5G Solutions

October, 2017

유광열 부장
기술지원부

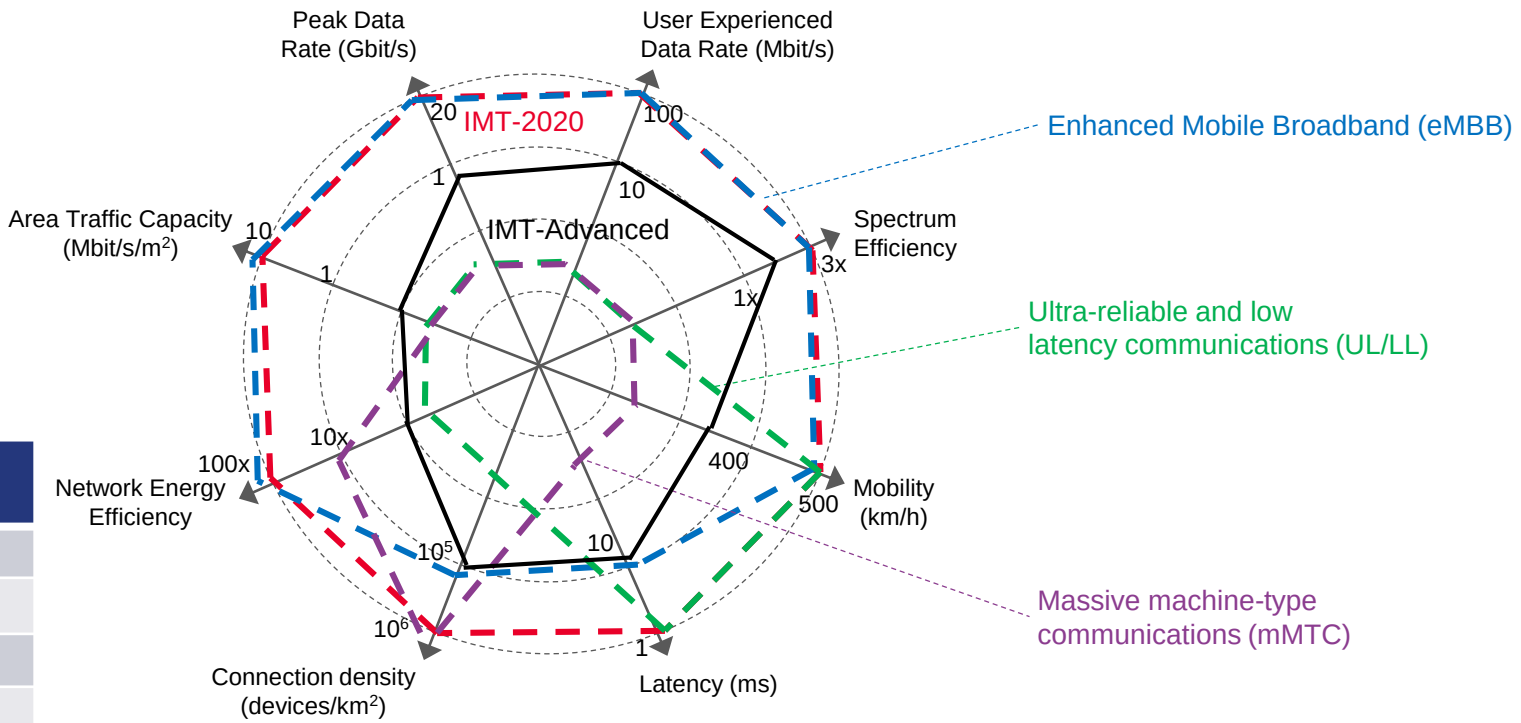
KEYSIGHT
TECHNOLOGIES

Agenda

- 5G Overview & 3GPP Update
- Trends and Insight for Test & Measurement Needs
- 5G Solution in Keysight
  - ✓ Keysight 5G Strategy
  - ✓ 5G Flexible testbed
  - ✓ 5G Solutions

5G Key Performance Indicator from ITU-R IMT-2020 vision

KPIs and Proposed 5G use cases



Additional KPI for IMT-2020
Reliability
Average spectral efficiency
Mobility interruption time
Bandwidth
5th percentile user spectral efficiency

Proposed 5G Use Cases

eMBB

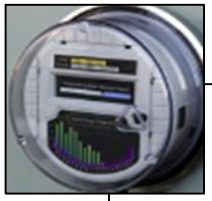
Enhanced Mobile Broadband (eMBB)

- 10-20 Gbps peak
- 100 Mbps whenever needed
- 10000x more traffic
- Support for high mobility (500 km/h)
- Network energy saving by 100 times

Virtual Reality

Augmented reality

mMTC



Massive Machine Communication (mMTC)

- High density of devices (2x10^5 - 10^6/km^2)
- Long range
- Low data rate (1 - 100 kbps)
- M2M ultra low cost
- 10 years battery
- Asynchronous access

UR/LL

Ultra reliability and low latency (UR/LL)

