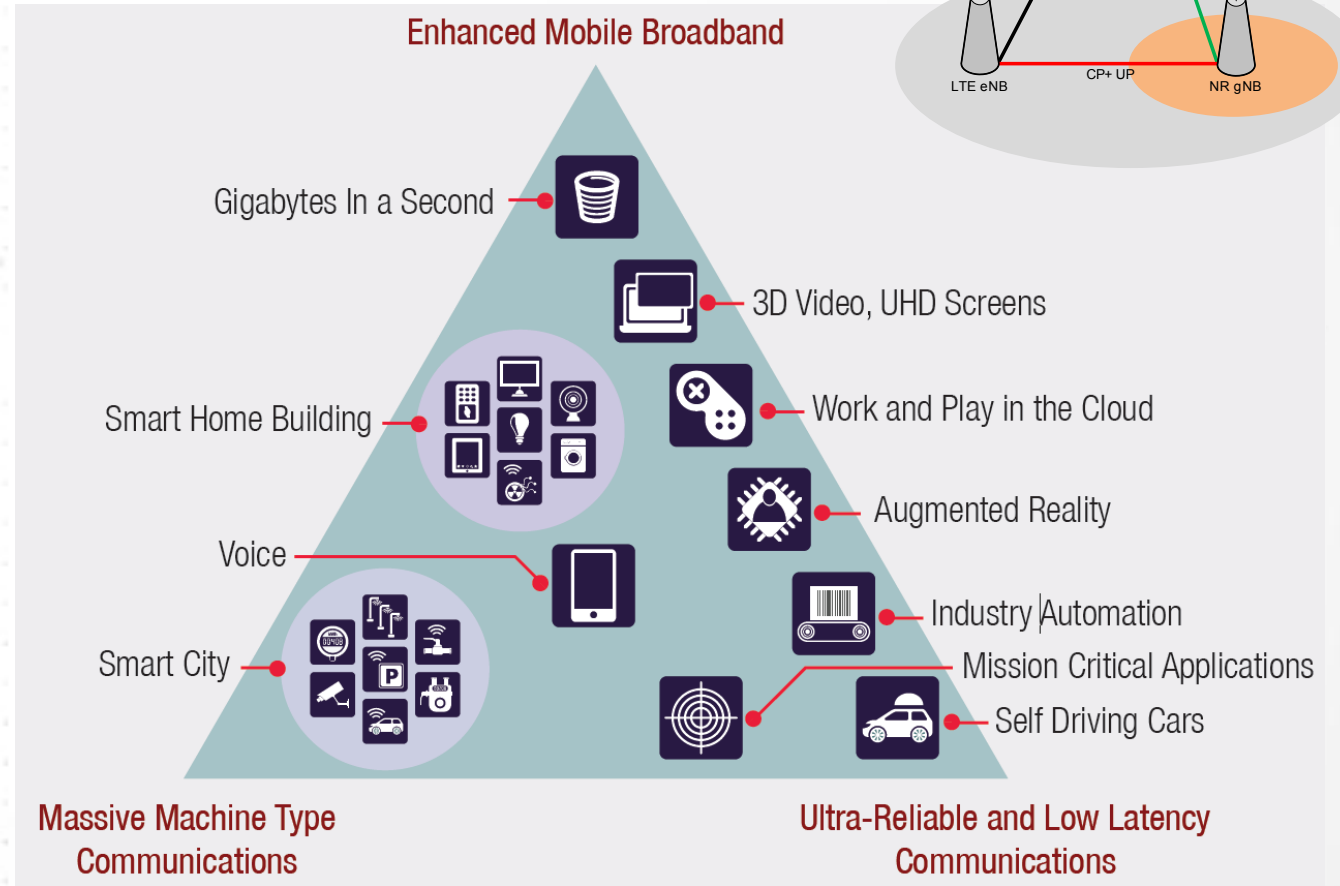# 5G NR Use Cases

eMBB – mMTC – uRLCC

- The first NR specification (3GPP Release 15) supports increased data throughput and greater capacity for eMBB.

- It also sets a foundation for support of URLLC mission-critical use cases such as autonomous automobiles.

- The NR air interface can work in either standalone or non-standalone mode where an existing LTE network is used for control plane.

- Standalone mode and core network specifications are planned for June'18.

EPC

CP+ UP

UP

LTE eNB

CP+ UP

NR gNB

Enhanced Mobile Broadband

Gigabytes In a Second

3D Video, UHD Screens

Smart Home Building

Work and Play in the Cloud

Augmented Reality

Voice

Industry Automation

Smart City

Mission Critical Applications

Self Driving Cars

Massive Machine Type Communications

Ultra-Reliable and Low Latency Communications

KEYSIGHT
TECHNOLOGIES

New Spectrum and Bandwidth

IMPACTS SIGNAL QUALITY

- 5G NR specifies new frequency ranges up to **52.6 GHz (Rel-15)**, and up to 100 GHz for future implementations.

- Implementing air interfaces at millimeter wave (mmWave) frequencies with up to 1 GHz bandwidth means you'll need to correct for signal quality issues like path loss, flatness, phase noise, and linearity.

