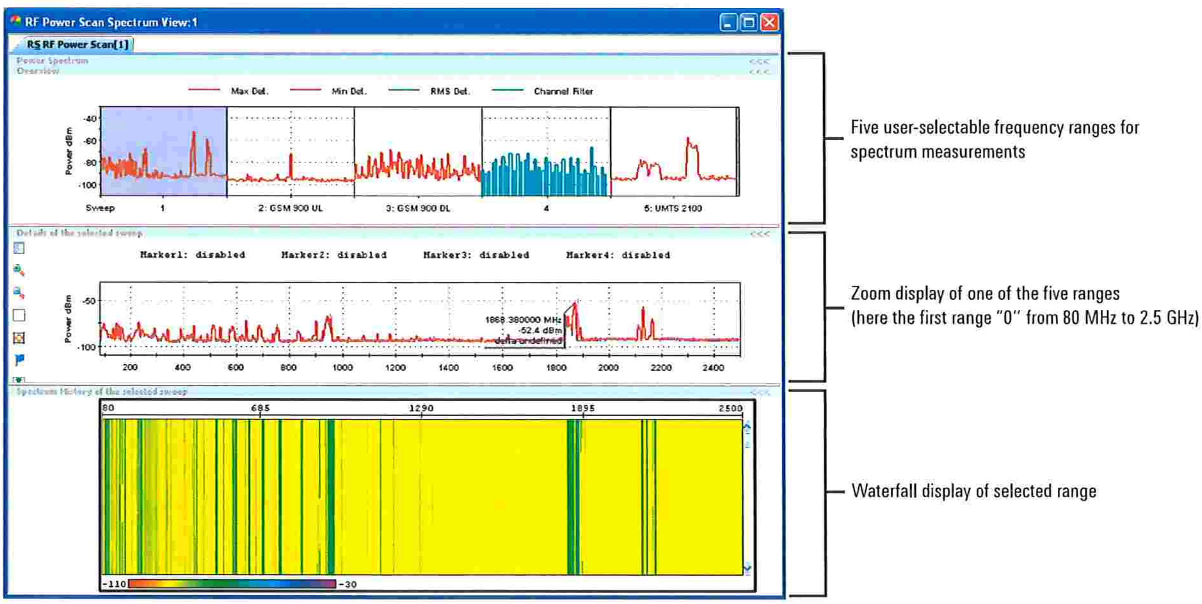
The waterfall diagram gives the user a general idea of the air interface and its history. This makes it very easy to locate broadband interferers or external interference. All the user needs to do is move the mouse pointer over the waterfall diagram. At any desired spot, timestamp and frequency are displayed,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

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 and NB-IoT base stations

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

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 GSM, WCDMA, CDMA2000® 1xEV-DO, LTE and NB-IoT 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 2G/3G/4G scanner.

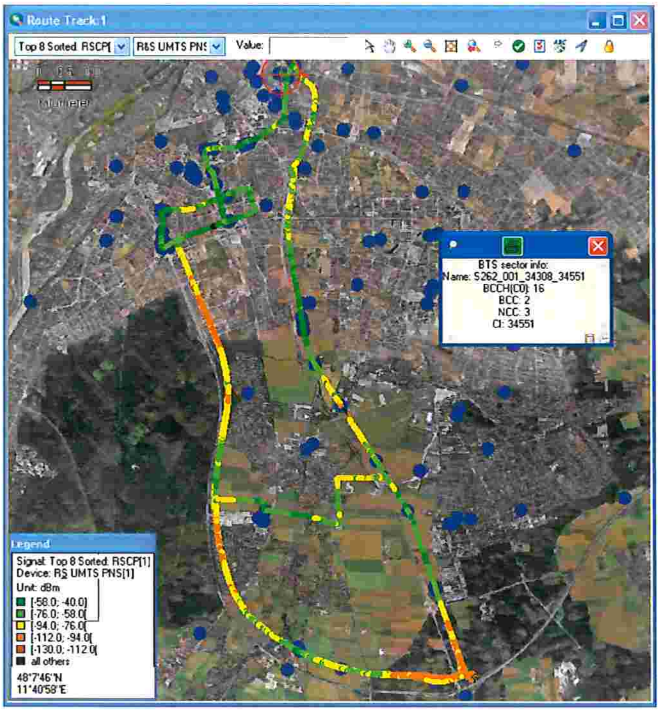
The R&S®ROMES4 software and the R&S®ROMES4LOC driver allow the scanners not only to detect the main levels of the BTS (2G: RxLev, 3G: RSCP, 4G: RSRP) but also to demodulate the broadcast channels (BCH). Important time information as well as details of the transmitting BTS are thus obtained.

The maximum likelihood method is used to calculate the geographic position of the individual BTS from the measured data provided by the GPS receiver, BCH time information and level changes during the drive test.

Following the drive test, the calculation results are exported to a base station list and the located base stations are displayed on an underlying street map.

Selecting the BTS opens another window in which the characteristic data of the BTS is displayed.

The calculated position of a BTS lies within an error ellipse (approx. 200 m) that is also 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

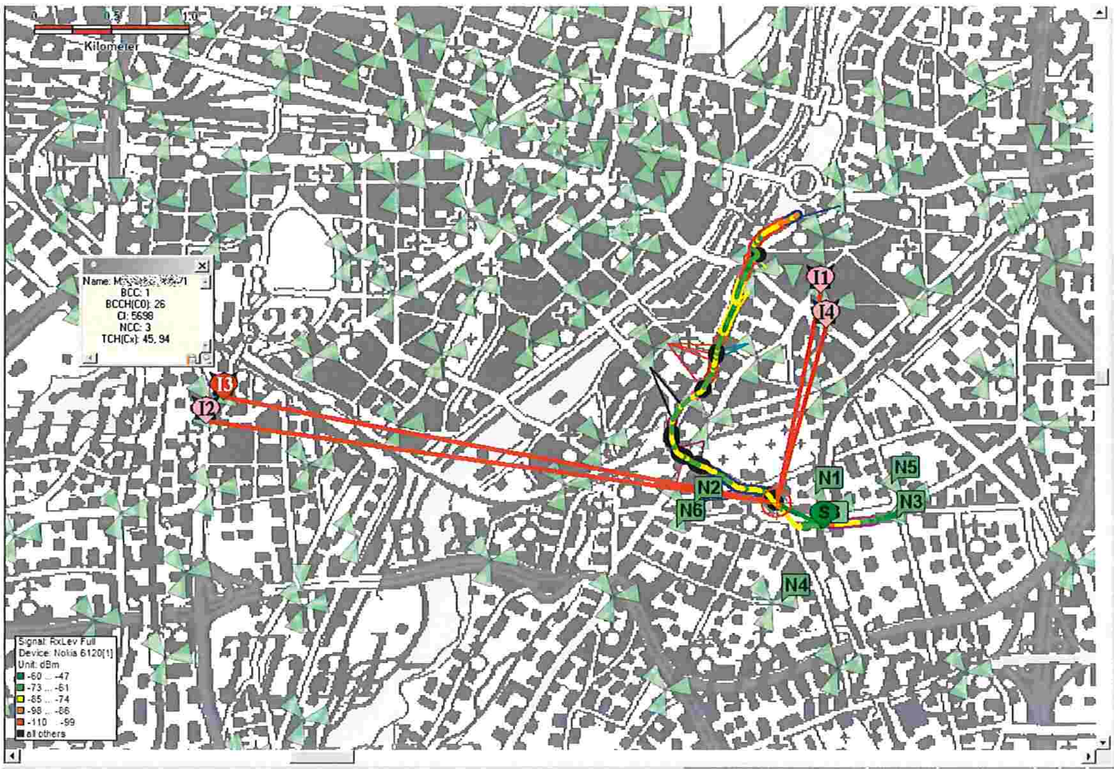
Requirements
- R&S®ROMES4
- R&S®ROMES4COI
- R&S®ROMES4T1W or R&S®ROMES4T1E
- R&S®TSMx GSM scanner
- Test mobile phone
- R&S®ROMES4QC (Qualcomm driver) or R&S®ROMES4SAM (Samsung driver)

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.).