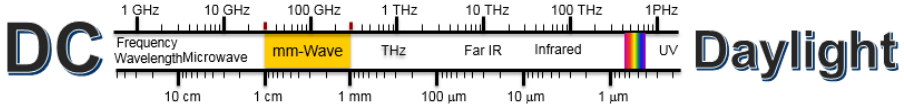
- Ultra responsive
  - <1 ms air interface latency
  - 5 ms E2E latency
- Ultra reliable and available (99.9999%)
- Low to medium data rates (50 kbps - 10 Mbps)
- High speed mobility

Driverless car

Remote surgery

KEYSIGHT TECHNOLOGIES

5G Enabling Technologies



Evolution of existing technology + Revolution of new technology

New Technology (Revolution)

- Microwave and mmWave frequency bands
- Wide bandwidth – up to 2 GHz or wider
- Massive MIMO - Number of BS antennas >> Number of UE's
- New waveforms and new radio access technology (NR)
- In-band full duplex
- Software based network architecture: SDN and NFV

Evolution of existing technology (Sub-6 GHz)

- Evolution of current cellular technologies – LTE-A/LTE-A Pro
  - Example: license assisted access (LAA); enhancement to machine type communication (MTC) or NB-IoT
- New waveforms and new radio access technology (NR)
- New frequency bands below 6 GHz
- Ultra-dense networks – small cells and WLAN access points
- Evolution of RAN architecture (Advanced C-RAN)

With tight interworking between exiting technologies and the new technologies

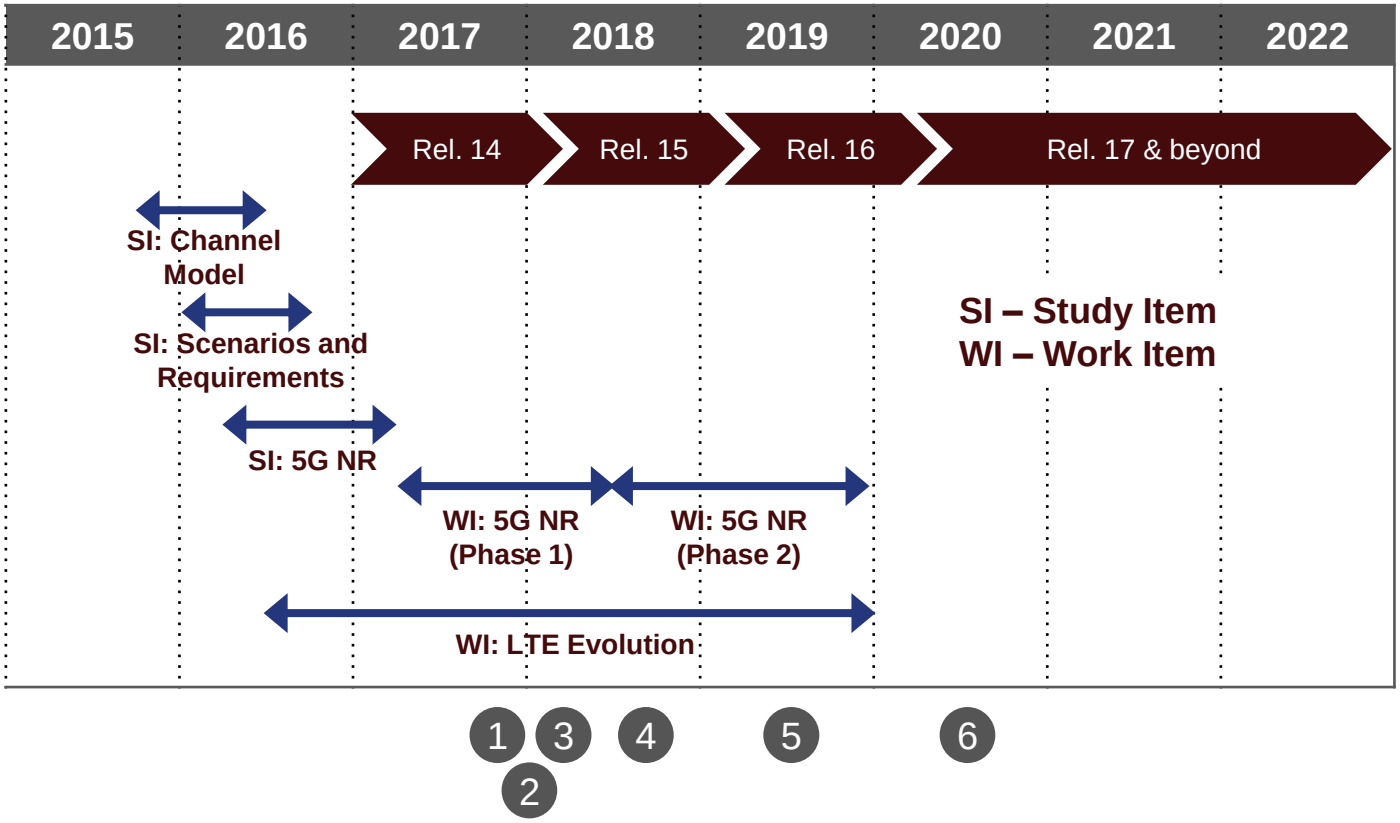
3GPP 5G standards development

3GPP branding

3GPP has been branding some standards since LTE in Release 8

Release	Applicability	Branding	Logo
8, 9	LTE	LTE	
10, 11, 12	LTE	LTE-Advanced	
13, 14	LTE	LTE-Advanced Pro	
15 and beyond	All 3GPP standards	5G	