Country	5G NR Frequency Bands
USA	27.5 – 28.35 GHz and 37 – 40 GHz Pre-commercial deployments in 2018, 64-71 GHz future
South Korea	26.5 – 29.5 GHz trials in 2018 Commercial deployments in 2019, 37.5 – 50 GHz future
Japan	27.5 – 28.28 GHz trials planned from 2017 and potentially commercial deployments in 2020
China	24.25 – 27.5 GHz and 37 – 43.5 GHz studies
Sweden	26.5 – 27.5 GHz awarding trial licenses for use in 2018 and onwards
EU	24.25 – 27.5 GHz for commercial deployments from 2020

KEYSIGHT TECHNOLOGIES

3

Advanced Beamforming Techniques

REQUIRE SYSTEM-LEVEL DESIGN

- 5G NR uses advanced beamforming to overcome the path loss and multi-path signal propagation issues that come with mmWave frequencies.

- The benefit of beamforming is that it can use steerable antenna arrays that deliver antenna gain and better SNIR to a specified UE.

- To make the most of the technology, however, new design and system-level test approaches are required.
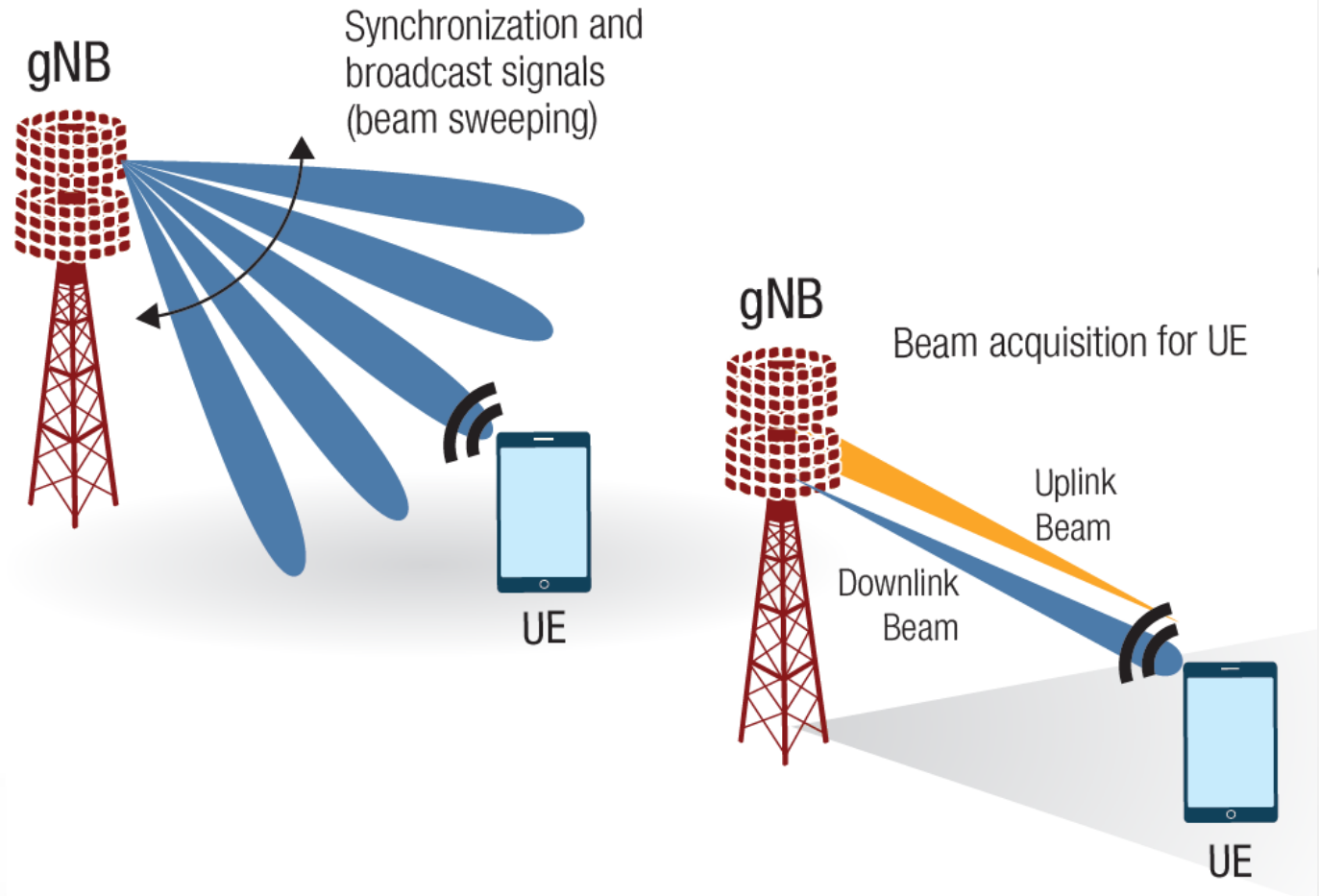
New Waveform and Scalable Numerology

MEANS PAPR CHALLENGES

- Scalable subcarrier spacing

$$\Delta f = 2^{\mu} \cdot 15\ kHz$$

- Scalable numerology allows for multiplexing of services with different quality and latency requirements and provides larger subcarrier spacing for mmWave carriers.