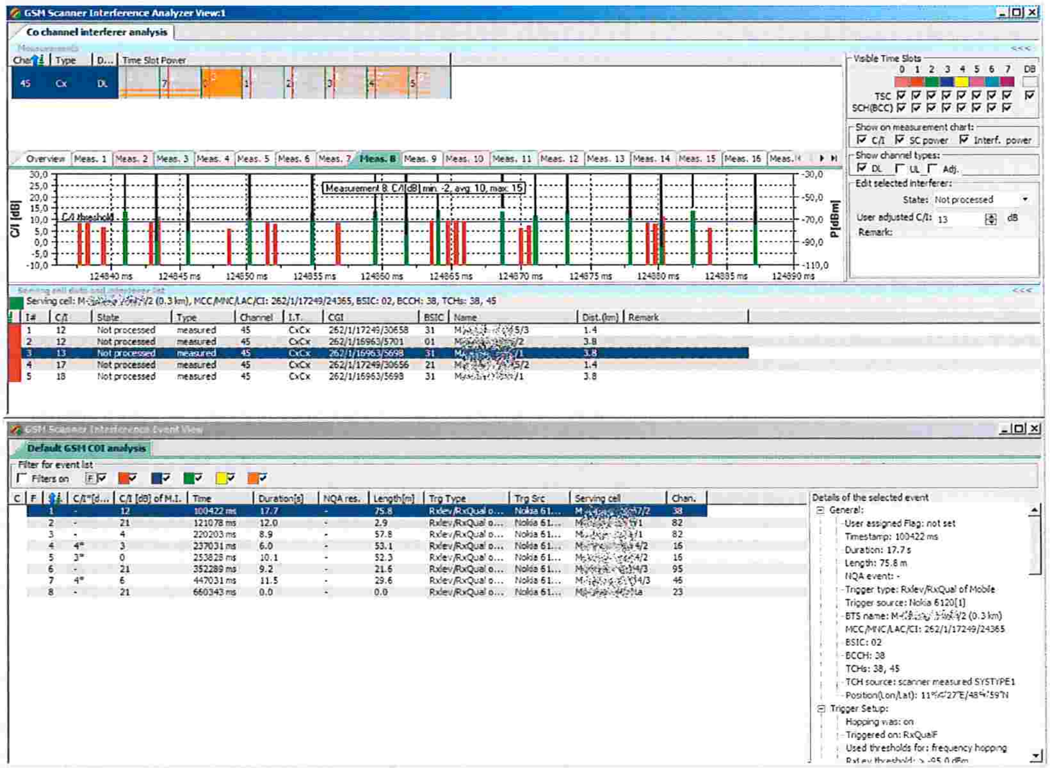
Detection of adjacent-channel and co-channel interferers

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
- R&S®ROMES4QC (Qualcomm driver) or R&S®ROMES4SAM (Samsung driver) or or R&S®ROMES4TET (TETRA driver)

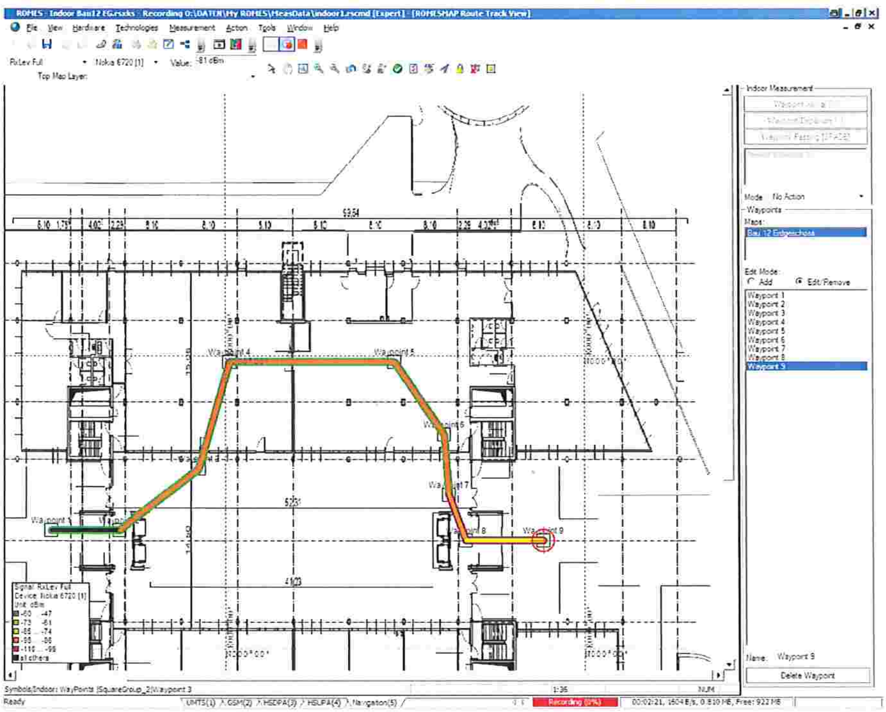
Stationary or moving measurements indoors without a GPS signal

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 as 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

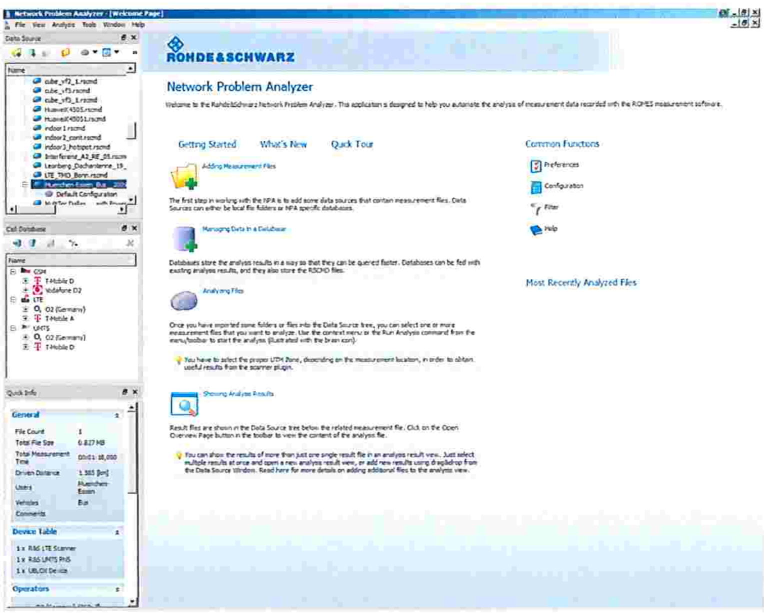
The easy-to-use interface guides the user through the process, from reading in the measured data (from one or more drive tests) and selecting the analysis criteria to retrieving the automatically generated list of trouble spots.