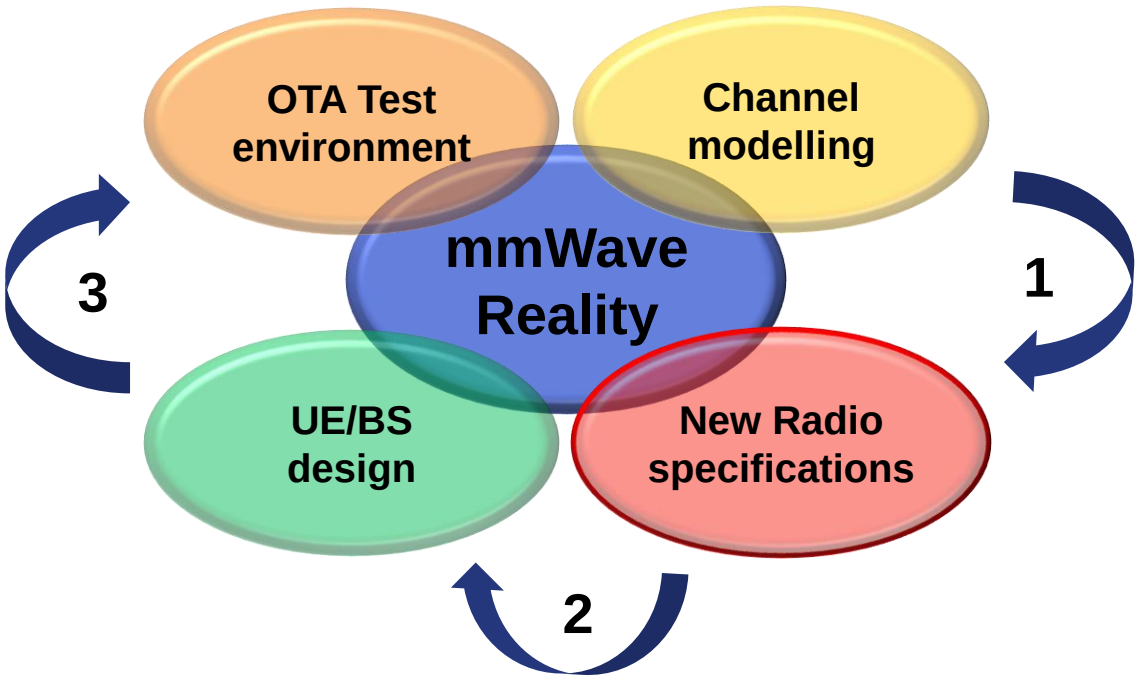
3GPP 5G Timeline (accelerated) with key early deployments



Key dates

1. 3GPP release accelerated standard for non-standalone NR (LTE + NR CA)
2. Verizon deploy pre-5G at 28 GHz in 11 US cities
3. Korea Telecom showcase pre-5G at PyeongChang Winter Olympics
4. AT&T plan 39 GHz US deployment
5. KT plan commercial 3GPP launch
6. Docomo target 3GPP launch for 2020 summer Olympics

New radio design starts by modelling the radio propagation characteristics



For NR < 6 GHz we have good channel understanding

But for mmWave, how many beams? How wide? How dynamic – spatial, power, temporal, frequency? 3GPP does not yet have all the answers

