# 5G Solutions for Network Equipment Manufacturers

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KEYSIGHT

BROCHURE

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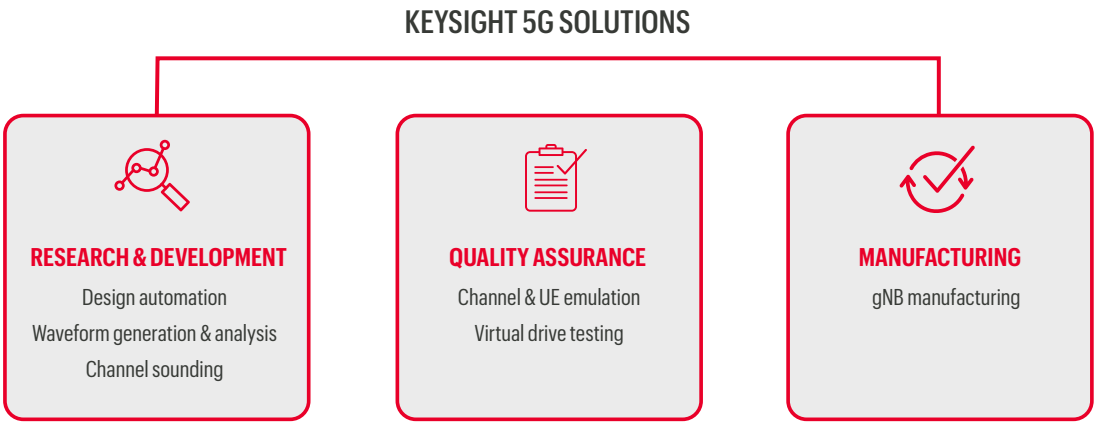
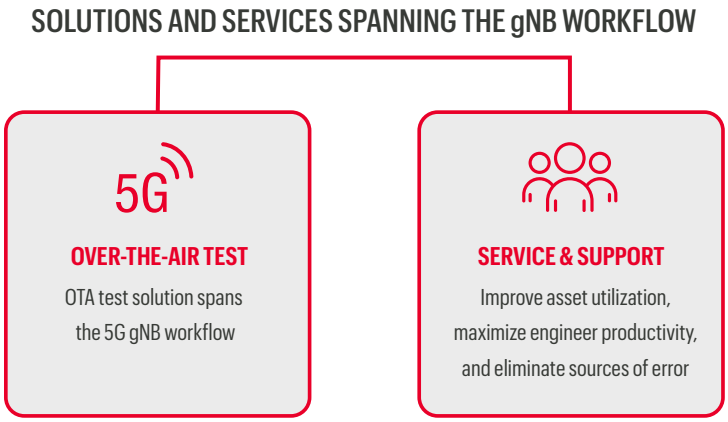
# 5G Solution for Network Equipment Manufacturers

Network equipment manufacturers (NEMs) continue to accelerate product launches to gain 5G market share. 5G requires new technologies and performance improvements that challenge the way engineers design, test, and optimize 5G base stations (gNB) and network equipment.

Keysight's expertise and solutions for radio frequency (RF) design and Internet Protocol (IP) networking enable NEMs to accelerate the delivery of secure, reliable, and cost-effective 5G products.



"5G NR leverages massive MIMO and beamforming capabilities, which need to be extensively tested in a field environment."

"Keysight's 5G field measurement solutions help our field verification teams verify feature performance and ensure proper functionality prior to network deployment."

"A single, portable solution capable of measuring both mmWave and sub-6 GHz frequency ranges allows us to verify 5G coverage in both indoor and outdoor environments."

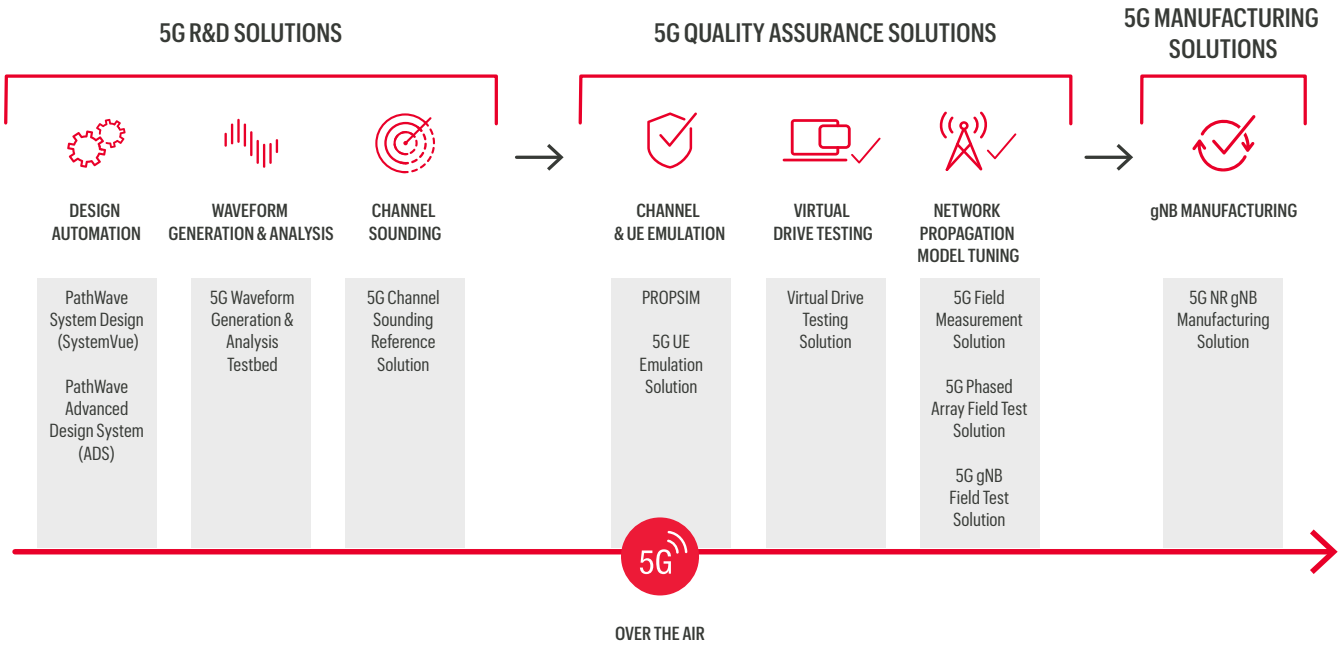
– Erkka Ala-Tauriala
Head of Cloud Development Services
Nokia

# Overview: End-to-End 5G Solutions Connect and Accelerate the Workflow

Since the launch of the first 5G chipsets in 2018, chipset vendors, device makers, NEMs, and service providers have been jockeying for leadership position. The 5G rollout phase is in full swing, with new commercial 5G deployments added every week as service providers rush to expand 5G coverage.

