

Be ahead in 5G.  
Be ready  
for the future.

Test solutions  
for 5G



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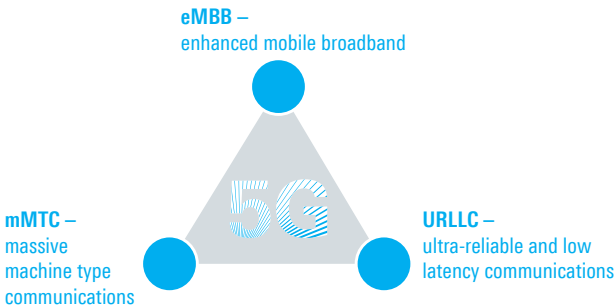
**ROHDE & SCHWARZ**

Product	Development of RF and baseband	Development of protocol stack	Verification and conformance tests	Production and service	Network deployment and optimization
<b>Signal generation</b>					
R&S®SMW200A vector signal generator with optional fading simulator	FWA, eMBB, NB-IoT		FWA, eMBB, NB-IoT		
R&S®SMW-K144 5G NR signal generation	eMBB				
R&S®SMW-K114 OFDM signal generation	FWA		FWA		
R&S®SGT100A SGMA vector RF source	NB-IoT		NB-IoT	NB-IoT	
<b>Signal and spectrum analysis</b>					
R&S®FSW signal and spectrum analyzer	FWA, eMBB, NB-IoT		FWA, eMBB, NB-IoT		
R&S®FSW-K144/-K145 5G NR DL/UL signal analysis	eMBB				
R&S®VSE-K96 OFDM signal analysis software	FWA		FWA		
R&S®VSE-K106 NB-IoT vector signal explorer software	NB-IoT		NB-IoT		
R&S®FSW--K18/-K18D amplifier measurements	FWA, eMBB			FWA, eMBB	
<b>Network analysis</b>					
R&S®ZNB/ZNBT/ZVA vector network analyzers	eMBB		eMBB	eMBB	
<b>Power measurements</b>					
R&S®NRPM OTA power measurement solution	FWA, eMBB		FWA, eMBB	FWA, eMBB	
R&S®NRP power sensor family	eMBB, NB-IoT		eMBB, NB-IoT	eMBB, NB-IoT	
R&S®RT-ZVC04 multichannel power probe	NB-IoT			NB-IoT	
<b>Wireless communications testing</b>					
R&S®CMW500 wideband radio communication tester	NB-IoT	NB-IoT	NB-IoT		
R&S®CMWrun battery life measurements	NB-IoT				
R&S®CMW-KM052 IP connection security analysis for R&S®CMW500	URLLC				
R&S®CMW100 communications manufacturing test set				eMBB, NB-IoT	
R&S®TS8991 OTA performance test system	FWA, eMBB, NB-IoT		FWA, eMBB, NB-IoT		
R&S®AMS32 OTA measurement software	eMBB		eMBB		
<b>Mobile network testing</b>					
R&S®TSME ultra-compact drive test scanner					FWA
R&S®ROMES drive test software					FWA
<b>System components and shielded chambers</b>					
R&S®TS7124 RF shielded box	eMBB, NB-IoT		eMBB, NB-IoT	eMBB, NB-IoT	
R&S®DST200 RF diagnostic chamber	eMBB, NB-IoT		eMBB, NB-IoT		
R&S®ATS1000 antenna test system	eMBB		eMBB		
R&S®OSP open switch and control platform	FWA, eMBB		FWA, eMBB	FWA, eMBB	

# Be ahead in 5G. Be ready for the future.

**At Rohde & Schwarz, your test and measurement challenges are our motivation to provide solutions for your success.**

Up to now, concrete and confined use cases such as mobile voice for 2G and mobile data for 4G dominated the definition of cellular technologies. The next generation of mobile networks, 5G, introduces a paradigm change towards a user and application centric technology framework, with the goal of flexibly supporting three important use case families:



Enhanced mobile broadband (eMBB) focuses on supporting the ever-increasing end user data rate and system capacity, while massive machine type communications (mMTC) targets the cost-efficient and robust connection of billions of devices without overloading the network. With ultra-reliable low latency communications