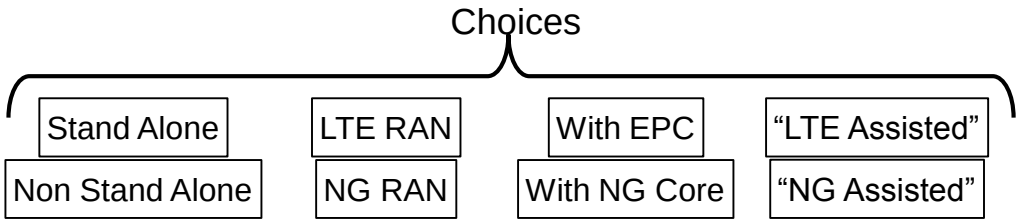
Spectrum

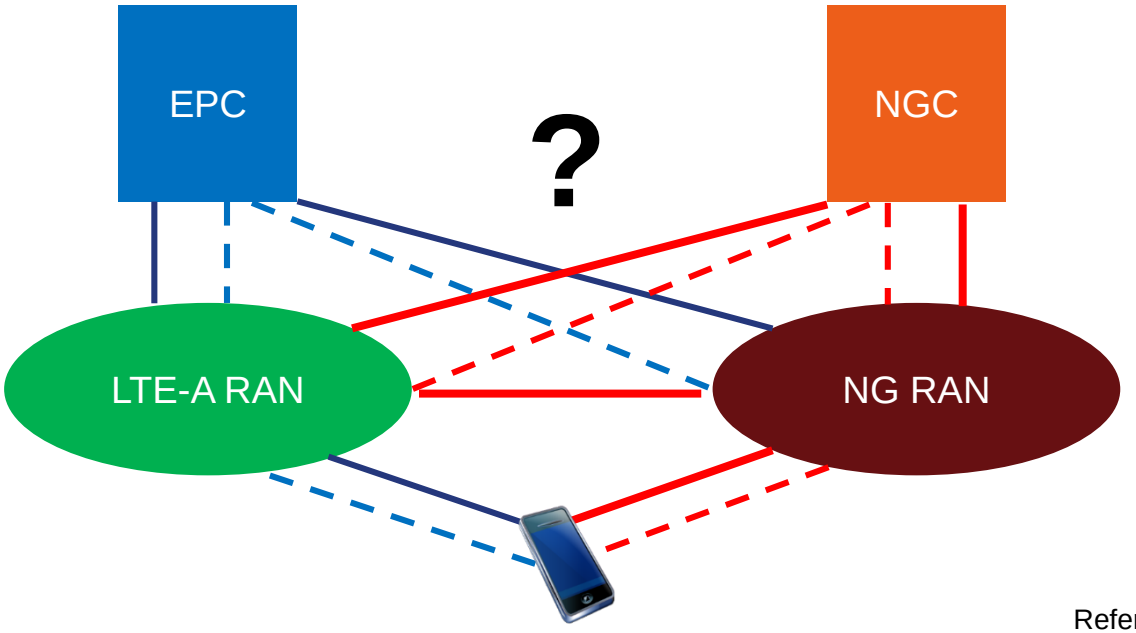
NR new frequency ranges and applicability for existing LTE bands in Rel-15

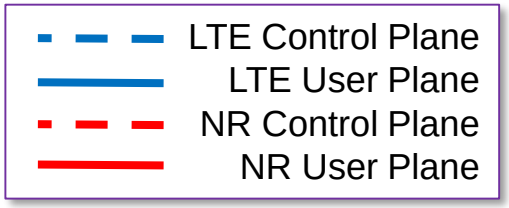
Frequency range / LTE band	other supporting companies (min. 3)
3.3-4.2 GHz	NTT DOCOMO, KDDI, SBM, CMCC, China Unicom, China Telecom, KT, SK Telecom, LG Uplus, Etisalat, Orange, Telecom Italia, British Telecom, Deutsche Telekom
4.4-4.99 GHz	NTT DOCOMO, KDDI, SBM, CMCC, China Unicom, China Telecom,
24.25-29.5 GHz	NTT DOCOMO, KDDI, SBM, CMCC, KT, SK Telecom, LG Uplus, Etisalat, Orange, Verizon, T-mobile, Telecom Italia, British Telecom, Deutsche Telekom
31.8-33.4GHz	Orange, Telecom Italia, British Telecom
37-40 GHz	AT&T, Verizon, T-mobile
1.427-1.518G	Etisalat
Band 3 – 1.8 GHz	CMCC, China Telecom
Band 7 – 2.6 GHz	CHTTL, British Telecom
Band 8 – 900 MHz	CMCC
Band 20 – 850 MHz	Orange
Band 28 – 750 MHz	Orange, Swisscom, Telecom Italia, Telefonica, Vodafone
Band 41 – 2.6 GHz	Sprint, China Telecom, C-Spire, China Unicom
Band 66 – 1.7 & 2.1 GHz	T-mobile, DISH
Band 1 – 2.1 GHz	China Unicom, China Telecom

Network Architecture

Many combinations fewer priorities







Reference: 3GPP RP-161266 (Deutsche Telekom AG)

NR : New Radio (access) – **applicable from 500 MHz – 100 GHz**
NG-RAN : Next Generation RAN (using NR access)
NGC : Next generation Core network

3GPP NR Scenarios & KPIs

3GPP TR 38.913 V14.2.0 (2017-03)

12 Deployment scenarios					
Indoor hotspot	Dense urban	Rural	Urban macro	High speed	Urban coverage for massive connection
Extreme long distance coverage	Highway scenario	Commercial Air to Ground scenario	Light aircraft scenario	Satellite extension to Terrestrial	Urban grid for connected car