Standards have continued to evolve since 5G New Radio (NR) emerged in 2017 with the approval of the non-standalone (NSA) version. The standalone (SA) version and other releases followed in 2018. Release 16 in 2021 brought necessary capabilities for vehicle-to-everything and Industrial Internet of Things applications, unlicensed bands, and high frequencies. Release 17 will add even more enhancements in 2022.

Technical complexity is high. NEMs need to integrate complex multichannel antennas over many frequency bands. Other objectives include lower latency and support for a broad range of machine and user behaviors in base stations. NEMs need test solutions that accelerate time to market.



RESEARCH & DEVELOPMENT

# Research and Development Solutions to Accelerate Innovation

## Scenario

NEMs building 5G base stations need to integrate complex multichannel antenna arrays from sub-6 GHz to millimeter-wave (mmWave) frequencies. They also need to deliver lower latency and support a comprehensive range of machine-to-machine user behaviors. Keysight partnered early with chipset makers, device manufacturers, and network operators to understand 5G challenges for designers.

The goal: to deliver innovative 5G design automation, waveform and signal generation analysis, and over-the-air (OTA) test solutions.

# Design Automation Solutions

## PathWave System Design (SystemVue)

Keysight's PathWave System Design (SystemVue) is electronic design automation (EDA) software for electronic system-level designs. The EDA software enables engineers to innovate the physical layer (PHY) of wireless communication systems. The solution features baseband exploration and verification libraries to create and quickly verify algorithms and high-performance system architectures. It also includes application personalities and design kits for deeper analysis and implementation tasks. Beam performance in a system is a key application addressed by System Vue.

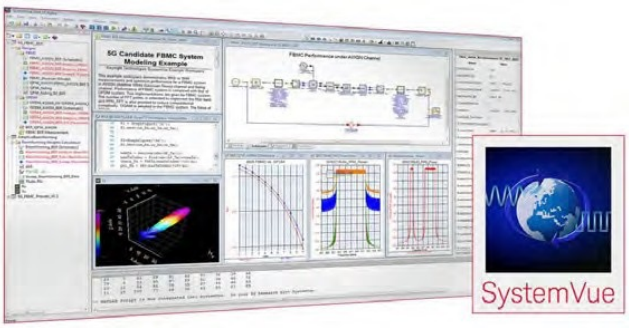
**PathWave System Design (SystemVue) Benefits:**

Reduce PHY development and verification time by 50%.

Maximize design margins with best-in-class RF fidelity.

Accelerate innovation from architecture to verification.

Capitalize on baseband and RF synergies.




### PathWave System Design (SystemVue) baseband verification and exploration libraries

Access a compilation of sources, receivers, functions blocks, reference designs, native source code for PHY blocks, and standard documentation. These libraries help you verify algorithms and high-performance system architectures quickly. PathWave System Design (SystemVue) standards-based baseband PHY libraries include the following:

- W4522E PathWave 5G and Cellular Library
- W4503E PathWave Phased Array Simulation

- W1918EP LTE-Advanced Baseband Verification Library* (also includes LTE)
- W4501E PathWave Comms / DSP Simulation

Perform deeper analysis and implementation tasks with the following application personalities and design kits:

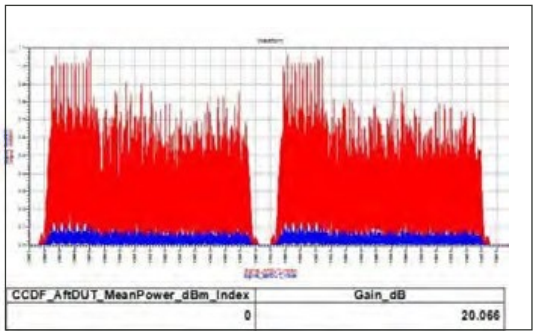
- W4503E PathWave Phased Array Simulation
- W4502E PathWave RF Simulation

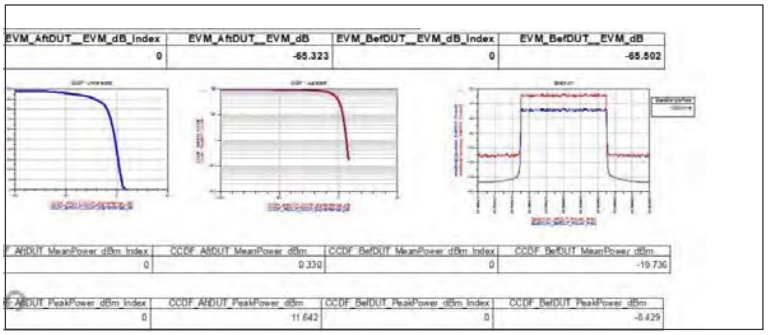
*Included in W4522E PathWave 5G and Cellular Library

## PathWave Advanced Design System

Keysight's PathWave Advanced Design System (ADS) is the industry-leading EDA and design automation software. Engineers can verify their designs for existing and emerging wireless standards with the wireless libraries.

Signal generation and demodulation algorithm compliance with Keysight instrumentation brings instrument-level compliance and accuracy into circuit simulation and verification results. Keysight's active participation in standards committees gives you an edge over your competition.