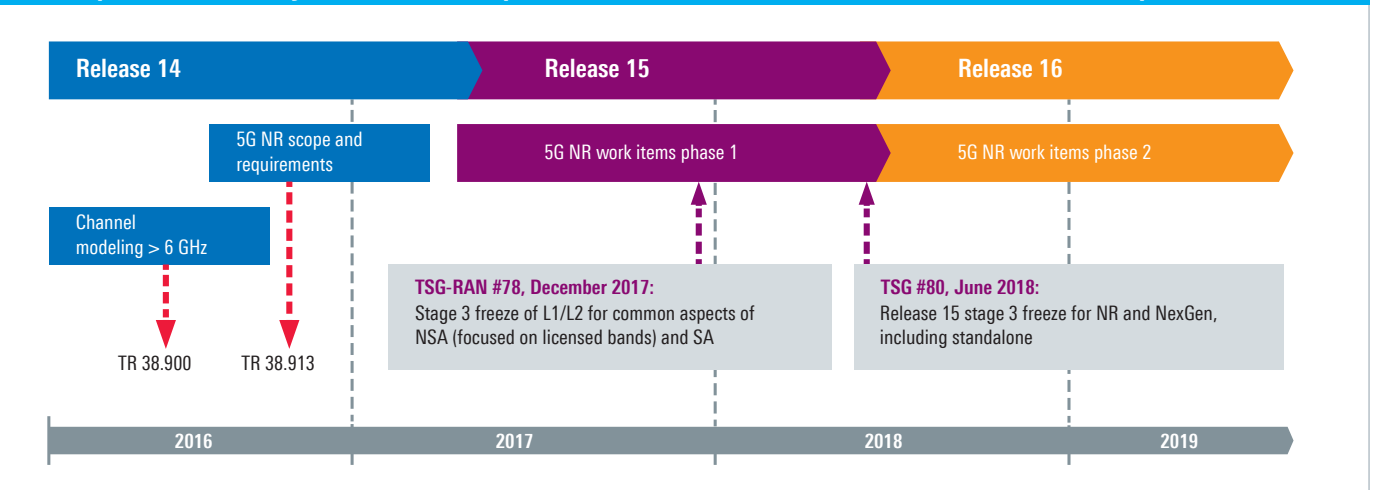
(URLLC), 5G opens up an entirely new use case family by supporting new requirements from vertical industries such as autonomous driving for the automotive industry, remote surgery for eHealth and cloud robotics for Industry 4.0.

All three use case families require new technology components – from components and chipsets to assembled user devices and base stations – that challenge product development. Cellular network installation in the field also creates new demands. 3GPP, the responsible standardization body, will initially cover 5G specification work in two successive releases: 3GPP Release 15 and 16. Release 15 describes the 5G NR physical layer and was officially released in December 2017. Pre-5G systems are being implemented ahead of the 3GPP 5G specifications. These systems address specific scenarios such as fixed wireless access (FWA) for last mile connections of households and eMBB use cases to support mobility based on tightly coupled LTE interworking.

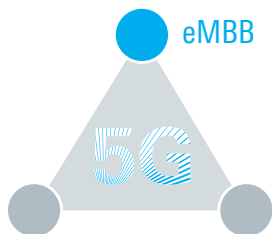
## Be ahead in 5G device and infrastructure equipment testing

Technological innovations combined with close and trustworthy customer relationships lead to innovative test and measurement solutions that allow customers to launch their products more quickly and safely. Rohde & Schwarz was one of the first to generate and analyze pre-5G signals that operate in the 28 GHz (or 39 GHz) frequency band and apply a cyclic prefix OFDM-based waveform with 75 kHz subcarrier spacing. Latest enhancements make it possible to generate and analyze 5G NR sub-6 GHz and mmWave signals. As a world market and technology leader in all areas of RF and microwave test and measurement equipment, Rohde & Schwarz supports the entire mobile technology lifecycle for performing measurements in the lab, in production and in the field.