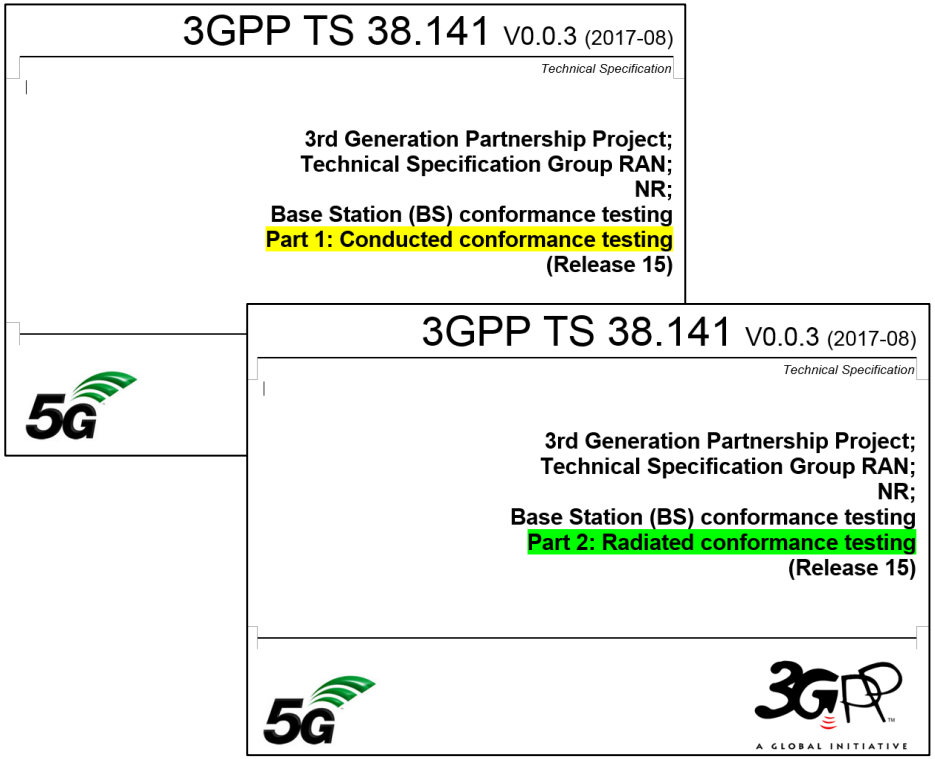
URLLC mMTC eMBB

	19 KPIs ➔ Value		
1	Peak Data Rate ➔ DL: 20Gbps UL: 10Gbps	11	Area Traffic Capacity ➔ Factored by SE, site density, BW
2	Peak Spectral Efficiency ➔ DL: 30bps/Hz UL: 15bps/Hz	12	User Experience Data Rate ➔ Factored by 5% SE & BW
3	Bandwidth ➔ Up to IMT-2020 Requirement	13	Reliability(eV2X) ➔ $(1\text{-}10^{-5})$ with latency 2~10ms
4	Control Plane Latency ➔ 10ms	14	Coverage ➔ MCL:164dB(160bps) Function of data rate
5	User Plan Latency URLLC ➔ 0.5ms eMBB: 4ms	15	UE Battery Life ➔ 10 years (15y is desirable)
6	Latency for Infrequent Small Packets ➔ No worse than 10s	16	UE Energy Efficiency ➔ Qualitative
7	Mobility Interruption Time ➔ 0ms	17	Mobility ➔ 500km/h
8	Inter-system Mobility ➔ btw IMT-2020 & IMT	18	Connection Density ➔ 10^6 devices/km2
9	Reliability(URLLC) ➔ $(1\text{-}10^{-5})$ with latency 1ms	19	5th Percentile User Spectral Efficiency ➔ 3x IMT-Advanced
10	Cell/TRP Spectral Efficiency ➔ 3x IMT-Advanced		

3GPP Base Station Conformance testing

TS 38.142 test specification for the NR BS will be composed of two parts :
Part 1: Conducted conformance testing
Part 2: Radiated conformance testing

It still has only the skeleton for the test item, so the details are still empty.



3GPP TS 38.141 V0.0.3 (2017-08)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group RAN;
NR;
Base Station (BS) conformance testing
Part 1: Conducted conformance testing
(Release 15)

3GPP TS 38.141 V0.0.3 (2017-08)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group RAN;
NR;
Base Station (BS) conformance testing
Part 2: Radiated conformance testing
(Release 15)

A GLOBAL INITIATIVE

6 Radiated transmitter characteristics
6.1 General
6.2 Radiated transmit power
6.3 OTA Base station output power
6.4 OTA Output power dynamics
6.5 OTA Transmit ON/OFF power
6.6 OTA Transmitted signal quality
6.7 OTA Unwanted emissions
6.7.1 General
6.7.2 OTA Occupied bandwidth
6.7.3 OTA Adjacent Channel Leakage Power Ratio (ACLR)
6.7.4 OTA Operating band unwanted emissions
6.7.5 OTA Transmitter spurious emissions
6.8 OTA Transmitter intermodulation

7 Radiated receiver characteristics
7.1 General
7.2 OTA sensitivity
7.3 OTA Reference sensitivity level
7.4 OTA Dynamic range
7.5 OTA In-band selectivity and blocking
7.6 OTA Out-of-band blocking
7.7 OTA Receiver spurious emissions
7.8 OTA Receiver intermodulation
7.9 OTA In-channel selectivity

Pre-5G Standards

Verizon Wireless

– Verizon 5G Technical Forum - www.5gtf.org
  - Formed in 2015 with partners: Cisco, Ericsson, Intel, LG, Nokia, Qualcomm and Samsung
  - Operates primarily in the US 28 GHz band but also 39 GHz – TDD only
  - 28 GHz spectrum primarily owned nationally by Verizon (except New York City)
  - Based on a 5x multiplier of LTE
    - 8 x 100 MHz contiguous channels
    - 5x LTE subcarrier spacing – 75 kHz

– Deployment plans
  - Focussed on “last km” fixed wireless as competitor for cable/fibre
  - Limited (28 GHz only) commercial deployment in eleven municipalities planned for Q4 2017
  - Customer Premises Equipment (CPE) only, no mobiles

Pre-5G Standards

Korea Telecom (KT)