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:
- NQA (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

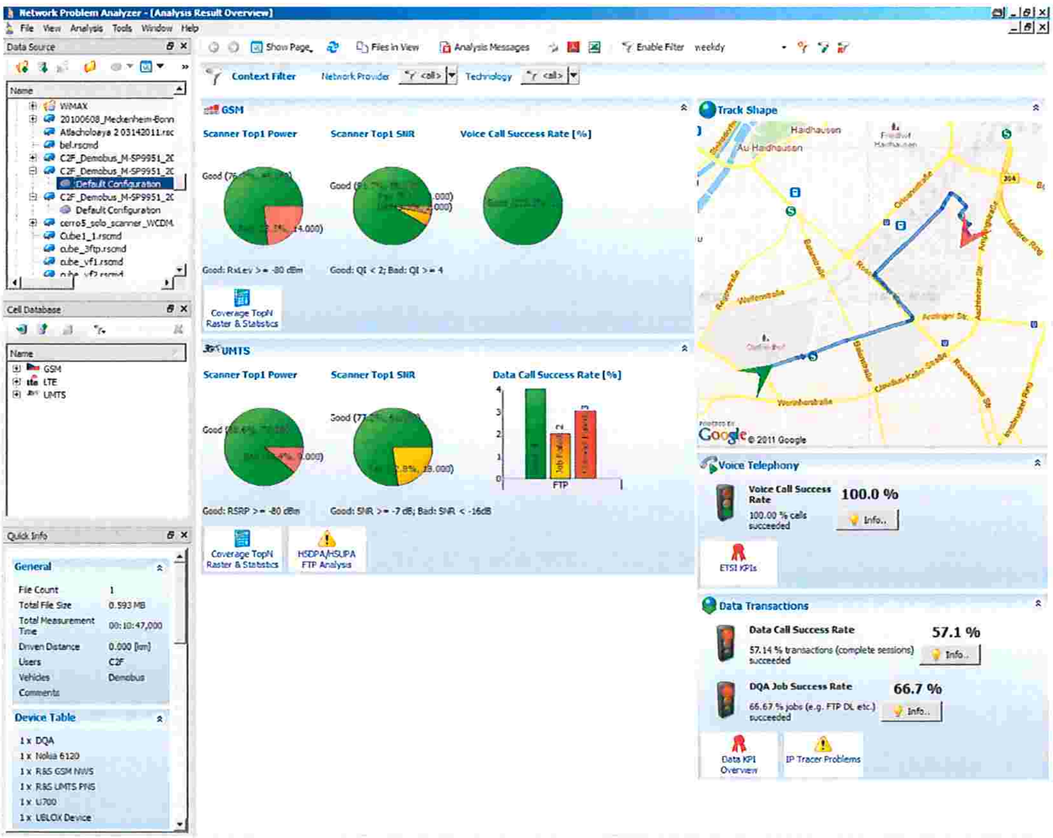
Coverage data (GSM, WCDMA, CDMA2000® 1xEV-DO, TETRA, LTE, LTE-M) measured with Rohde & Schwarz scanners is rasterized and displayed on a map using Google Maps or OpenStreetMap (OSM). This makes it easy to generate coverage plots and create and visualize overshooting problems. Optimizations can be checked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

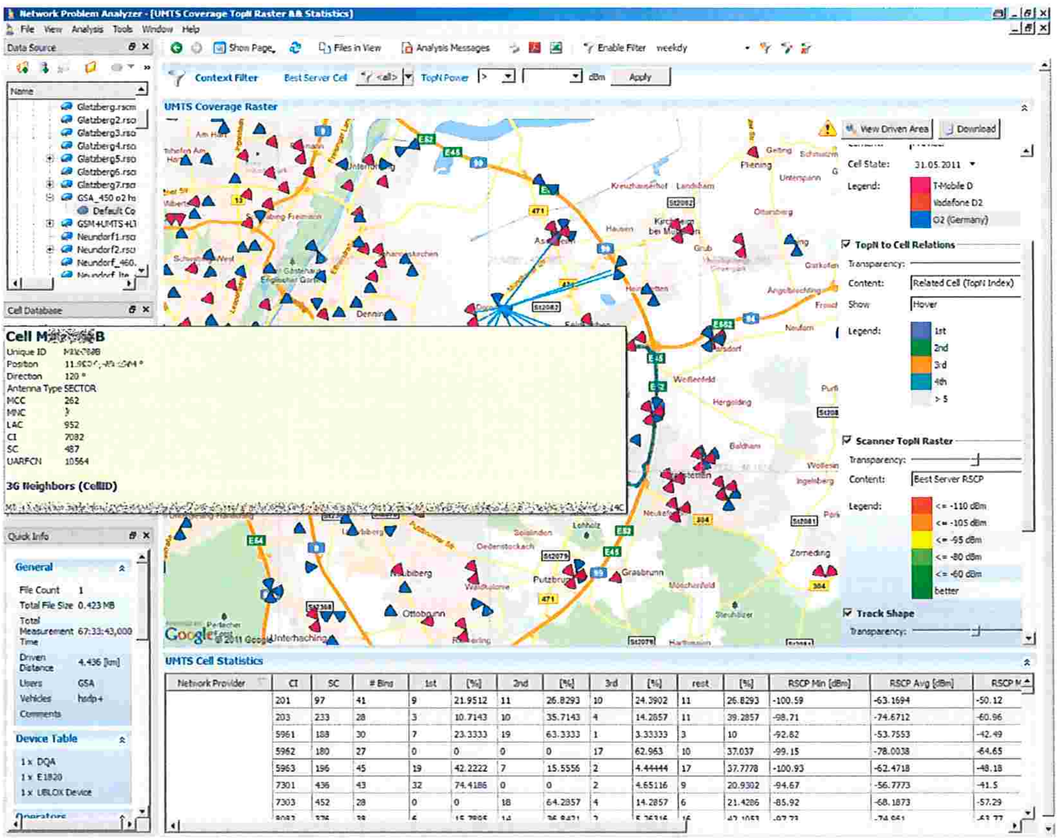
To ensure a consistently high degree of network quality, continual improvements must be made to the mobile network, such as updating the parameters for a mobile base station, replacing hardware or adding new base stations. Each time such improvements are made, the effects on neighboring base stations 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)