μ	Δf = 2^μ·15 kHz	Cyclic Prefix
0	15 kHz	Normal
1	30 kHz	Normal
2	60 kHz	Normal, Extended
3	120 kHz	Normal
4	240 kHz	Normal
5	480 kHz	Normal

Where
$\Delta f = 2^{\mu} \times 15\ kHz$
Example: 15 kHz, 30 kHz, 60 kHz ... 480 kHz subcarrier spacing
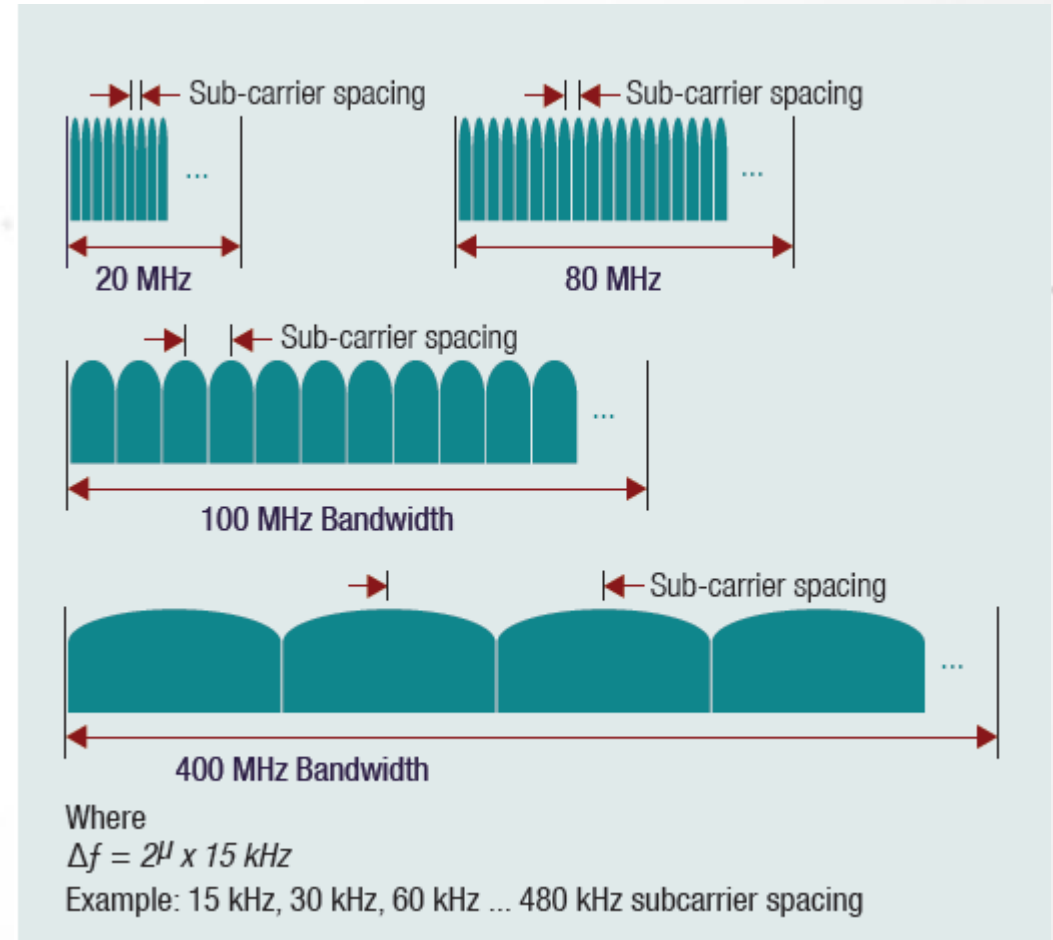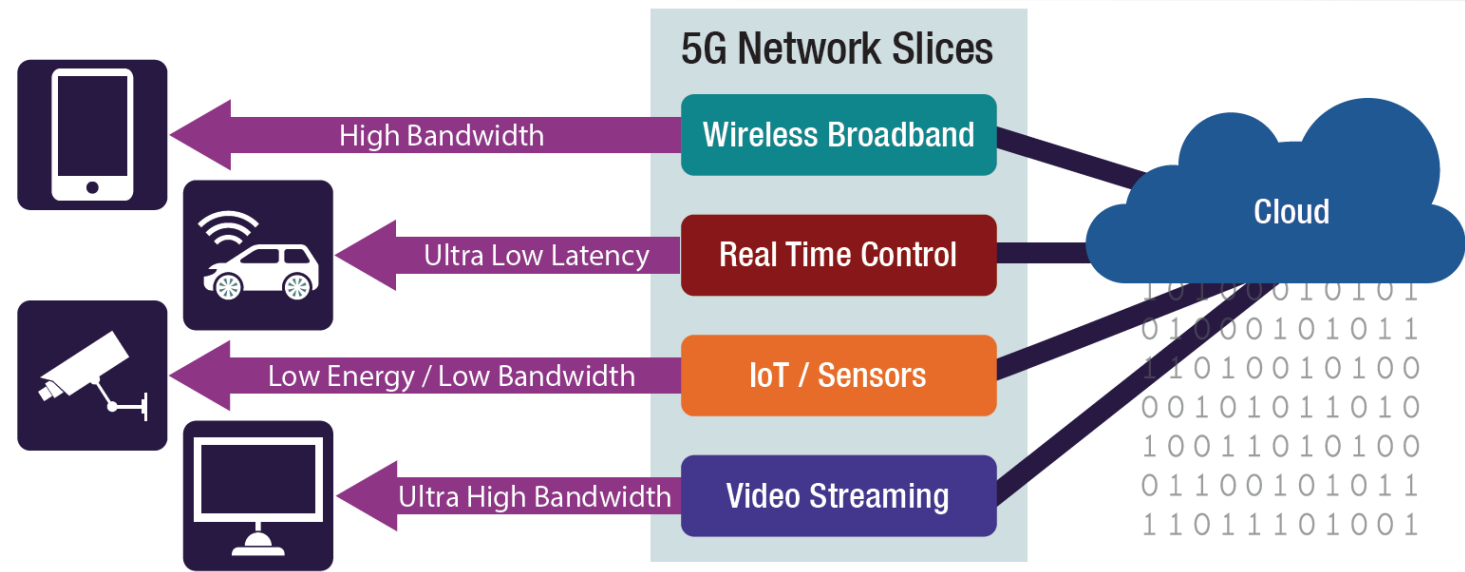
Multi-Waveform Coexistence