W2383EP 5G modem for ADS

## Solution highlights

- preconfigured simulation setups with golden reference sources to save time and design with greater confidence
- faster time to market through full demodulation compliance with wireless specifications
- PathWave System Design (SystemVue) 5G verification test bench components for schema-based component palette list and component library browser
- source and measurement setups from PathWave System Design (SystemVue) to perform verification using real-world complex modulated signals that conform with standards
- analysis test benches for 5G filter bank multicarrier import capability for customized 5G verification test benches from PathWave System Design (SystemVue) to build upon work completed earlier in the workflow

### PathWave (ADS) Benefits:

Achieve first-pass design success using powerful desktop simulation tools and workflows.

Leverage 30+ years of expertise in design with application-specific guides.

Access software supported by leading industry and foundry partners.

# 5G Waveform Generation and Analysis Solutions

Keysight's 5G waveform generation and analysis solution generates and analyzes 3GPP Project standards-compliant and custom 5G waveforms at frequency range 1 (FR1) and frequency range (FR2) millimeter-wave (mmWave) frequencies. Factory-calibrated instruments enable metrology-grade measurements at 5G frequencies, amplitudes, and modulation bandwidths. Easily accomplish de-embedding by importing the S-parameters of the test fixtures to move the calibration plane to the device-under-test (DUT) interface.

**5G Waveform Generation and Analysis Testbed Benefits:**

Save time with built-in 5G signal creation and signal analysis tools.

Widest measurement bandwidth up to 110 GHz, ready for 5G and future requirements.

Multichannel capability support for phased array, MIMO, and gNB conformance test needs.

## Three configurations are available to address different application requirements:

### 110 GHz 5G testbed, traditional configuration

Keysight's M9484C VXG microwave signal generator and N9042B UXA signal analyzer address the most demanding 5G applications. This configuration performs various RX tests with the VXG, including creating the wanted and interfering signals blocking and intermodulation testing, 4x4 MIMO spatial multiplexing tests, and beamforming. For the most challenging design work, design engineers can use these VXG features:

- four-channel capability
- frequency coverage up to 54 GHz internally (with up to 110 GHz using the compact remote upconverters)
- eight virtual baseband generators per RF channel
- 2.5 GHz channel bandwidths (with up to 5 GHz bandwidths through channel bonding)

- nonlinear instrument corrections to push output power to extreme levels
- unparalleled signal purity from the direct digital synthesis architecture and ultra-stable reference system

Transmitter tests with the UXA include in-channel measurements like error vector magnitude (EVM) and channel power and out-of-channel and out-of-band measurements like adjacent channel leakage ratio and spurious measurements. Design engineers can use these UXA features:

- 4 GHz internal digitizer bandwidth and the 11 GHz bandwidth analysis with the external Keysight M8131A digitizer
- 50 GHz internal frequency coverage and up to 110 GHz with the frequency extender
- combined LNA and preamp to optimize analysis for low-level signals

The VXG and UXA can also work together for various stimulus-response measurements of components, including digital predistortion measurements of power amplifiers.

## Massive MIMO 5G testbed

The testbed uses the M9484C VXG signal generator and the Keysight UXR1104A high-performance oscilloscope to perform time-aligned, phase-coherent measurements for up to four channels with frequency coverage up to 110 GHz. Typical measurements include 4x4 MIMO signal creation and analysis and phase-coherent measurements of phased array antenna systems.

The VXG architecture enables scaling RF signal creation from four channels to virtually any number by cascading multiple chassis together to provide time-aligned and phase-coherent channels. Substitute the MXR oscilloscope for the UXR to enable analysis of up to eight channels for sub-6 GHz measurements. Add the Keysight L8990M switch matrix system to enable calibrated magnitude and phase measurements and time alignment error for a reference port or channel relative to the other ports in the system. The massive MIMO 5G testbed can also make switched measurements of transmitter characteristics or test receiver performance with blocking on one port at a time of a massive MIMO radio.

## 110 GHz 5G, wideband testbed

This configuration enables signal creation of up to 110 GHz with very wide bandwidths. The M9484C VXG microwave signal generator can produce 2.5 GHz wide signals or 5 GHz bandwidth signals through channel bonding up to 110 GHz frequencies. Combined with Keysight's M9195A arbitrary waveform generator and an external mixer, it can create bandwidths up to 10 GHz. The VXG, with its extremely low phase noise, can serve as the local oscillator (LO) mixer for upconversion to the desired frequency range.

For analysis, the Keysight N9042B UXA with the V3050A frequency extender can demodulate signals up to frequencies of 110 GHz with 4 GHz of analysis bandwidth. Pair the M8131A digitizer with the UXA to increase the demodulation bandwidth up to 11 GHz.

Finally, the UXR oscilloscope offers 10-bit ADC and 256 GSa/s sample rate. It can provide near-signal-analyzer-like in-channel measurement quality for signals with up to 110 GHz bandwidth using up to four channels simultaneously if required.

# Wideband RF / mmWave signal creation

The Keysight PathWave Signal Generation software, N7631APPC PathWave Signal Generation for 5G NR, enables design engineers to generate 5G NR waveforms quickly. 5G features include carrier aggregation. Engineers can quickly test transmitters and receivers with channel coding and multiantenna support. Download and play back 5G-compliant signals with Keysight's portfolio of wideband signal generators, such as the VXG microwave signal generator or the M819xA series of arbitrary waveform generators.