- KT PyeongChang 5G-SIG & Development Forum - www.kt.com/eng/biz/kt5g_02.jsp
  - Formed in 2015 to develop the specifications and system components
  - Operates primarily in the 28 GHz band (27.5 GHz to 28.35 GHz) – TDD only
  - Developed in cooperation with Verizon to minimize Pre-5G fragmentation
  - Based on a 5x multiplier of LTE
    - 8 x 100 MHz contiguous channels
    - 5x LTE subcarrier spacing – 75 kHz
- Deployment plans
  - Non-commercial demonstration targeted at PyeongChang Feb 2018 winter Olympics
  - Focus on high mobility high definition low latency video applications
  - KT Commercial deployments planned for 2019 based on 3GPP specs

Verizon vs. KT 5G vs. 3GPP NR

3GPP TR 38.802 V14.0.0 (2017-03)

	Verizon Pre-5G	KT 5G-SIG	3GPP NR - not finalized
Duplexing	Dynamic TDD	Dynamic TDD	FDD, Dynamic TDD
Beamforming	Yes	Yes	Yes
Frequency bands	28 GHz	28 GHz	Up to 100 GHz
Carrier Bandwidth	100 MHz	100 MHz	Sub-6GHz - 100 MHz > 6 GHz (400, 800, 1000 MHz)?
Carrier aggregation	8	8	8 – 32
Waveform	OFDMA	OFDMA	OFDMA (DL&UL), SC-FDMA (opt UL), other waveforms for mMTC & high freq.
Modulation	Up to 64QAM	Up to 64QAM	Up to 256QAM (1024QAM?)
Use cases	eMBB fixed access	eMBB mobility	eMBB, mMTC, URLLC
Network deployment	Standalone	Non-Standalone (with LTE)	Standalone, Non-standalone
Multiplexing of different numerologies	No	No	Yes
Spectrum	Licensed	Licensed	Licensed, unlicensed, shared acce ss
Channel coding	TBCC, LDPC Turbo Code (optional)	TBCC, LDPC	LDPC (for eMBB data), Polar Cod e (for eMBB control)

Numerology = LTE x 5

Sampling frequency = 153.6 MHz (30.72 MHz x 5)

Subcarrier spacing = 75 kHz (15 kHz x 5)

Carrier bandwidth = 100 MHz (20 MHz x 5)

https://www.kt.com/biz/kt5g_02.jsp

www.5gtf.org

KEYSIGHT TECHNOLOGIES

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  - ✓ Keysight 5G Strategy
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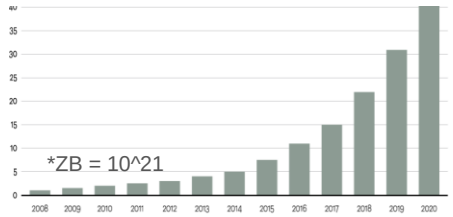
Six Key Trends in Wireless Infrastructure Industry

1 Exploding Data Growth

> 40% CAGR

Will Reach 45 Zetabytes by 2020



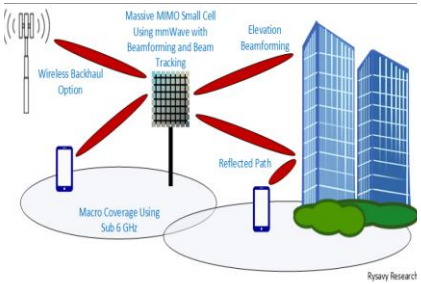
2 Wireless CAPEX

Spending is flat despite data growth, yet NEM equip prices falling

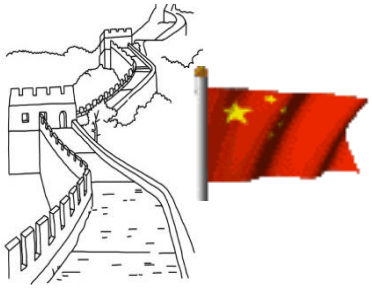
3 Cloud economics – Servers, NFV, SDN, Analytics, Open Source

4 Complex 5G technologies:

Integrated, Massive MIMO, mmW, Large Bandwidths, Connectorless

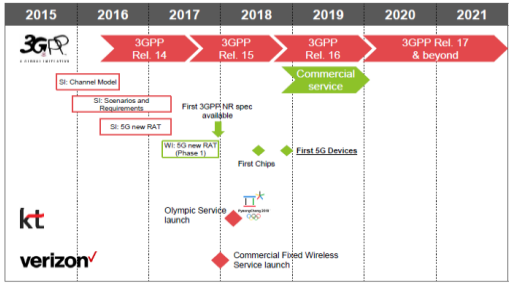


5 Intense Competition: Rise of Asian companies & Influence in Standards



6 Aggressive Timelines

Stds & deployment pulling forward

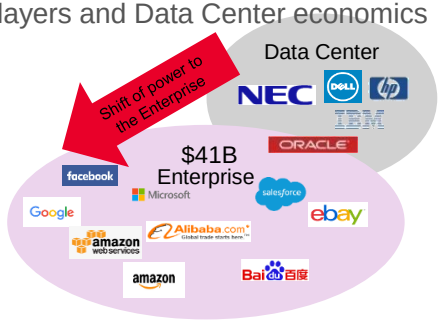


KEYSIGHT TECHNOLOGIES

Six Insights Driving Our Thought Process

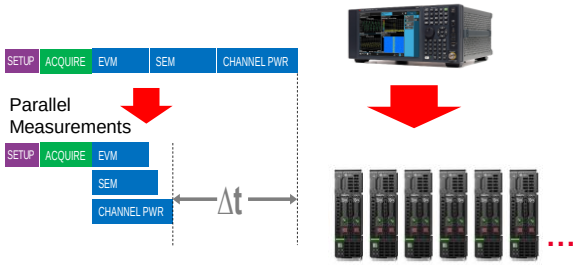
1 Macro Cost Pressure

Traditional NEM margins come under pressure from China vendors, Cloud Players and Data Center economics