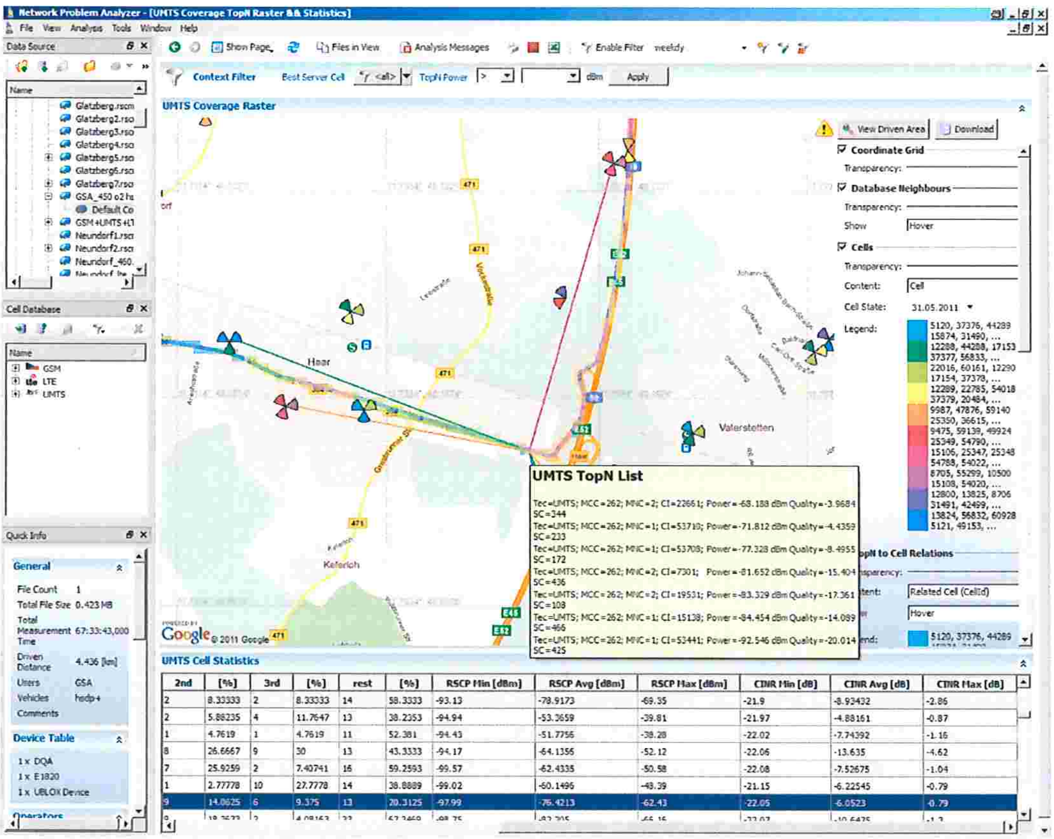
As the use of data is increasing exponentially, mobile networks need to provide higher-speed data links to their customers. When uplink carrier aggregation is used to provide this capability, this module analyzes the results and shows detailed information such as how many carriers a mobile phone uses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

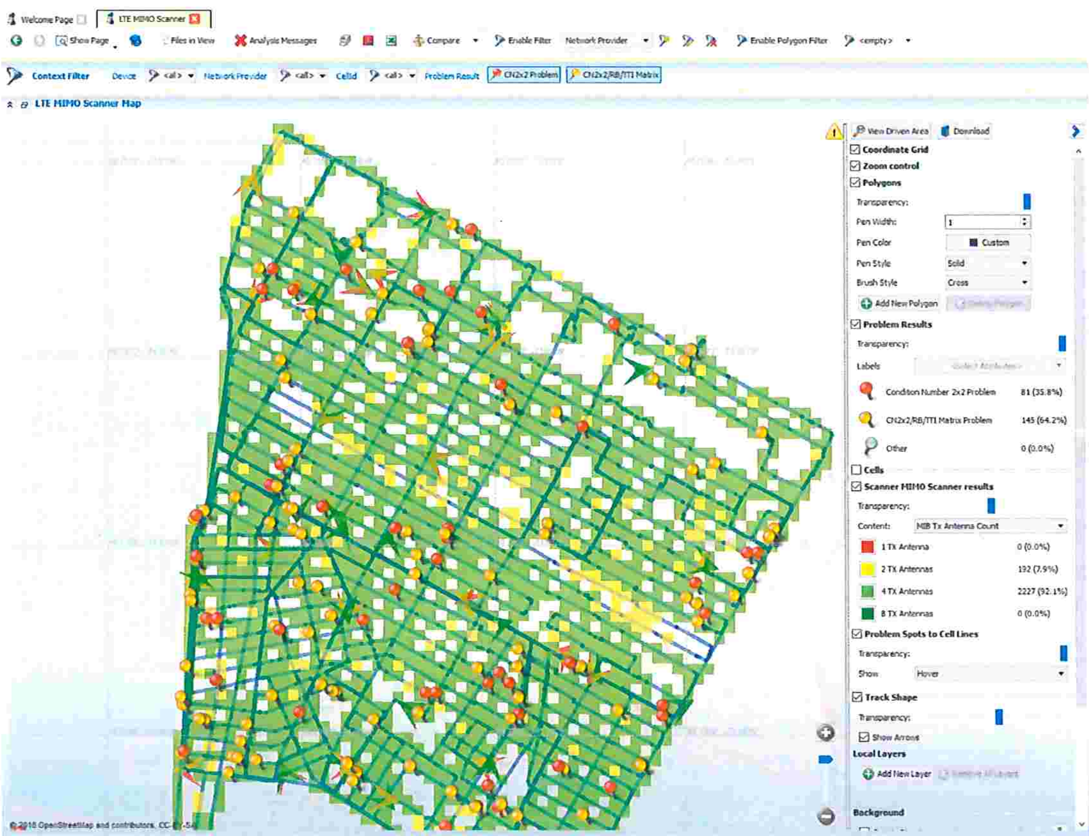
This module delivers dedicated coverage and problem spot reporting as well as cell statistics for NB-IoT analysis based on scanner measurements.

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).

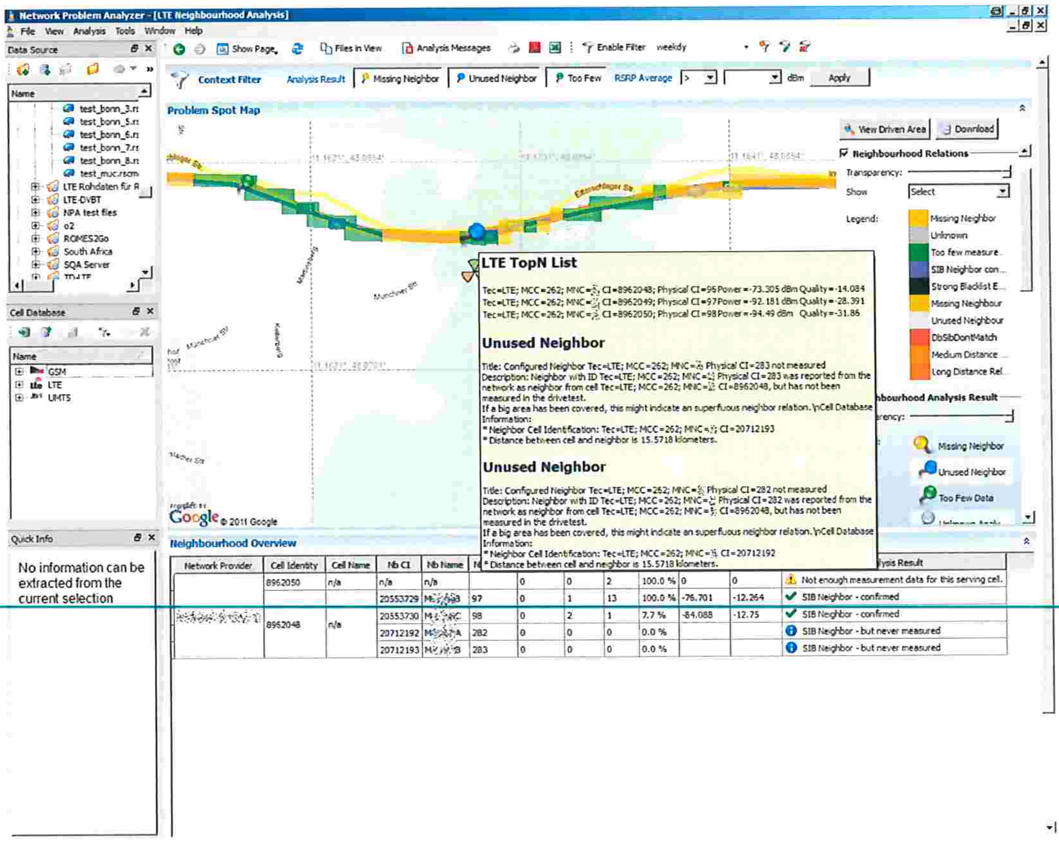
A further way to evaluate analysis results in greater detail is to use sophisticated filter algorithms (e.g. for examining only one operator/one cell or only specific times or days of the week). The dynamic context filter algorithm makes this even easier and faster. For analyzing dedicated geographical 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.