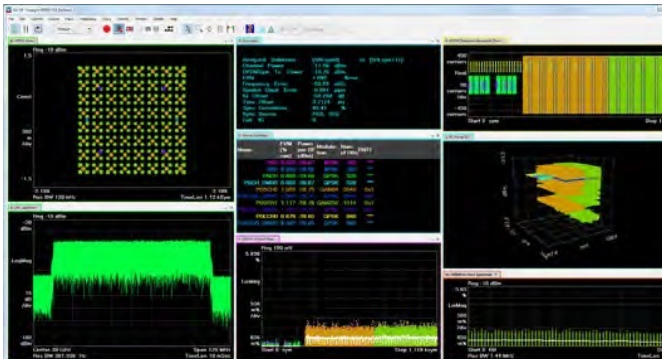
X-Series signal generator with Signal Studio software and X-Series analyzer

## Solution highlights

- generates, exports, downloads, and plays back 3GPP 5G NR waveforms for testing components and receivers
- creates downlink and uplink signals with low-density parity-check (LDPC) and polar codes for receiver testing
- offers multiantenna port transmission, including spatial multiplexing and transmit diversity
- includes downlink and uplink channels and signals to support all channel and signal types defined by 3GPP

# Wideband RF / mmWave signal analysis

Keysight's PathWave Vector Signal Analysis (89600 VSA) software with 5G NR modulation analysis provides a comprehensive and forward-compatible toolset for demodulation and vector signal analysis. With a Keysight signal analyzer, oscilloscope, or digitizer, users can demodulate and analyze 5G waveforms in different downlink, uplink, or coexistence scenarios.



89601BHNC PathWave VSA 5G NR Modulation Analysis

## Solution highlights

- provides deeper insights via detailed analysis and troubleshooting traces with coupling measurements across domains, including EVM versus spectrum, EVM versus time, constellation, and 3D resource element power
- confirms successful transmission of base station initial access with automatic detection of SS physical broadcast channel (SS / PBCH) and analyzes beam sweeping with SS / PBCH phase and power traces
- enables testing beyond the physical layer with LDPC and polar decoding capability
- provides CRC pass / fail for each channel and all the information carried within the PBCH and the physical downlink control channel

# 5G Channel Sounding Solution

Keysight's 5G Channel Sounding, Reference Solution consists of multiple hardware and software elements to provide multichannel, wideband signal generation and analysis to characterize 5G radio channels. This solution helps research engineers advance 5G channel modeling at mmWave frequencies.

The test platform addresses the challenges posed by mmWave frequencies and wide analysis bandwidths for 5G channel capture and characterization. Researchers can determine the properties of a radio channel by understanding the impact of path loss, Doppler effect, and other issues on signal transmission. The solution easily scales up by adding Keysight upconverters, downconverters, and digitizers.

**5G Channel Sounding, Reference Solution Benefits:**

Achieve breakthroughs using multichannel high-precision instrumentation.

Reduce time to insight with MIMO channel sounding and real-time data processing capability.

Address evolving measurement requirements with one versatile test platform.

## Solution highlights

- comprehensive measurements of frequency response
  - amplitude and unwrapped phase and group delay
  - absolute path loss and power delay profile
  - angle of arrival
  - angle of departure
  - angular spread
- wideband transmitter and receiver test calibration, including vector precorrections, IQ frequency response, IQ imbalance, and channel-to-channel skew for complete measurement and decision confidence
- precise transmit / receive timing and synchronization for high measurement accuracy when capturing and characterizing potential channels
- configuration and test tools for input / output control, system-wide calibration, data storage, and streaming for the efficient characterization of complex 5G channels
- three standard configurations — 40 GHz and four channels, 40 GHz and eight channels, and 44 GHz — and four channels
- custom solutions for higher frequencies, wider analysis bandwidths, and channel counts (up to 104 channels) to address a wide range of applications

QUALITY ASSURANCE

# Quality Assurance Solutions to Accelerate Validation

## Scenario

More demanding users and the competitive nature of the commercial wireless communications industry make it critical for NEMs to validate network equipment performance. Keysight solutions accurately emulate and measure 5G devices, operator networks, and extensive subscriber behavior scenarios. Expertise in RF, mmWave design, and IP networking enables NEMs to accelerate the delivery of secure, reliable, and cost-effective 5G networking equipment.

# 5G channel and UE emulation solutions

## 5G channel emulation

Keysight's PROPSIM 5G Channel Emulation Solution allows NEMs to validate new product releases and features. This solution tests the performance of 5G network equipment, including base stations and small cells. Users validate protocol layers and RF performance and gain access to key performance indicators. The PROPSIM solution covers beam management, data throughput, and stability under 5G fading channel conditions.

Wider bandwidths, mmWave frequencies, and beamforming used in 5G result in complex 3D propagation channels. Keysight's PROPSIM F64 5G Channel Emulation Solution enables quick network and user equipment (UE) emulation in the laboratory. It has the widest signal bandwidth and the highest number of channels for analyzing MIMO fading conditions.

This 5G NR channel emulation solution enables end-to-end realistic and repeatable real-world performance testing in the laboratory.

Keysight's network emulation solutions integrate seamlessly to bridge the gaps between the different phases of the workflow — from research and development (R&D) to design validation and manufacturing. Reduce your time to market and development time to keep ahead of the competition.

**PROPSIM Benefits:**

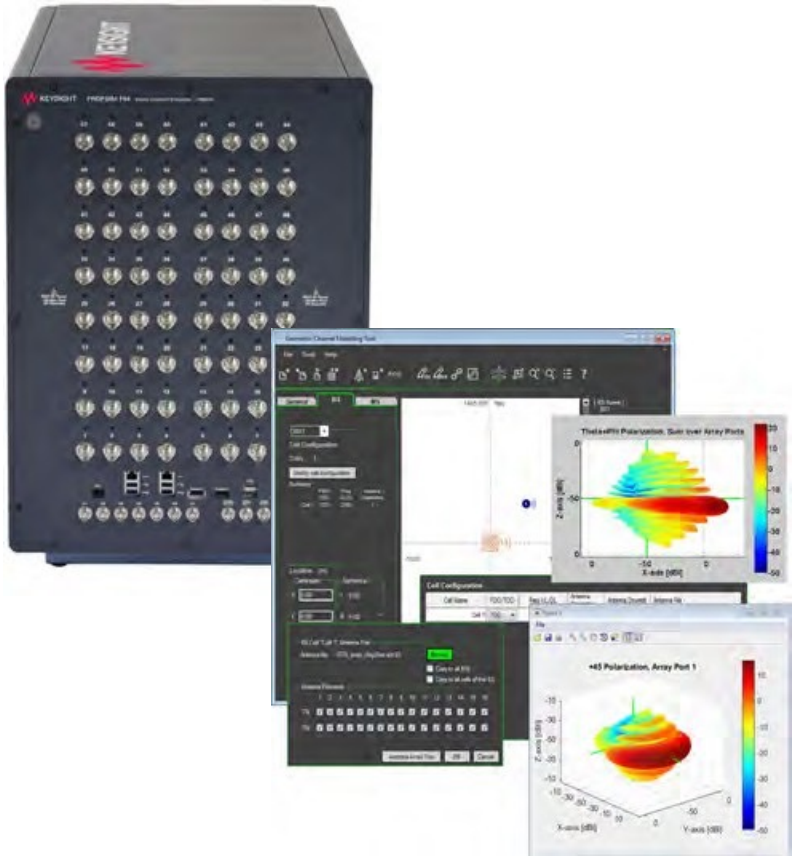
Gain full confidence in new product and feature performance with complete real-world testing.