### 3GPP specifies two major architecture options: non-standalone (NSA) and standalone (SA) operation



# Be ahead in mobile broadband



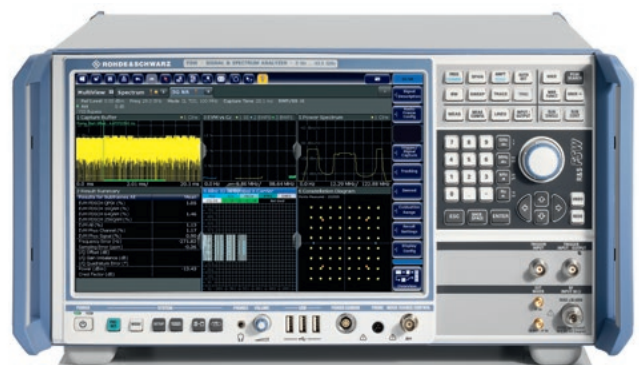
eMBB introduces two major technology enhancements: shifting the frequency spectrum to the cmWave and mmWave range for much higher bandwidth allocations and an advanced antenna array that includes tens or even hundreds of TX/RX antenna elements to enable massive MIMO.

## Efficient mmWave component testing

Beside conventional sub-6 GHz frequency bands, 3GPP has initially defined a frequency range of 24.25 GHz to 52.6 GHz for 5G NR operation. First commercial deployments will use 26 GHz to 28 GHz and 39 GHz frequencies. Higher frequencies and larger bandwidth place challenging demands on RF components such as filters, mixers, power amplifiers and antennas that are used in mobile devices and infrastructure systems. To efficiently and reliably characterize these components, measurement systems must offer wide frequency coverage, high dynamic range, high output power, signal stability and signal quality with as little distortion and as few harmonics as possible.

Rohde & Schwarz offers test and measurement equipment that fulfills the demanding requirements for component characterization in all specified 5G NR frequency ranges, for instance the R&S®ZNB/ZNBT/ZVA vector network analyzers. To generate and analyze wideband signals with up to 2 GHz bandwidth, the R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer are the instruments of choice. Both support sub-6 GHz and mmWave signals and provide dedicated 5G NR measurement options that fully support the 5G NR flexible numerology, e.g. in terms of subcarrier spacing and multiple bandwidth parts. They also provide outstanding performance, achieving an EVM of better than 1 % over a 10 dB power range. Power amplifiers are crucial to link performance, particularly in mmWave frequency bands. The R&S®FSW-K18 uses CW and modulated stimuli to characterize power amplifiers (PA) in detail, efficiently determining amplifier KPIs such as EVM, AM/AM plus AM/PM conversion and gain compression from a single measurement.

Powerful solution to generate and analyze wideband signals for characterizing demanding RF components such as power amplifiers.





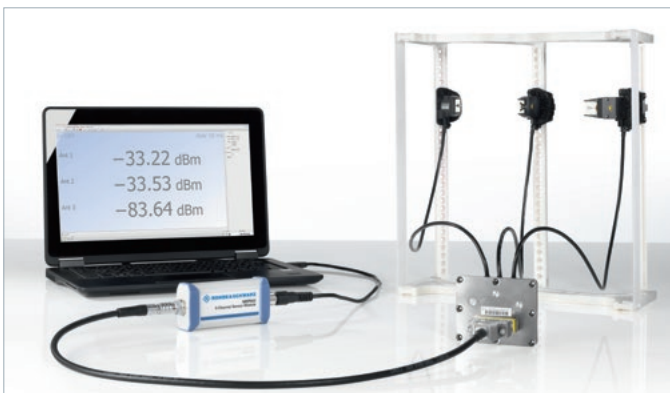
## Accurate antenna testing for massive MIMO

Massive MIMO has two basic capabilities: it supports multiple spatial data streams and steerable beam patterns. Both techniques are flexibly applied in real-world networks to increase data throughput and coverage. LTE networks already apply spatial multiplexing with a couple of antenna elements. Massive MIMO with tens or even hundreds of antenna elements becomes indispensable in 5G to compensate for the high path loss in the cmWave and mmWave spectrum. Initially, massive MIMO is applied at base stations. Basic beamforming schemes can also be implemented in user devices.