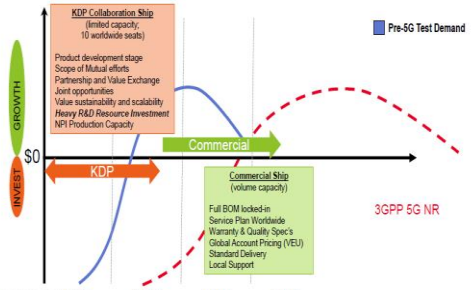
2 Cost of Test

Current *Cost Of Test* trend unsustainable – apply Cloud economics to T&M in MFG



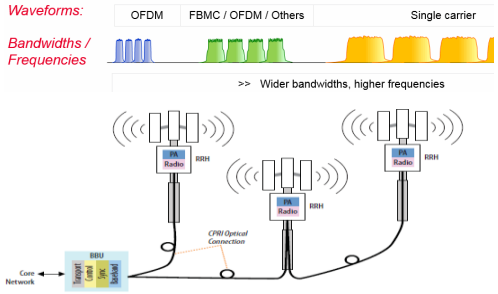
3 Collaborate-To-Market

Collaborative R&D with key 5G market makers is critical - Emphasis is shifting towards earlier access, functional end-to-end test



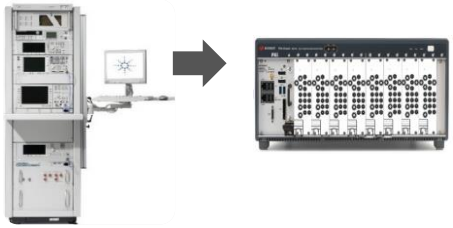
4 RAN Complexity

5G new radio interface & new network architecture - complex technologies, new spectrum, multiple difficult bands, X-haul of huge amounts of data



5 Flexibility

Single Channel Fixed Solutions are Insufficient – Multiple Channels Needed, flexibility, price per channel critical