Accelerate development time with PROPSIM's superior user experience.

Address 3GPP and Tier 1 operators' test requirements with one solution.

## Solution highlights

- full-stack end-to-end protocol signaling and RF performance testing for base stations and devices to ensure confidence in product quality
- FR1 MIMO, massive MIMO beamforming, device MIMO, and mmWave MIMO OTA testing capabilities for flexibility and scalability
- full 5G NR support, including 400 MHz signal bandwidth and continuous (up to 1.2 GHz) and noncontinuous (up to 16CC) carrier aggregation schemes
- testing capability for a wide range of 5G NR deployment scenarios, with or without an LTE anchor cell, to ensure coexistence with existing wireless technologies

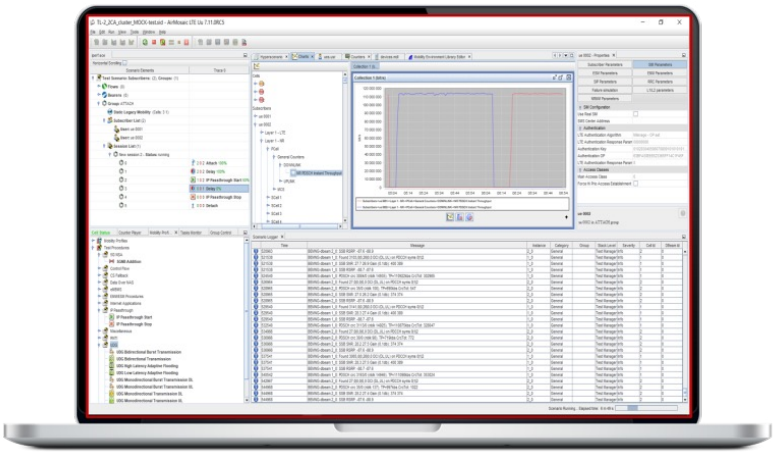


# UE emulation for RAN testing

UeSIM UE emulation solutions enable infrastructure vendors, chipset providers, and mobile operators to validate end-to-end RAN performance by emulating real network traffic over radio and O-RAN fronthaul interfaces. Keysight's systems are fully scalable and designed to accelerate multistandard end-to-end network verification by generating IP traffic load, simulating applications running on thousands of concurrent devices operating real voice and data sessions. UeSIM supports conducted and live testing across the full range of frequencies, with the ability to cover real-world scenarios spanning protocol and load testing in the lab and field testing, trials, and deployments.

## Solution highlights

- full protocol stack assessment from Layer 1 to Layer 7
- functional testing — layer by layer — up to thousands of UEs
- load testing of 5G RAN — NSA and SA modes
- gNB wraparound testing with core emulation option
- O-RAN fronthaul interface support with different 5G RAN split architectures options
- real smartphones applications and traffic profiles simulation
- service quality validation with subscriber modeling and multiplay voice, video, and data traffic generation: eMBMS, VoLTE, ViLTE
- advanced mobility scenarios, fading, and cross-cell interference simulation



# 5G RAN functional and performance testing

Keysight's 5G RAN testing solution performs end-to-end 5G RAN functional and load testing. It stimulates stateful UEs by modeling real-world behavior. It is also a performance tester with the capacity to scale up to several thousand UEs.

## Solution highlights

- full-featured 5G NR UE emulation for testing completeness
- coverage to address all 5G NR modes
- enhanced mobile broadband, ultra-reliable low-latency communications, and massive machine-type communication
- supports
  - 6 GHz and mmWave frequencies
  - 100, 200, and 400 MHz bandwidths
  - 2x2 and 4x4 MIMO (8x8 MIMO ready)
  - four aggregated carriers (eight carriers ready)

### 5G RAN Testing Solution Benefits:

Achieve high confidence in products with full protocol stack and layer-by-layer testing.

Accelerate 5G innovation by performing complex UE modeling faster using easy-to-configure traffic models and call patterns.

Prepare for the future with scalability to 1,000 UEs, 8x8 MIMO, and 8xCC.

# 5G core performance testing

Keysight's 5G Core testing solution validates critical 5G requirements for maximizing network reliability and performance. The solution scales up to millions of subscribers and performs comprehensive testing of all nodes and interfaces. It provides in-depth quality-of-experience (QoE) statistics and metrics.