PRESENTS INTERFERENCE ISSUES

- 5G NR must coexist with the many already existing services and with new services that will be introduced to support 5G use cases.

- Different signals can be found in adjacent and in non-contiguous spectrum, making interference a big issue.

- To reduce adjacent spectrum interference, in-band and out-of-band emissions must be minimized.
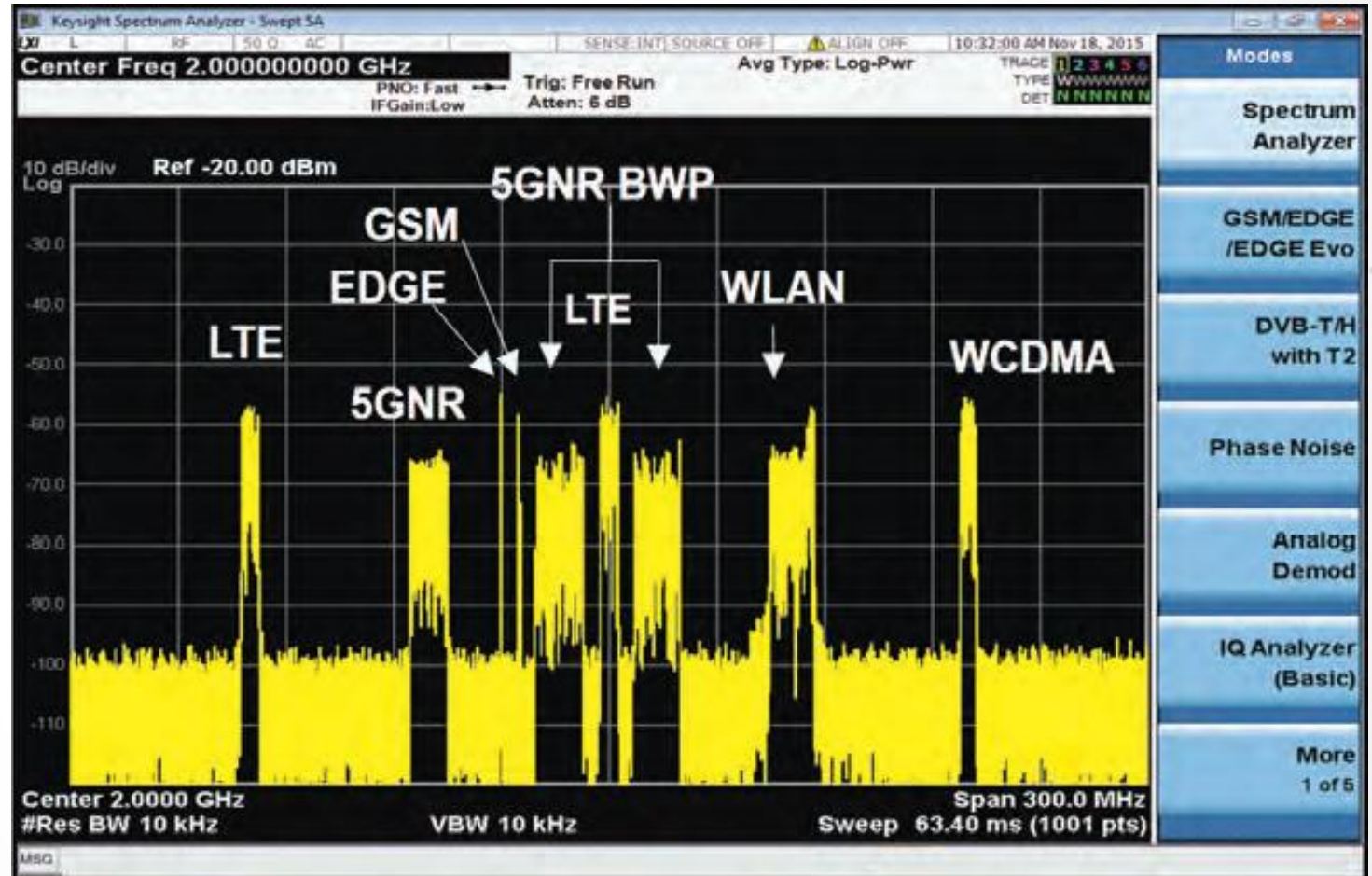
Network Changes Are Inevitable

- 5G NR will drastically increase network traffic. To support the 5G NR use models and minimize cost, new network technologies are required.