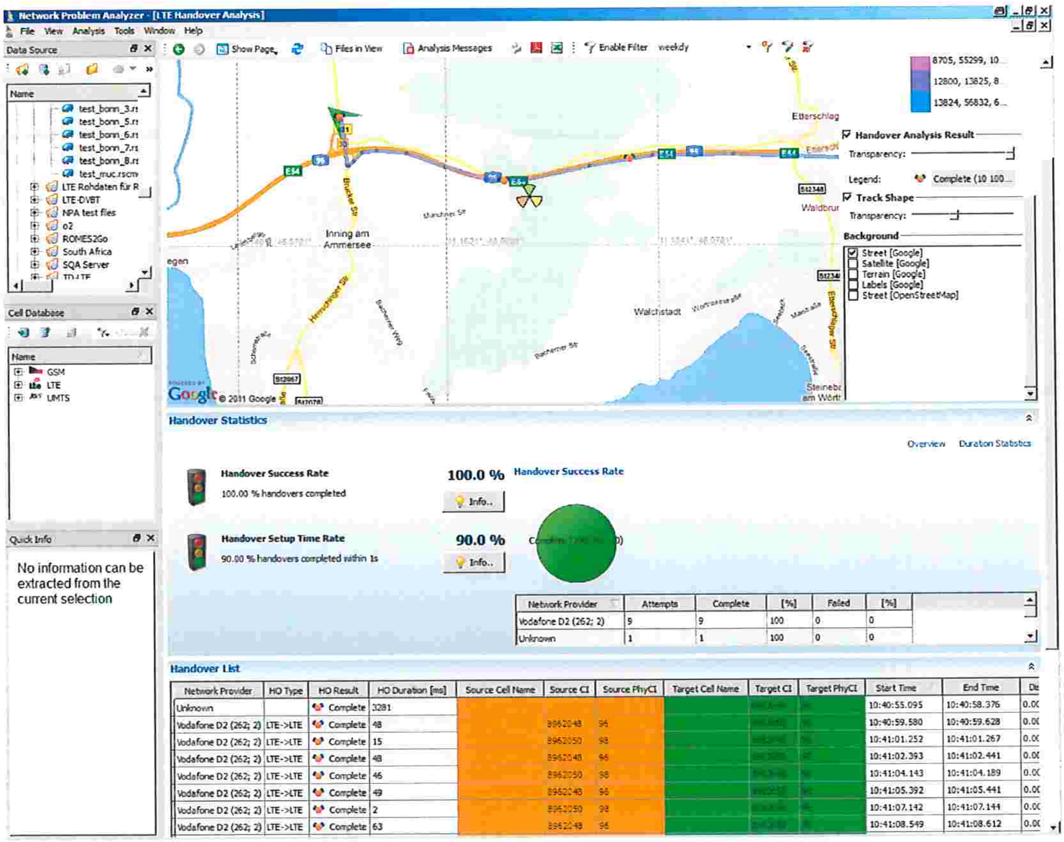
R&S®ROMES4NPA uses sophisticated algorithms to help users find problem causes. More in-depth analyses can be performed at any time. A large amount of measured data can be automatically and quickly processed; reports (for management and for general documentation) are generated without requiring user interaction.

Random access statistics distributed on CE level as a 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



LTE handover analysis: map, KPIs and detailed list



System configuration for various application scenarios

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

R&S®FR4 Freerider 4 backpack

The R&S®FR4 Freerider 4 backpack is a compact, lightweight backpack for walk test and drive test campaigns. Supporting for up to 12 test mobile phones and high-performance scanner measurements (including 5G millimeterwave 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.

Maximum flexibility and future readiness

Extensive test mobile support

The R&S®FR4 Freerider 4 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.

User-specific cabling

For 5G NR millimeterwave, 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 [1]
	storage temperature range	–40°C to +55°C
Damp heat		+25°C/+55°C, < 95% relative humidity, cyclic, non-condensing, in line with EN 60068-2-14
Connectors		▪ power in ▪ 5 x LAN (5) ▪ 16 x USB (optional)
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	typ. 90 W
Maximum inrush current		11 A at 19 V
Product conformity		
Electromagnetic compatibility	EU: in line with EMC directive 2004/108/EC	applied harmonized standards: ▪ EN 55032: 2012/EN 61326-1: 2006 (home location, class B) ▪ EN 55024: 2010 ▪ EN 61000-6-2: 2005/EN 61326 (industrial location, class B)
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.

[1] 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 5G UE driver	Qualcomm IoT driver, Neul IoT driver	R&S®TSMA driver, R&S®TSME driver, R&S®TSMW driver	R&S®TSMA6 driver, R&S®TSME6 driver
GSM/GPRS	•		•				•	•
EDGE	•		•				•	•
WCDMA Rel. 99			•				•	•
HSPA+			•				•	•
CDMA2000® 1xEV-DO		•					•	•
WiMAX™ IEEE 802.16e							•	•
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
- 8 Gbyte RAM for Windows 7/10, 64 bit
- 255 Gbyte SSD
- DVD ROM drive
- USB 2.0 and LAN ports
- 15" monitor with a resolution of 1024 × 768 pixel
- Windows 7/10, 64 bit

Recommended notebook
- Dell Latitude E6540 (or newer)

Application: TETRA

Requirements
- R&S®TSMW scanner or R&S®TSME/R&S®TSME6 scanner or R&S®TSMA/R&S®TSMA6 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.