### 5G Core Testing Solution Benefits:

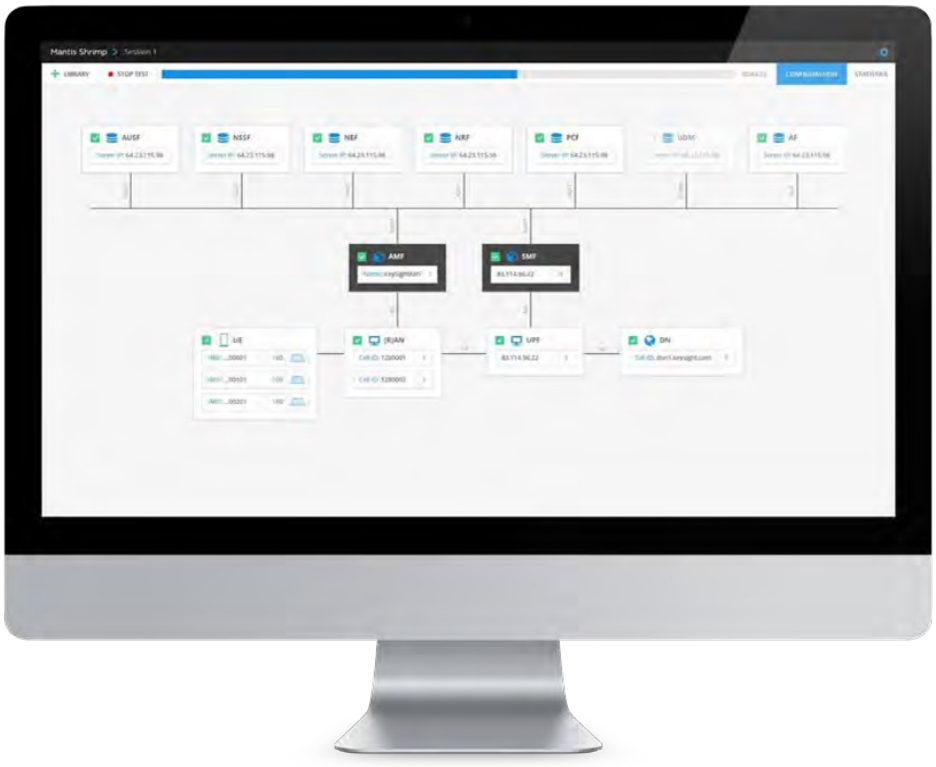
Maximize product deployment success by validating using real-world subscriber simulation.

Ensure product performance by simulating UEs over the radio and any node or interface.

Enable a virtuous cycle of product quality via regressions using automation.

## Solution highlights

- comprehensive network re-creation in the laboratory with a topology-based user interface
- capability for user plane function to generate close to line-rate User Datagram Protocol and Transmission Control Protocol traffic using CloudStorm load module
- superior flexibility with hardware and virtual machines
- public-cloud ready via microservices and containers



5G Core Test Engine

# 5G Virtual Drive Testing Solutions

Keysight's virtual drive testing solution enables NEMs to conduct performance testing to achieve a high level of confidence in their designs for a wide range of scenarios.

This performance and interoperability testing solution brings real-world multipath propagation conditions to the laboratory, enabling engineers to replicate complex 3D radio channel conditions in drive or indoor test routes. It enables NEMs to assess the actual performance of network infrastructure equipment. Keysight's virtual drive testing solution accelerates product rollouts and quality assurance (QA) testing without compromising QoE.

**Virtual Drive Testing Solution Benefits:**

Save time and costs with automated testing of devices and base stations in the laboratory under realistic conditions.

Accelerate acceptance testing at service providers by maximizing product performance.

Foster repeatability and control in the real world using field traces and proactively address issues service providers will face during deployment.

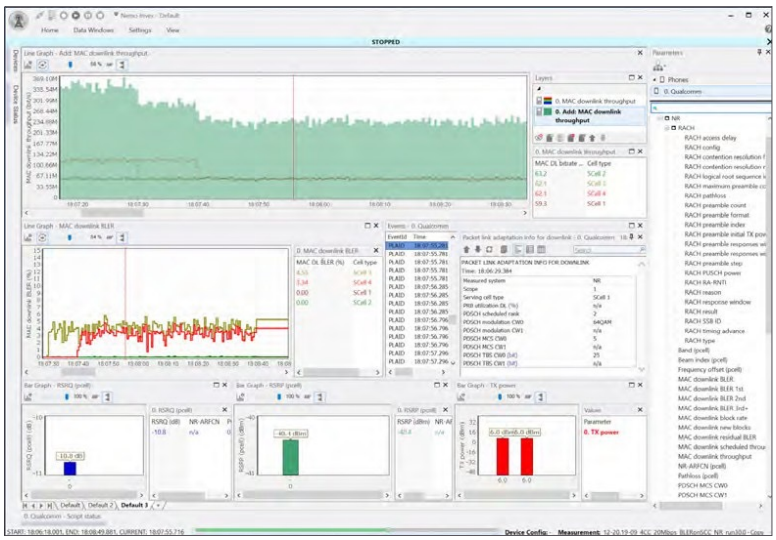
## Solution highlights

- allows users to replicate and repeat a real-world environment with real devices in a laboratory environment
- uses data captured in the field
- includes advanced test automation capability with ready-to-run test case packages
- provides automated 24/7 analysis and reporting capabilities to accelerate performance and interoperability validation
- covers all 5G spectrum FR1 and mmWave frequencies
- covers common and supplementary carrier test plans to ensure compliance with any mobile operator
- supports all wireless technologies for a high return on investment

# 5G network propagation model tuning

## Early 5G field measurements for path loss and link budget verification

Keysight's 5G field measurement solution is a complete system for early 5G NR radio propagation and coverage verification. These initial measurements give insights into 5G network propagation to create data useful for accurate network planning. Calibrate the propagation model and provide precise coverage prediction results using measurement data imported into the planning tool.



### 5G Field Measurement Solution Benefits:

Understand beam characteristics by measuring the signal power level from base stations.

Take just three steps to conduct early 5G coverage field testing.

Accelerate time to market for 5G gNBs by performing signal propagation and attenuation, band clearing measurements, and interference testing.

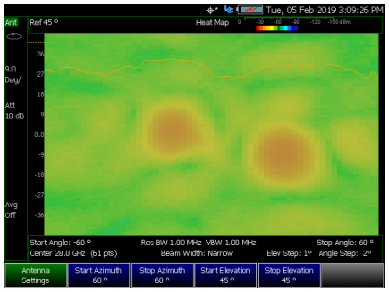
## Solution highlights

- coverage to measure and verify spectrum, reflection, and penetration in indoor and outdoor environments — FR1 and mmWave frequencies
- measurement of total channel power over bandwidth to evaluate and verify propagation models for different frequencies and accelerate time to market for 5G gNBs
- visualization, including a spectrum view of the 5G signal and analysis capabilities to determine data usability quickly

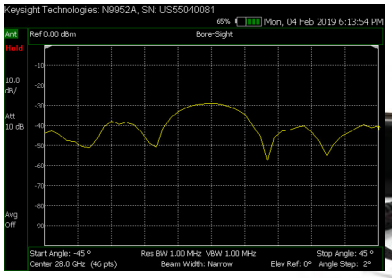
# 5G gNB field test

5G operators and NEMs will need new OTA test tools for network and UE field tests, as well as optimization tools to deploy and verify the performance of these networks. Keysight's FieldFox handheld analyzer, combined with a phased array antenna, provides a unique, portable solution for measuring and analyzing the 5G air interface in the field.