- Network slicing makes the network more dynamic, enabling operators to allocate speed, capacity, and coverage.

- Cloud RAN moves baseband processing into the cloud, making mobile connections more efficient.

5G Network Slices

High Bandwidth	Wireless Broadband
Ultra Low Latency	Real Time Control
Low Energy / Low Bandwidth	IoT / Sensors
Ultra High Bandwidth	Video Streaming

Cloud

Millimeter Wave Frequencies Require OTA Test

CATR

- At mmWave frequencies, small-size antennas require testing to be conducted over-the-air (OTA) – a complex and expensive approach.

- A compact antenna test range (CATR) uses a parabolic reflector system and rotating positioner to eliminate the need for extremely large and expensive chambers
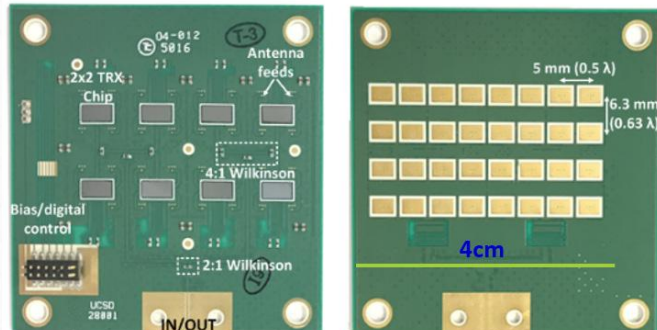
LTE vs. NR Comparison

PHYSICAL LAYER SPECIFICATIONS

	LTE	New Radio (Based on 3GPP Rel. 15)
Frequency band	Sub-6 GHz	Sub-6 GHz, mmWave (up to 52.6 GHz)
Maximum Bandwidth (per CC)	20 MHz	50 MHz (@ 15 kHz), 100 MHz (@ 30 kHz), 200 MHz (@ 60 kHz), 400 MHz (@120 kHz)
Maximum CCs	5 (Rel.10) / 32 (Rel.12). Current implementation is 5.	16 (allowed BW and CCs combinations TBD)
Subcarrier Spacing	15 kHz	$2^n \cdot$ 15 kHz TDM and FDM multiplexing
Waveform	CP-OFDM for DL; SC-FDMA for UL	CP-OFDM for DL; CP-OFDM and DFT-s-OFDM for UL
Modulation	Up to 256 QAM DL (moving to 1024 QAM) Up to 64 QAM UL	Up to 256 QAM UL & DL
Maximum Number of Subcarriers	1200	3300
Subframe Length	1 ms (moving to 0.5 ms)	1 ms
Latency (Air Interface)	10 ms (moving to 5 ms)	1 ms
Slot Length	7 symbols in 500 µs	14 symbols (duration depends on subcarrier spacing) 2, 4 and 7 symbols for mini-slots
Channel Coding	Turbo Code (data); TBCC (control)	LDPC (data); Polar Codes (control)
Initial Access	No beamforming	Beamforming
MIMO	Up to 8x8	Up to 8x8
Duplexing	FDD, Static TDD	FDD, Static TDD, Dynamic TDD
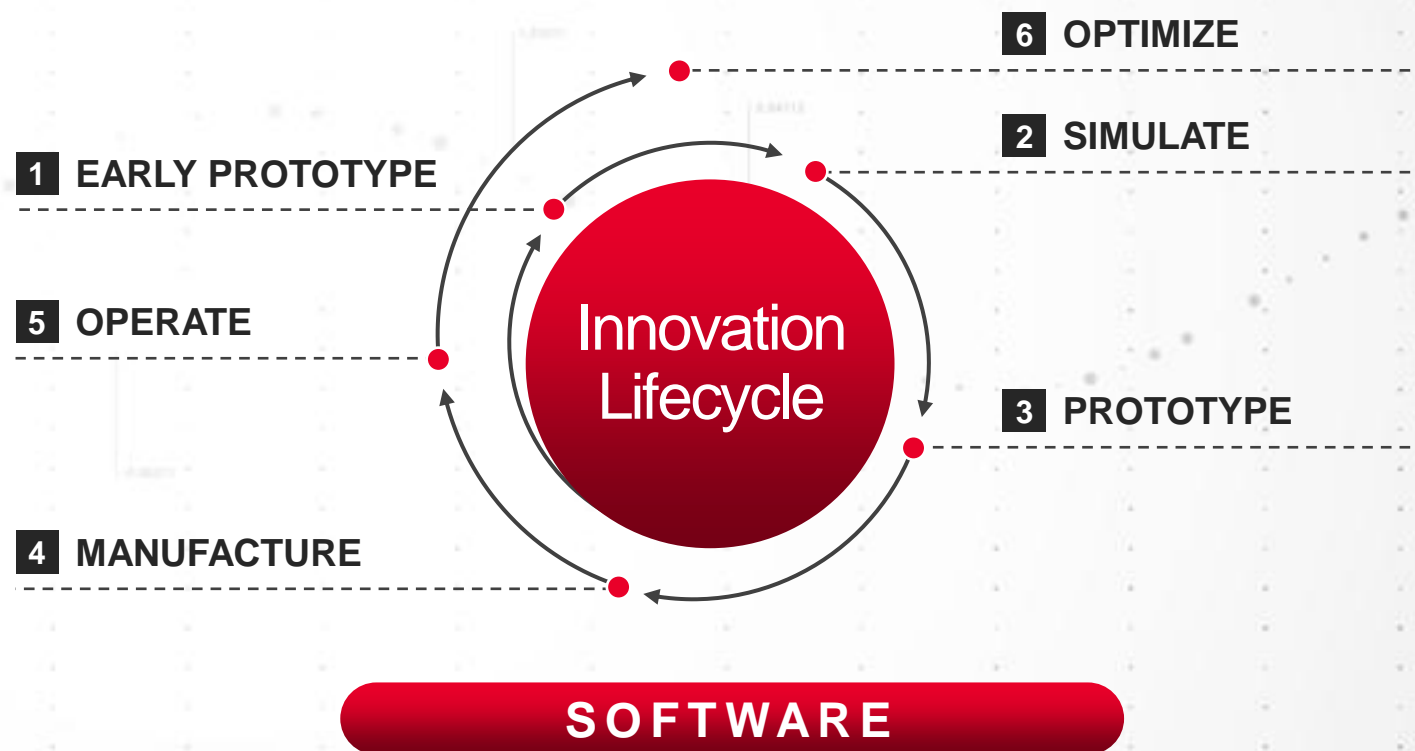
Keysight Now Provides Insight Across the Entire Stack