ASIO
COMPATIBLE

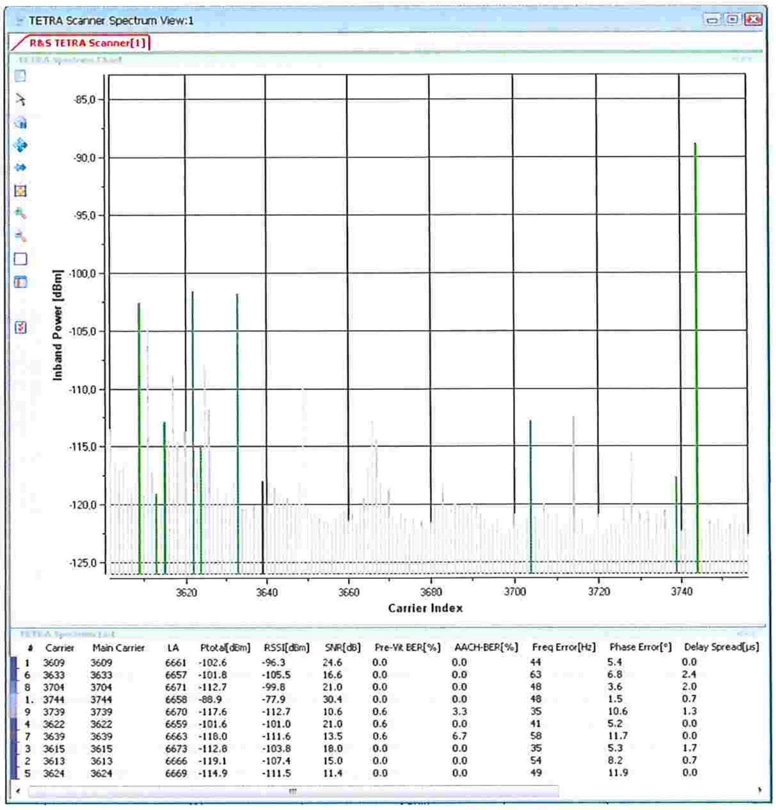
In the downlink, measurements performed using the R&S®TSMW in the D-CT and D-CTT operating modes include the following:

- 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, 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
- R&S®ROMES4SAM (Samsung driver)
- R&S®ROMES4QC (Qualcomm LTE driver)
- R&S®ROMES4T1W or R&S®ROMES4T1E (scanner driver)
- R&S®TSMW scanner or R&S®TSME scanner or R&S®TSMA scanner

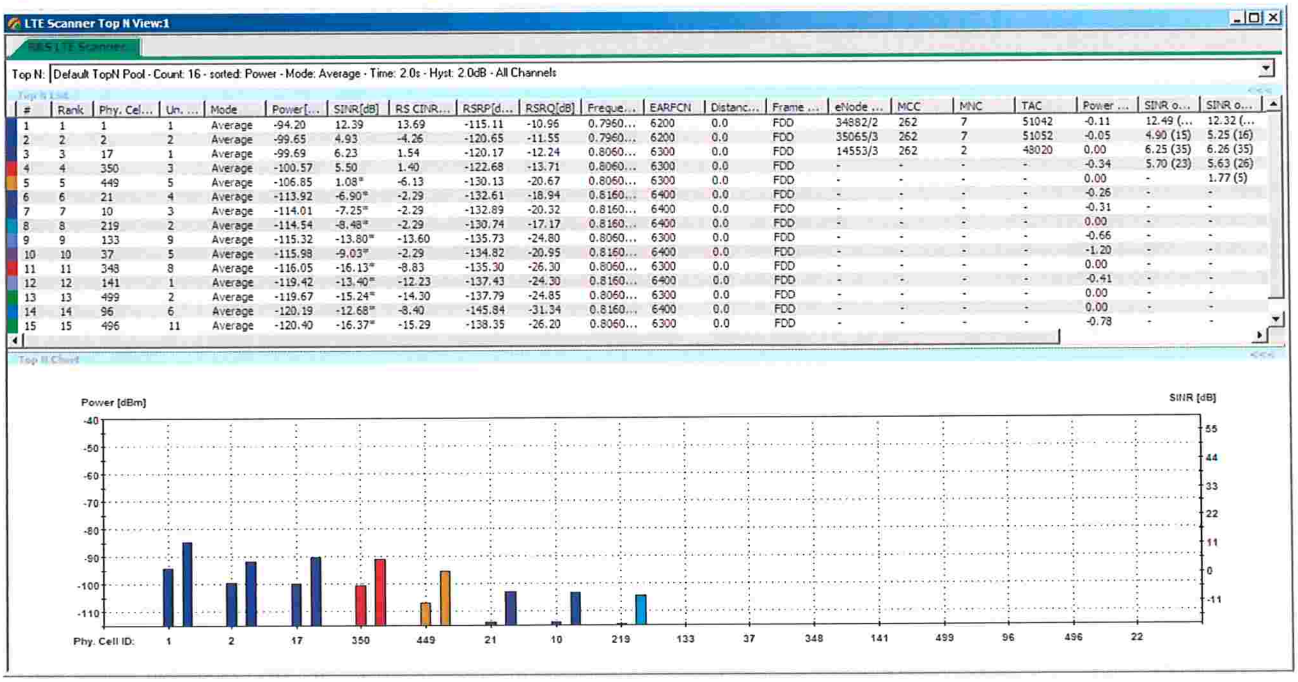
Coverage analysis with Rohde & Schwarz scanners

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.

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.

TopN View shows eNodeB signals sorted by strength



#	Rank	Phy. Cel...	Un. ...	Mode	Power[...	SINR[dB]	RS CINR...	RSRP[d...	RSRQ[dB]	Freque...	EARFCN	Distanc...	Frame ...	eNode ...	MCC	MNC	TAC	Power ...	SINR o...	SINR o...
1	1	1	1	Average	-94.20	12.39	13.69	-115.11	-10.96	0.7960...	6200	0.0	FDD	34882/2	262	7	51042	-0.11	12.49 (...	12.32 (...
2	2	2	2	Average	-99.65	4.93	-4.26	-120.65	-11.55	0.7960...	6200	0.0	FDD	35065/3	262	7	51052	-0.05	4.90 (15)	5.25 (16)
3	3	17	1	Average	-99.69	6.23	1.54	-120.17	-12.24	0.8060...	6300	0.0	FDD	14553/3	262	2	48020	0.00	6.25 (35)	6.26 (35)
4	4	350	3	Average	-100.57	5.50	1.40	-122.68	-13.71	0.8060...	6300	0.0	FDD	-	-	-	-	-0.34	5.70 (23)	5.63 (26)
5	5	449	5	Average	-106.85	1.08*	-6.13	-130.13	-20.67	0.8060...	6300	0.0	FDD	-	-	-	-	0.00	-	1.77 (5)
6	6	21	4	Average	-113.92	-6.90*	-2.29	-132.61	-18.94	0.8160...	6400	0.0	FDD	-	-	-	-	-0.26	-	-
7	7	10	3	Average	-114.01	-7.25*	-2.29	-132.89	-20.32	0.8160...	6400	0.0	FDD	-	-	-	-	-0.31	-	-
8	8	219	2	Average	-114.54	-8.48*	-2.29	-130.74	-17.17	0.8160...	6400	0.0	FDD	-	-	-	-	0.00	-	-
9	9	133	9	Average	-115.32	-13.80*	-13.60	-135.73	-24.80	0.8060...	6300	0.0	FDD	-	-	-	-	-0.66	-	-
10	10	37	5	Average	-115.98	-9.03*	-2.29	-134.82	-20.95	0.8160...	6400	0.0	FDD	-	-	-	-	-1.20	-	-
11	11	348	8	Average	-116.05	-16.13*	-8.83	-135.30	-26.30	0.8060...	6300	0.0	FDD	-	-	-	-	0.00	-	-
12	12	141	1	Average	-119.42	-13.40*	-12.23	-137.43	-24.30	0.8160...	6400	0.0	FDD	-	-	-	-	-0.41	-	-
13	13	499	2	Average	-119.67	-15.24*	-14.30	-137.79	-24.85	0.8060...	6300	0.0	FDD	-	-	-	-	0.00	-	-
14	14	96	6	Average	-120.19	-12.68*	-8.40	-145.84	-31.34	0.8160...	6400	0.0	FDD	-	-	-	-	0.00	-	-
15	15	496	11	Average	-120.40	-16.37*	-15.29	-138.35	-26.20	0.8060...	6300	0.0	FDD	-	-	-	-	-0.78	-	-

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.