Polar antenna pattern with a compass



2D scan heat map (azimuth vs. elevation)



Boresight scan


### 5G Phased Array Field Test Solution Benefits:

Understand 5G gNB beam characteristics by measuring signal power level across azimuth and elevation from base stations.

Reduce measurement complexity with integrated RF probe and phased array solution to capture energy radiated from 5G gNBs.

Simulate 5G UE antenna performance with calibrated-grade mmWave phased array antenna.

Phased array performance verification shows boresight, polar antenna pattern with compass, and heat map (azimuth vs. elevation).

Keysight's 5G gNB field test solution is based on the FieldFox analyzer. It provides complete tool kits for RF engineers and technicians to install and troubleshoot 5G networks. The solution serves as an all-in-one instrument that users can configure as a spectrum analyzer, real-time spectrum analyzer, cable and antenna tester, and more. FieldFox LTE FDD and 5G TF OTA can measure primary synchronization signal, secondary synchronization signal, and decode cell ID, which are key parameters of effective 5G coverage.

5G control channels are based on beamforming and are not always on, making it challenging to determine the location of the 5G signal. Switching to real-time spectrum analysis (RTSA) mode on FieldFox can quickly and reliably detect 5G signals, reveal control channels, and provide insights into beamforming performance.

### 5G gNB Field Test Solution Benefits:

Get support for both FR1 and FR2 5G bands, 5 kHz to 50 GHz.

Achieve 5G gNB RF parametric test OTA in the field and mmWave beam sweep survey.

Record and play back data with GPS time stamping and geolocation information.

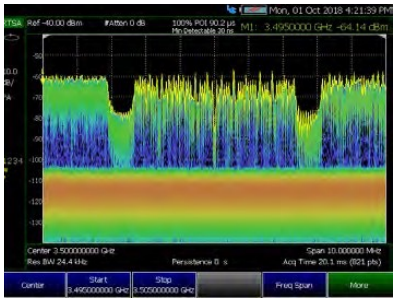
Take path loss measurements with an independent signal source.

Test 5G gNBs under any condition with battery power, no fans or vent, and IP53 design.

## Solution highlights

- features continuous frequency coverage from 5 kHz to 50 GHz
- serves as an all-in-one instrument: spectrum analyzer, cable and antenna analyzer, real-time spectrum analyzer, LTE and 5G TF over-the-air demodulation, independent signal source for path loss measurement, power meter, and GPS
- records data with GPS geolocation and time stamp information; plays back recorded data on the instrument or offline on a PC


5G TF OTA measures control channels and displays cell ID




Switching into RTSA mode detects various 5G control channels

MANUFACTURING

# Manufacturing Test Solutions to Accelerate Time to Market and Lower Costs

## Scenario

NEMs must find ways to test infrastructure equipment cost-effectively and remain flexible to address spikes in volume, channel requirements, and more frequency bands. NEMs' greatest challenge in manufacturing is addressing these factors: increasing device complexity, finding breakthroughs to lower the cost of test, and reducing time to market. Keysight's expertise and solutions for RF design and IP networking accelerate testing of basestations and their subassemblies and reduce the cost of test.

# 5G Manufacturing Test

## S9100A 5G multiband vector transceiver

NEMs use Keysight's 5G manufacturing test reference solution for fast and cost-effective testing of base stations and subassemblies in volume production. The solution performs wideband signal generation and analysis of 5G NR waveforms for radio units and antenna modules. It operates as a single instrument for easy automation and delivers exceptionally high test throughput.

The M9410A VXT is at the core of this solution. NEMs can quickly increase the frequency range and number of channels to address mmWave frequencies, MIMO, and OTA tests. Flexibility and scalability lower the cost of test for 5G manufacturing during the transition from four- to eight-port 4G devices to 5G with 16, 32, 64, or 128 channels.

Test engineers can trust their results because mmWave and OTA challenges are at the heart of the solution. It uses remote heads that reduce path loss, increase phase linearity, and provide more robust connectors than traditional solutions.

### 5G NR gNB Manufacturing Solution Benefits:

Accelerate time to market and reduce the cost of test with a small footprint and fast test speed.

Facilitate the transition from validation to manufacturing by leveraging common software.

Scale manufacturing test capability to higher frequencies and channel counts.

## Solution highlights

- addresses the wider bandwidth requirements of 5G NR with up to 1.2 GHz wide bandwidth
- provides scalability and investment protection with FR1 and FR2 (mmWave) spectrum band coverage
- offers EVM and adjacent channel leakage ratio performance for higher measurement performance and improved yield
- includes proven X-Series measurement applications to reduce development efforts and accelerate time to market

# OTA Test Solutions That Keep Pace With Industry and Operator Requirements Scenario

Modem chipsets, antennas, base stations, and integrated devices require a mix of conducted and OTA tests. 3GPP defines OTA test methods for FR1 and FR2 conformance tests. Engineers need to perform OTA tests to characterize radiated beams in R&D, protocol and RF / radio resource management conformance testing, and device acceptance testing.