■ Keysight Classic   ■ Ixia   ■ Anite
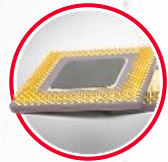
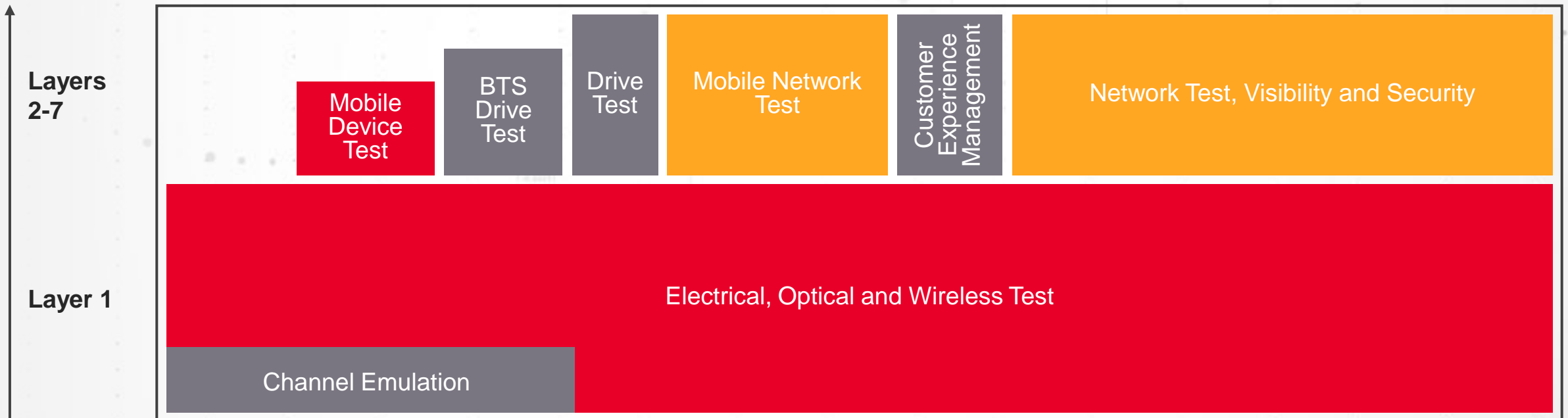**COMPONENTS & CHIPSETS** **DEVICES** **BASE STATIONS** **HYPERSCALE AND DATA CENTERS** **ENTERPRISE**

Layers 2-7

Mobile Device Test | BTS Drive Test | Drive Test | Mobile Network Test | Customer Experience Management | Network Test, Visibility and Security

Layer 1

Electrical, Optical and Wireless Test

Channel Emulation

KEYSIGHT TECHNOLOGIES

5G Ecosystems Have Formed

INTEROPERABILITY IS KEY FOR GLOBAL DEPLOYMENT

KEYS 5G Solutions

- Network Emulation
- mmW and OTA
- RFIC/RFFE
- Channel Emulation
- PHY Test Bed
- Channel Sounding
- Digital Interfaces
- Drive Test
- Network Load Test
- Network Monitoring

KEYSIGHT IS PROVIDING WORKFLOW SOLUTIONS WITH SCALABLE PLATFORMS

Transforming Your 5G Ideas into Reality

KEYSIGHT 5G PUBLIC COLLABORATIONS

- CommSolid
- Aselsan
- mmMagic
- Triangle
- 5G Automotive Association
- NGMN
- University of Bristol
- University of Surrey 5GIC
- University of Oulu

- Huawei
- China Mobile
- China Telecom
- ZTE
- Datang
- NAR Labs Taipei
- IMT2020
- FutureForum
- SEU Nanjing
- NTU Taipei
- NCTU Taipei