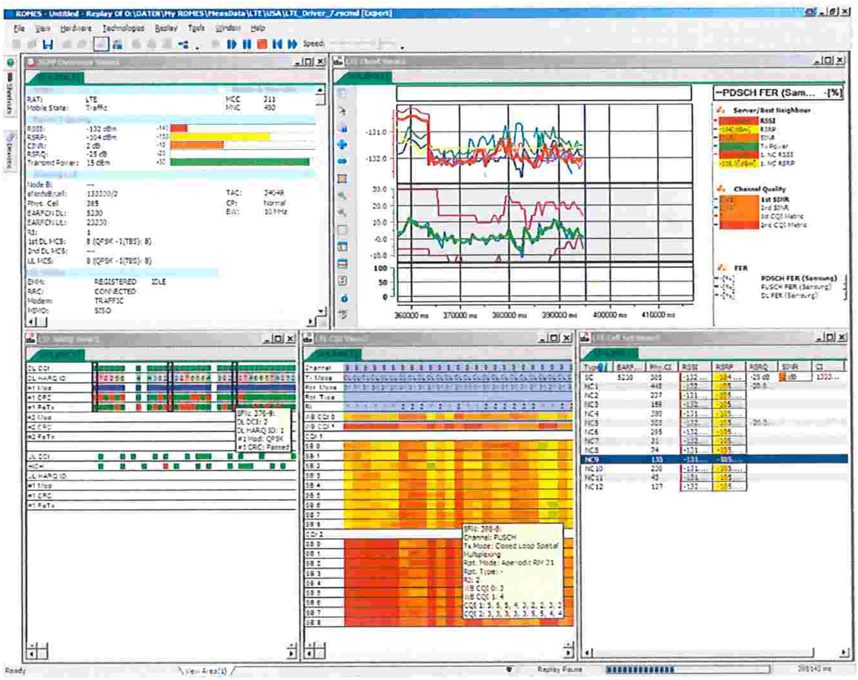
VoLTE measurements

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.

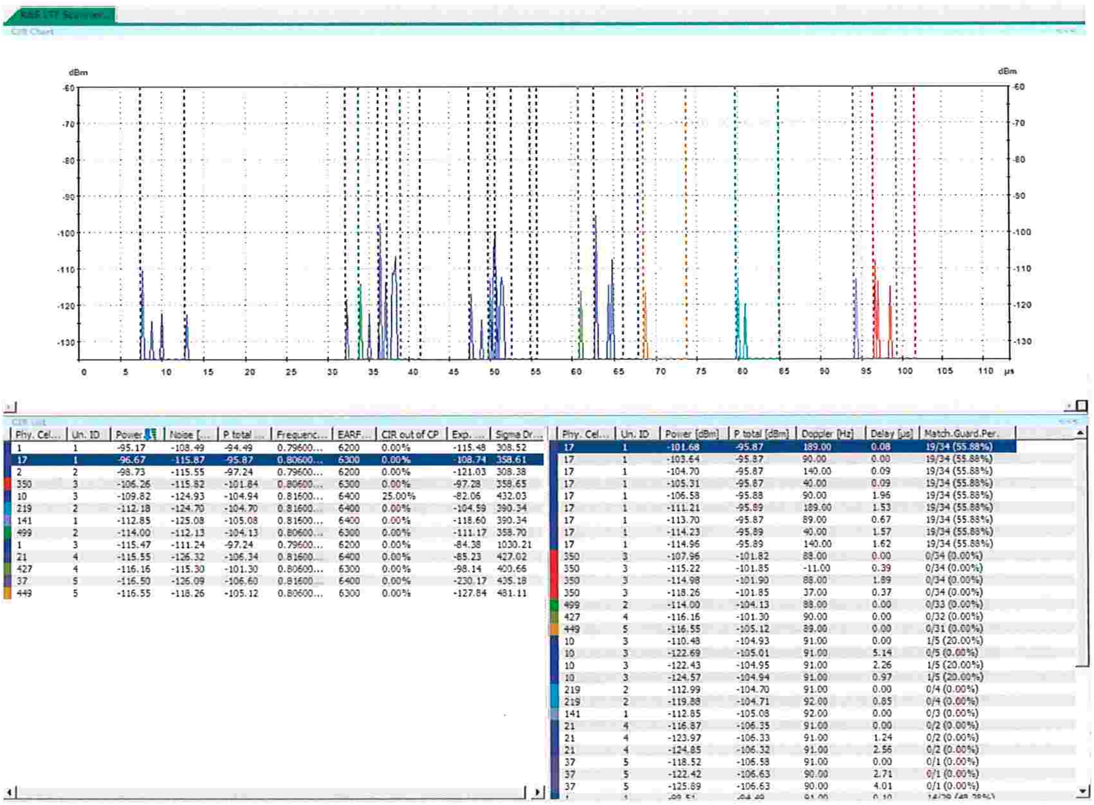
Demodulation of eNodeB broadcast information

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.