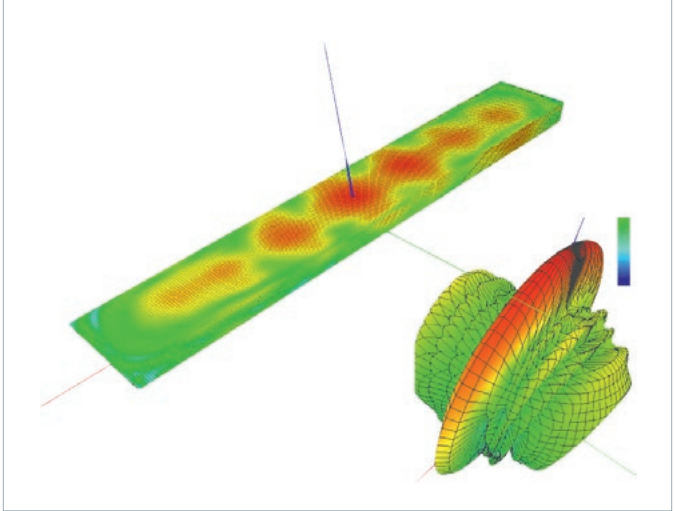
Testing massive MIMO requires a paradigm change. The large number of antenna elements together with the need for low path loss and small size lead to highly integrated PCBs that include antennas, amplifiers and analog phase shifters. As a result, no RF connectors are available anymore. 5G mmWave devices need to be tested over the air (OTA). The test challenges include calibrating over-the-air (OTA) antenna elements, measuring mutual coupling between the elements and characterizing the desired beam pattern, i.e. measuring radiated power, EVM and EIRP, and characterizing 3D antenna patterns.

Rohde&Schwarz offers a wide range of over-the-air test solutions for user devices and base stations in R&D and production. Near-field to far-field transformation considerably decreases the size of the shielding chambers for active antenna arrays (AAS) and leads to compact test systems like the R&S®TS8991 OTA performance test system, which was the first solution on the market to offer beam pattern measurements and compliance testing. With the R&S®TS-ATS1000 Rohde&Schwarz even offers a mobile OTA test system specifically designed for verifying user devices operating in the mmWave range. For production environments, the R&S®NRPM OTA power sensors are the ideal solution for performing fast and accurate realtime beam-steering and beam-tracking measurements.

Fast and accurate realtime OTA power measurements in production.



## Over-the-air antenna measurement

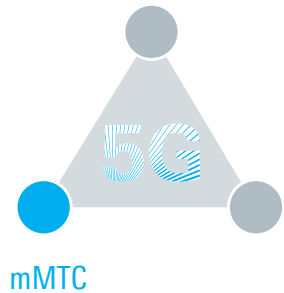


E-field visualization and accurate OTA beam pattern measurement for AAS.

R&S®ATS1000 antenna test system for passive and active antenna measurements in the mmWave range.



# Be ahead in connecting everything



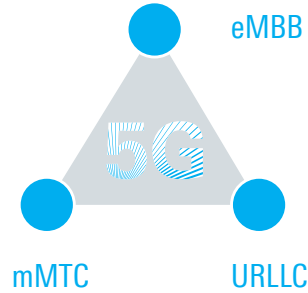
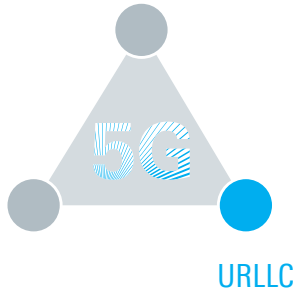
Wireless connectivity is a critical IoT success factor since expectations with respect to coverage, cost efficiency, security and longtime availability are extremely high. IoT applications such as parcel or goods tracking that require global coverage and mobility will focus on cellular technologies, especially on LTE-M and NB-IoT, and 5G NR IoT in the future. IoT devices that are used, for example, inside a building will also apply non-cellular technologies such as Bluetooth®, WLAN/Wi-Fi, ZigBee and Thread operating in the unlicensed frequency bands. Testing is essential in order to ensure proper functionality as well as lifetime quality, security and performance. Particularly the power consumption of IoT devices is critical since many IoT applications demand battery lifetimes of 10 years and more.

The R&S®SMx-K115 and R&S®SGT-K415 options together with the R&S®VSE-K106 software efficiently generate and analyze NB-IoT signals. Monitoring the impact of the application processor or the baseband chip on the total power consumption of an IoT device is also essential. The unique and cost-efficient solution consisting of the R&S®CMWrun sequencer software tool and the R&S®RT-ZVC04 power probe precisely measures power and current on IoT devices.



Precise power and current measurements on IoT devices.