- Qualcomm
- Skyworks
- Telecom Infra Project
- NYU Wireless
- UC San Diego

- Samsung
- DOCOMO
- Korea Telecom
- 5G Forum
- 5G MF
- Kwangwoon Seoul

mmWave

Massive MIMO

Beamforming

NB-IoT

CRAN

5G NR

5G TF

Commercial
Consortium
University

KEYSIGHT TECHNOLOGIES

5G UE

First 5G NR Device R&D Workflow Solutions

END TO END PORTFOLIO

5G Interactive R&D

- Protocol R&D*
- RF DVT*
- Functional KPI

*available

5G Device Acceptance
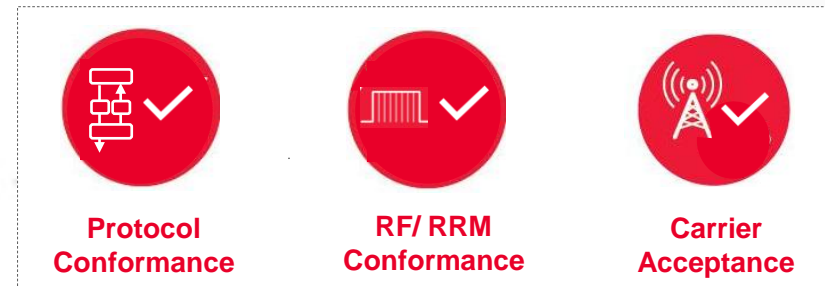
- Protocol Conformance
- RF/ RRM Conformance
- Carrier Acceptance

Network Emulator

Channel Emulator

Theta+Phi Polarization, Sum over Array Ports
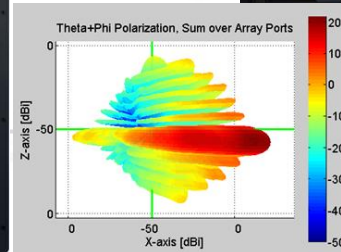
mmWave OTA Solutions

TAP Results Viewer
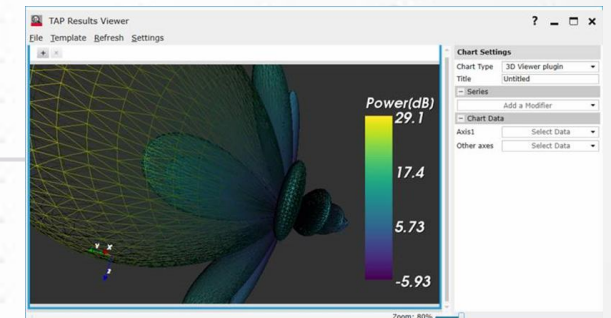
Interactive 5G stack and tools with **common scripting engine**

Common measurement science, **logging** and **automation**
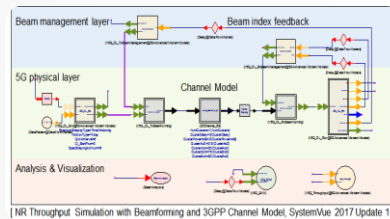
KEYSIGHT TECHNOLOGIES

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5G
UE

First Commercially Available 5G NR Solutions

ACROSS ENTIRE PRODUCT DESIGN CYCLE

First with 5G NR DL and UL and proven through industry leader collaborations
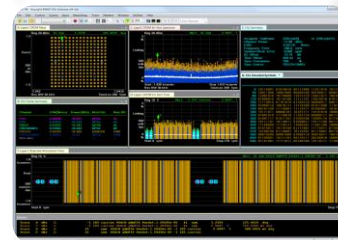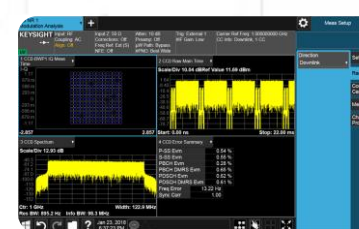
Simulate	Generate	Analyze	Test	Automate
SystemVue 5G Library	Signal Studio Pro for 5G NR	89600 VSA 5G NR	X-Series App 5G NR	PathWave Test
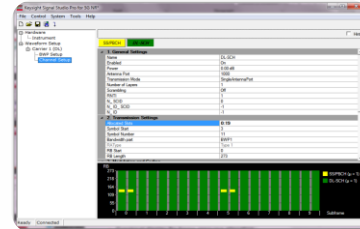
KEYSIGHT
TECHNOLOGIES
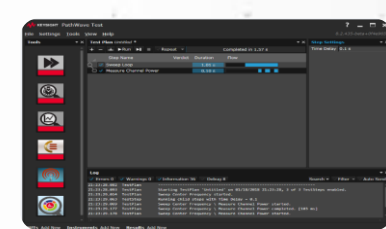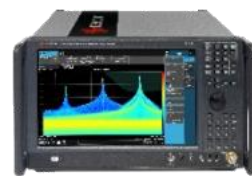
Nemo Outdoor Field Test