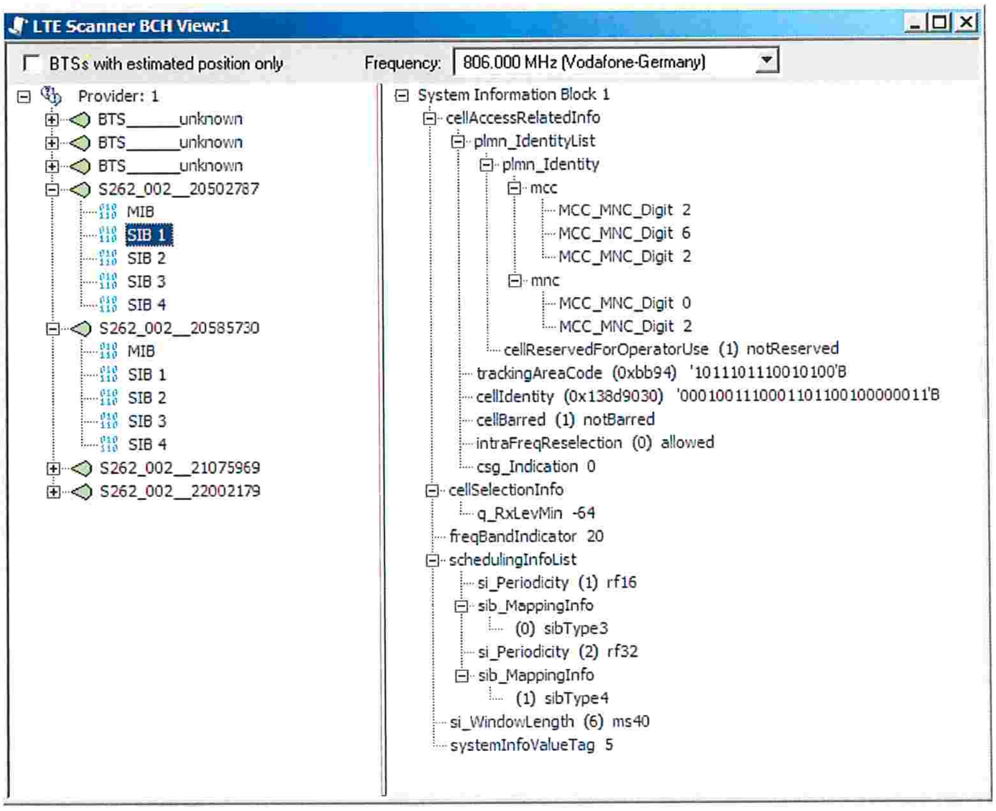
CIR View shows the channel impulse response (CIR) and all parts of the multipath propagation (echoes) together with a cell's cyclic prefix



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®TSME 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



Ordering information

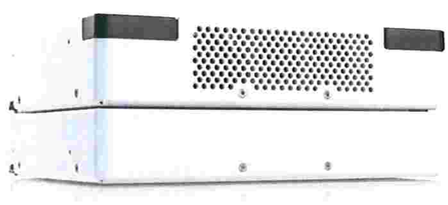
Designation	Type	Order No.
R&S®ROMES4 drive test software		
Platform for measurement and replay	R&S®ROMES4	1117.6885.04
Software replay version	R&S®ROMES4REP	1117.6885.34
Software maintenance contract and single software update		
Software maintenance contract for one year	R&S®ROMES4UPC	1510.8140.02
One-time software update within the R&S®ROMES4 generation	R&S®ROMES4UPS	1510.8140.03
One-time software update from the previous R&S®ROMES generation	R&S®ROMES4UPG	1510.8140.04
Scanner and receiver drivers		
R&S®TSMW driver	R&S®ROMES4T1W	1117.6885.02
R&S®TSME6, R&S®TSME, R&S®TSMA and R&S®TSMA6 driver	R&S®ROMES4T1E	1117.6885.82
R&S®TSME30DC downconverter driver	R&S®ROMES4T30D	4901.1004.02
Test mobile phone/data card drivers		
Qualcomm LTE/WCDMA/GSM	R&S®ROMES4QC	4900.5241.02
Qualcomm 5G NR UE	R&S®ROMES4NRQ	4900.5341.02
C2K Qualcomm CDMA2000® 1xEV-DO	R&S®ROMES4C2K	1117.6885.06
WLAN Windows	R&S®ROMES4WF2	1522.8211.02
Samsung 5G New Radio Exynos	R&S®ROMES4NRS	4900.5370.02
Samsung LTE/WCDMA/GSM	R&S®ROMES4SAM	1529.8100.02
Qualcomm eMBMS	R&S®ROMES4EMQ	1527.2034.02
Qualcomm NB-IoT	R&S®ROMES4NBQ	4900.5258.02
LTE carrier aggregation, downlink	R&S®ROMES4CA	1117.6885.90
LTE carrier aggregation, uplink (Qualcomm)	R&S®ROMES4CAU	4900.5270.02
LTE licensed assisted access	R&S®ROMES4LAA	4900.5312.02
VoLTE	R&S®ROMES4VO	1522.8186.02
Neul NB-IoT	R&S®ROMES4NBN	4900.5287.02
TETRA drivers (PEI) from Sepura including L3	R&S®ROMES4TET	1506.9930.02
QualiPoc test mobile support		
QualiPoc single phone support	R&S®ROMES4QP	49.00.5235.02
Special measurements and options		
Automatic channel detection	R&S®ROMES4ACD	1506.9869.03
GSM interference	R&S®ROMES4COI	1117.6885.56
Position estimation	R&S®ROMES4LOC	1117.6885.32
KPI enhancement: generation and measurement of user-specific KPIs	R&S®ROMES4KPI	1117.6885.66
Handover/neighborhood analysis for 3GPP (HOA/NBA 3GPP)	R&S®ROMES4HOA	1117.6885.22
Indoor	R&S®ROMES4IND	1117.6885.24
360 degree panorama measurement with R&S®HE300	R&S®ROMES4PAN	1117.6885.78
Remote control of scanner measurements	R&S®ROMES4RCO	1506.9917.02
Network problem analyzer (NPA)		
Network problem analyzer, base package	R&S®ROMES4NPA	1510.9276.02
NPA extended NQA plugin	R&S®ROMES4N11	1510.9299.11
Coverage plugin	R&S®ROMES4N15	1510.9424.02
Neighborhood analysis plugin	R&S®ROMES4N17	1510.9299.17
Spectrum analysis plugin	R&S®ROMES4N18	1117.6885.74
BTS evaluation	R&S®ROMES4N19	1522.8940.02
2G/3G/4G data plugin	R&S®ROMES4N20	1510.9299.20
Downlink carrier aggregation analysis plugin	R&S®ROMES4N21	1521.5360.02
VoLTE analysis plugin	R&S®ROMES4N22	1521.5377.02
Uplink carrier aggregation analysis plugin	R&S®ROMES4N23	4900.5306.02
Delta and comparative analysis plugin	R&S®ROMES4N30	1510.9299.30
LTE MIMO and downlink allocation analyzer	R&S®ROMES4N31	1510.9299.31

Designation	Type	Order No.
NB-IoT analysis plugin	R&S®ROMES4N34	4900.5206.02
NB-IoT UE analysis plugin	R&S®ROMES4N35	4900.5264.02
IoT test device		
Exelonix NB-IoT/LTE-M Qualcomm module	R&S®TMS-R410	3637.0473.02

Your local Rohde & Schwarz expert will help you find the optimum solution for your requirements.
To find your nearest Rohde & Schwarz representative, visit www.sales.rohde-schwarz.com

Related products
Mobile network scanners

R&S®TSMA6 ultracompact drive test scanner



- 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

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

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

All bands, all technologies simultaneously, ready for the future 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 ultracompact downconverter

- Ultra broadband RF frequency range for downconversion (24 GHz to 30 GHz)
- Parallel millimeterwave and sub-6 GHz measurements with a single scanner

Ultra broadband RF frequency range for downconversion (24 GHz to 30 GHz)

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

R&S®TSMA autonomous mobile network scanner

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

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.

R&S®TSME ultracompact drive test scanner

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

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.

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R&S®TSMW universal radio network analyzer

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

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, preselection 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.

R&S®TSML-CW radio network analyzer

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

Drive test scanner for CW measurements

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

Test mobile

QualiPoc Android

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

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

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

Sustainable product design

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

Certified Quality Management
ISO 9001

Certified Environmental Management
ISO 14001

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R&S® ROMES4 Drive Test Software
Data without tolerance limits is not binding | Subject to change

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