# Be ahead in network and mobile endpoint security



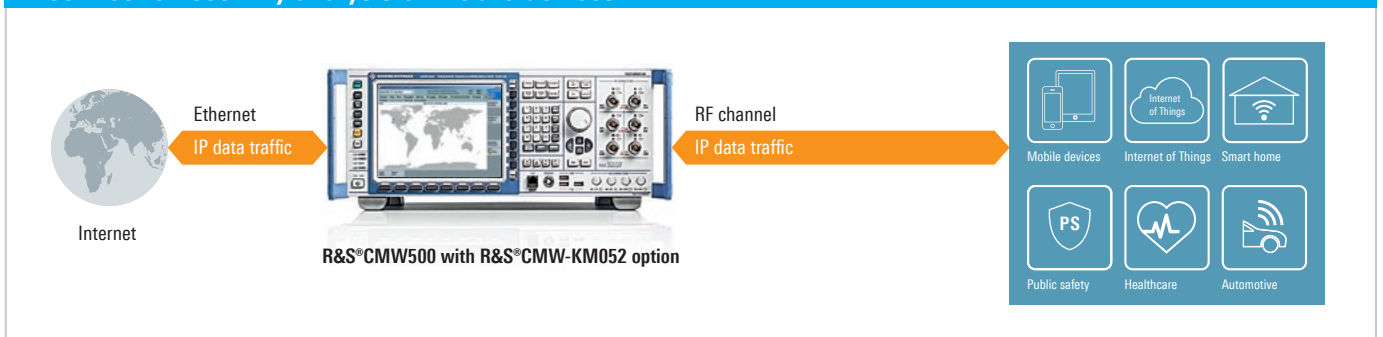
URLLC use cases drive the need to improve latency, reliability, availability and security to enable, for example, industrial control and tactile Internet applications. Shorter latency or higher reliability and availability require intensified testing and verification processes. Especially security plays an important role in many scenarios. The majority of URLLC use cases are expected to be part of 3GPP Release 16. LTE-Advanced Pro advancements specified in Releases 13 and 14 pave the way for 5G URLLC use cases such as autonomous driving for the automotive industry, remote surgery for eHealth and cloud robotics for Industry 4.0.

Test solutions from Rohde&Schwarz support the development of tailor-made communications solution for vertical industries, setting the foundation for connected mobility and automotive safety applications. The R&S®CMW500 wideband mobile communication tester was the first product on the market to analyze direct vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications in line with the 3GPP specifications.

IP connection security becomes an important topic, particularly when the mobile communications or IoT device will manage sensitive data or control systems. Authentication and encryption are required for all communications channels to the Internet in order to secure the information exchanged.

Again, Rohde&Schwarz is the first to offer a solution and has integrated IP connection security analysis into its established R&S®CMW500 wideband mobile communication tester. The solution detects and analyzes the IP data stream in realtime. Now, for the first time, manufacturers of mobile communications and IoT devices can identify vulnerabilities in the IP connection security under controlled network conditions in the lab. Development engineers can now improve the IP connection security of their devices at an early stage of development.

## IP connection security analysis of mobile devices



## Service that adds value

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

## About 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, this independent company has an extensive sales and service network and is present in more than 70 countries. The electronics group is among the world market leaders in its established business fields. The company is headquartered in Munich, Germany. It also has regional headquarters in Singapore and Columbia, Maryland, USA, to manage its operations in these regions.

## 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**

## Rohde & Schwarz GmbH & Co. KG

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

## Rohde & Schwarz training

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

## Regional contact

- | Europe, Africa, Middle East | +49 89 4129 12345  
[customersupport@rohde-schwarz.com](mailto:customersupport@rohde-schwarz.com)
- | North America | 1 888 TEST RSA (1 888 837 87 72)  
[customer.support@rsa.rohde-schwarz.com](mailto:customer.support@rsa.rohde-schwarz.com)
- | Latin America | +1 410 910 79 88  
[customersupport.la@rohde-schwarz.com](mailto:customersupport.la@rohde-schwarz.com)
- | Asia Pacific | +65 65 13 04 88  
[customersupport.asia@rohde-schwarz.com](mailto:customersupport.asia@rohde-schwarz.com)
- | China | +86 800 810 82 28 | +86 400 650 58 96  
[customersupport.china@rohde-schwarz.com](mailto:customersupport.china@rohde-schwarz.com)

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