VERIFY 5G COVERAGE IN LIVE NETWORKS

Cellular IoT Drive Test

- Measurement of air interface parameters in wireless networks
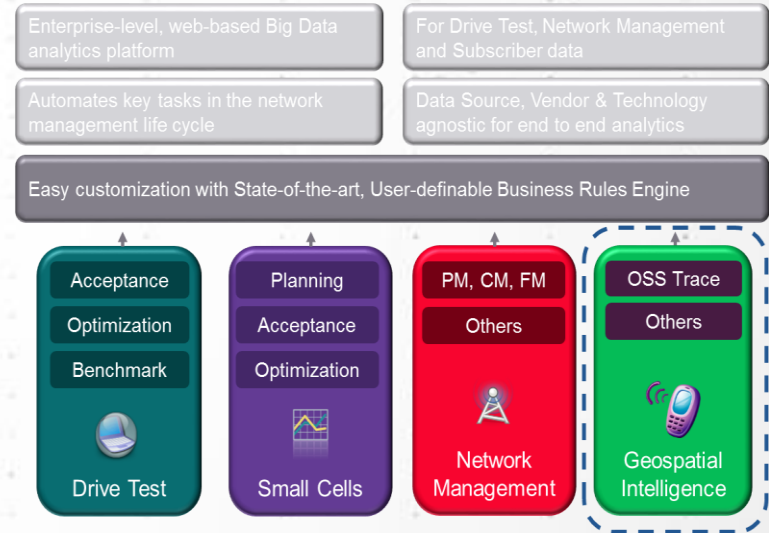- NB-IoT, LTE-M, 5G, LTE/LTE-A (Cat 16, VoLTE)

Nemo Outdoor 5G

- Measure, analyze and visualize the signal power level from 5G base station
- Outdoor/indoor coverage testing
- mmWave signal penetration tests

5G gNB

FieldFox Spectrum analyzer

Post-processing
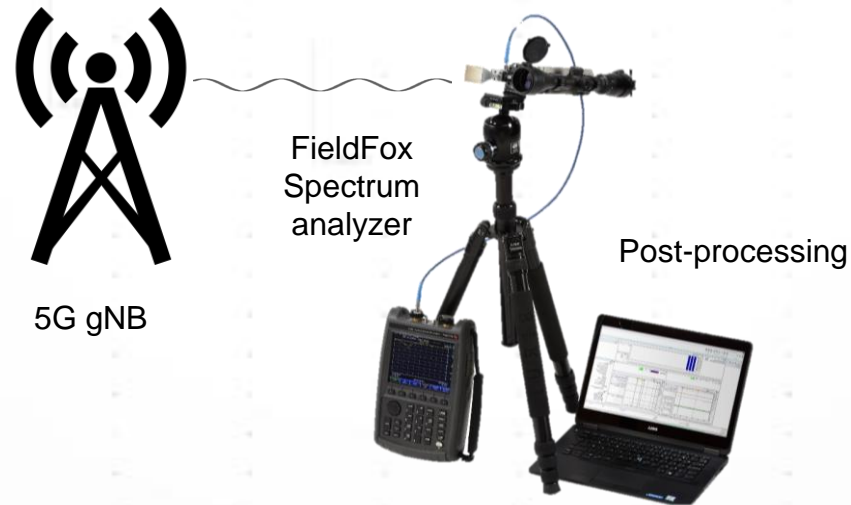
Nemo Xynergy RAN Analytics

- Web-based Enterprise level platform for analyzing Drive test, OSS call trace, small cell/DAS, and network management data

Enterprise-level, web-based Big Data analytics platform	For Drive Test, Network Management and Subscriber data
Automates key tasks in the network management life cycle	Data Source, Vendor & Technology agnostic for end to end analytics

Easy customization with State-of-the-art, User-definable Business Rules Engine

Acceptance	Planning	PM, CM, FM	OSS Trace
Optimization	Acceptance	Others	Others
Benchmark	Optimization		
Drive Test	Small Cells	Network Management	Geospatial Intelligence

First 5G Packet Core High Scale Network Solution

OPERATORS GAIN REAL-TIME INSIGHT INTO QUALITY OF SERVICE

5G Network

- Highest capacity and performance
  - All virtualized
  - Up to 7 million sessions / VM
- Native service with REST APIs
- Flexible design

KEYSIGHT	DUT	KEYSIGHT

UEs — gNB — N3 — UPF — N6 — IP Services

N4 — SMF
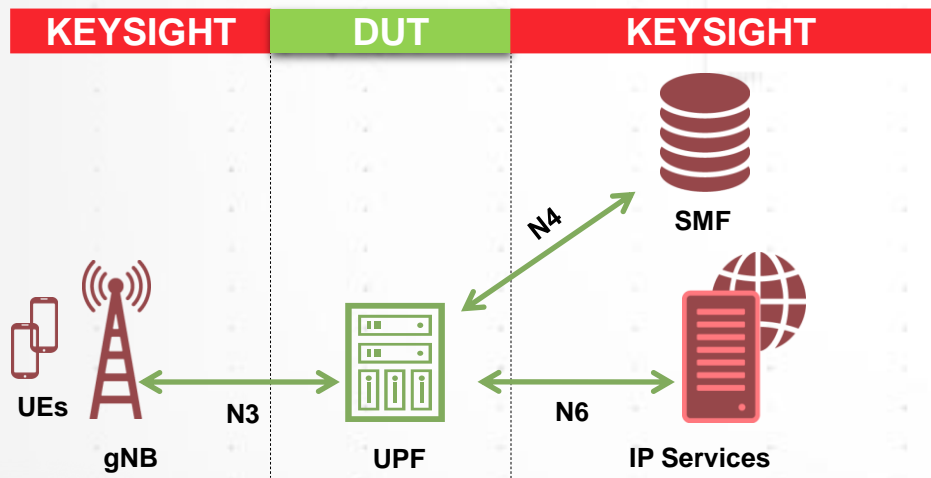
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KEYSIGHT TECHNOLOGIES

Helping you navigate
the most challenging technology waves

Thank You !