# 5G OTA Measurements

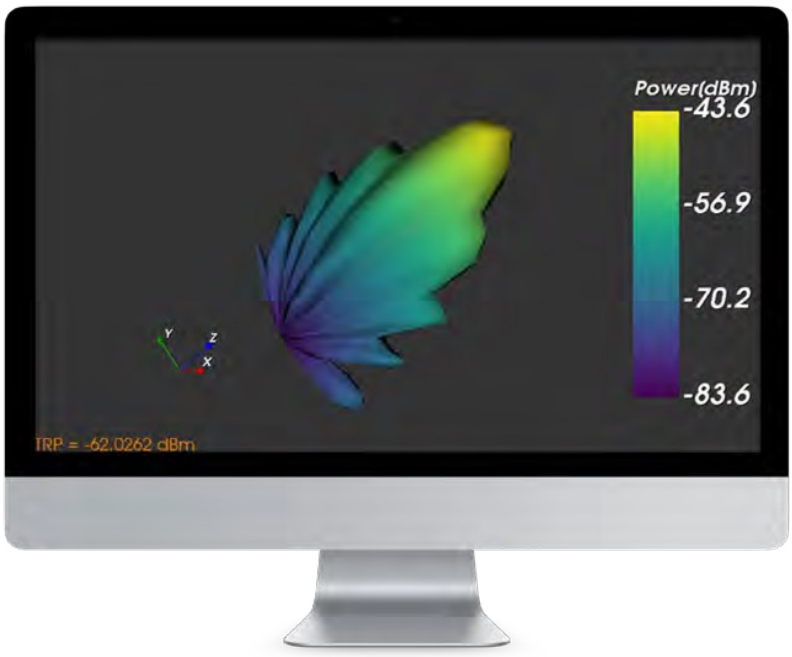
Keysight offers a portfolio of OTA solutions for FR1 and mmWave frequencies. A typical solution consists of measurement hardware and software, a network emulator to mimic the 5G gNB, and a channel emulator to imitate the radio conditions. RF enclosures, probe and link antennas, different DUT positioners, and associated control software complete the OTA test setup. Our solutions address the different test approaches and requirements across the workflow, from R&D to device acceptance test.

3GPP has accepted the compact antenna test range (CATR) methodology for RF performance measurements on mmWave devices. Keysight's OTA test solutions and expertise enable systems integrators to provide solutions that meet the requirements set by industry bodies. These include CTIA, 3GPP, and China Communication Standards Association. They also address the test plans mandated by major mobile operators.

**5G OTA Test Solution Benefits:**

Accelerate designs with integrated automated tests based on proven Keysight 5G solutions.

Reduce development risk with 3GPP-approved OTA test methodologies for components and devices that operate at sub-6 GHz and mmWave frequencies.




Position control and plotting software

CATR

# Scenario

When the pressure is on, costly delays result from waiting on tools, answers, or help with developing or deploying 5G solutions. KeysightCare offers a personalized, cloud-based customer experience. You can access a digital knowledge base 24x7 for answers, training, and expert guidance. Get faster response times, access to experts, and time to resolution through a single point of contact for your instruments, software, and solutions.

Learn more about KeysightCare services here.

### Education Services

5G creates real-world measurement challenges. With eLearning, you will gain the necessary skills to make more accurate, repeatable measurements. Start-Up Assistance complements that skill set with private, customized hands-on instruction designed to help you meet your application measurement objectives.

### Process and Consulting Services

The 5G transformation brings new growth opportunities and challenges. Keysight provides expert analysis with quantifiable metrics so you can analyze the current process, offer a quantified evaluation of alternatives, and accelerate time to market.

### Technology Refresh Services

Current test equipment will likely be unable to provide the increased levels of measurement capability required for 5G standards. Technology refresh offers an easy and cost-effective way to upgrade or trade in existing assets to obtain the test equipment performance for your new requirements.

### Test Asset Optimization Services

Navigating the transition to 5G NR and making the right equipment choices requires access to real-time asset data and effective management of all assets. Keysight Test Asset Optimization services offer an ideal solution to this challenge. Our services offer asset tracking and control capabilities, utilization and health data, and loan pool management tools.

### One-Stop Calibration Services

With increasingly complex multivendor 5G systems and test plans, ensuring accurate equipment calibration and maintaining maximum uptime are essential. Keysight One-Stop Calibration services increase uptime, ensure ongoing accuracy, and reduce logistical complexity with one point of contact for all calibration services — regardless of the manufacturer.

### Financial Services

You need to make the most of your operational and capital budgets to design, produce, and deploy new 5G solutions. Keysight financial options help you get the equipment you need to deliver on time and within budget. Keysight Instant-Buy* gives you the flexibility to make monthly payments at 0% interest over 18 months. With Keysight Rent-to-Own*, you can get the instrument you need now and decide to purchase later. Keysight Lease* lets you access leading technologies while managing your budget.

*Available in select countries

# Streamlining Base Station Time to Market

5G introduces disruptive change to NEMs across the entire workflow, from R&D and QA to manufacturing. Engineers struggle to design high-performance 5G base stations. They need to create innovative ways to implement the physical layer in communications systems. At the same time, NEMs need to verify that their designs comply with the latest 5G standards — a significant challenge because of rapid evolution.

Wider bandwidths, mmWave frequencies, massive MIMO, and beamforming are some of 5G's most challenging technical aspects. Signal propagation is less predictable at mmWave frequencies. Channel and UE emulation become more complex and time-consuming.

The importance of functional and load / performance testing has increased exponentially to meet the high expectations for services from enterprises and consumers. Thorough functional and performance testing spanning RAN and core aspects, as well as testing with real-world conditions, is essential to pass conformance tests.

In manufacturing, accelerating time to market while reducing the cost of test are top priorities. NEMs must ensure a smooth transition from QA to volume manufacturing by deploying innovative test strategies. Addressing the challenges from mmWave frequencies and OTA testing is critical.

With an increasing number of UEs, complex carrier aggregation schemes, more MIMO channels, and mmWave frequencies, NEMs must ensure the future scalability of their operations for continuous first-to-market success throughout the 5G cycle.

Learn more about Keysight solutions for each of these challenges here.

"Our future depends on our ability to innovate new products at competitive prices. ... Keysight helped us to innovate a new approach to testing. They really understood the problem and helped us design a solution, so we can transform and win in our market."

– Design and test director, worldwide original equipment manufacturer (OEM)

Radio equipment for 4G and 5G networks