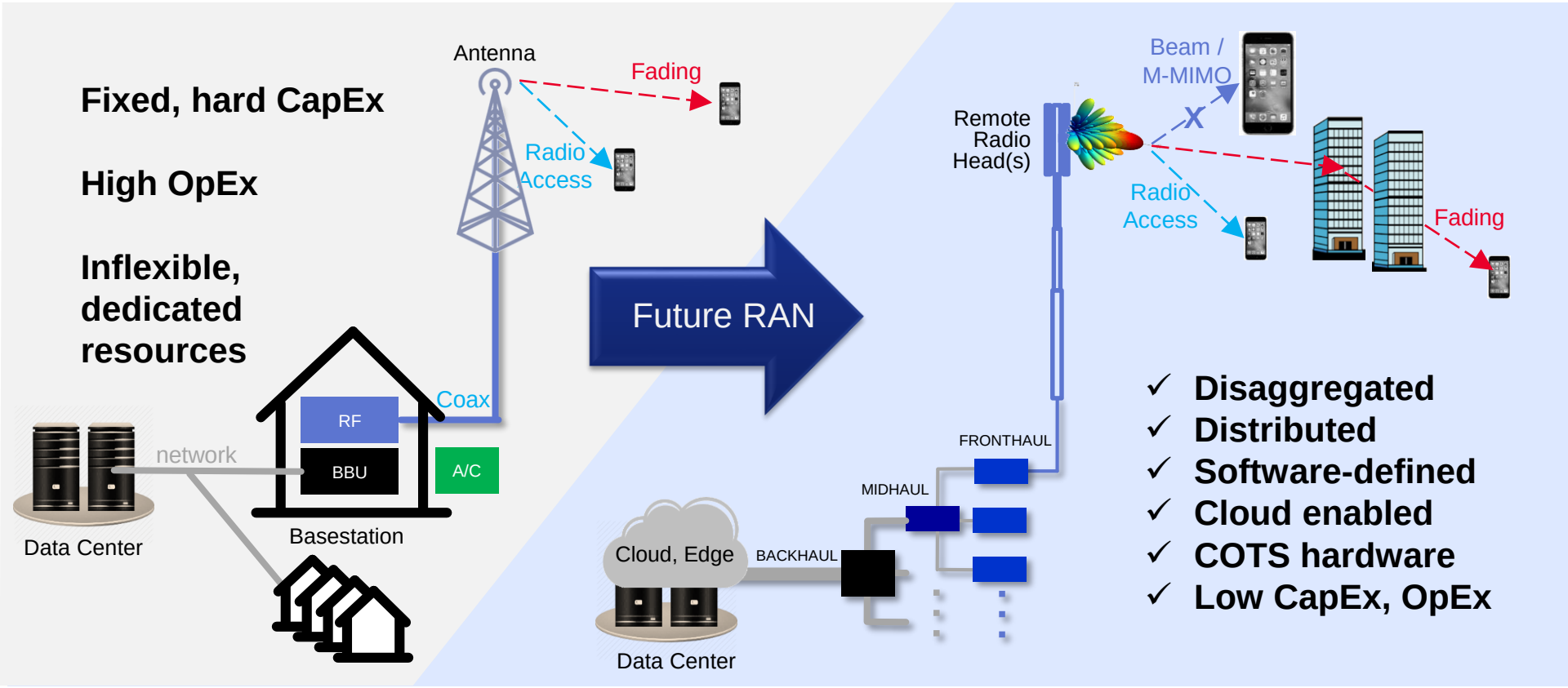


6 Over-the-Air (OTA)

mmW BTS Test requires new techniques, mini chambers, near-field measurements

KEYSIGHT TECHNOLOGIES

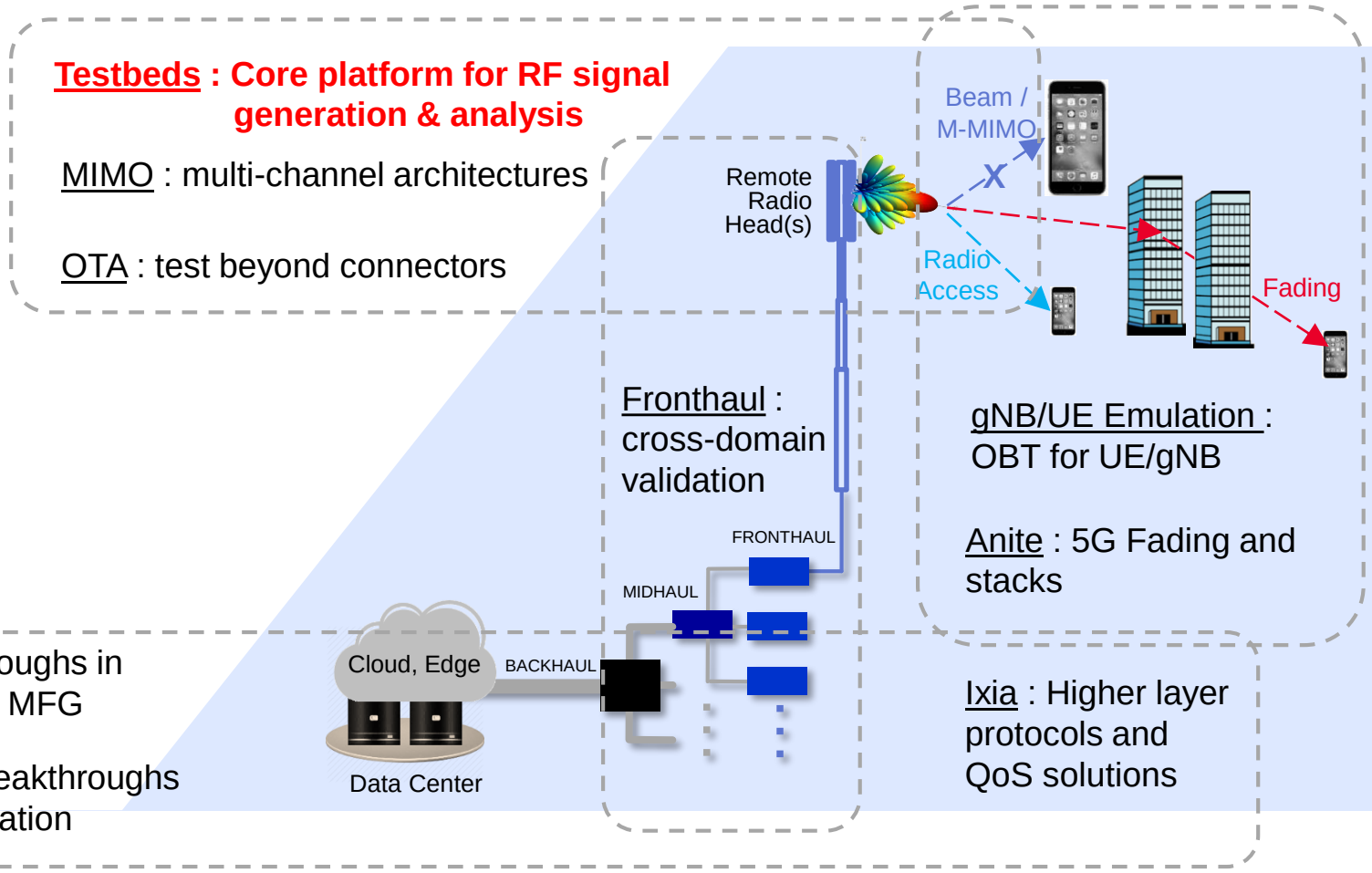
Evolution of 5G Architectures



This architecture evolution is also actively re-shaping T&M

Where is Keysight Investing to Serve 5G Architectures

Stimulus/response Testbeds are still the foundation



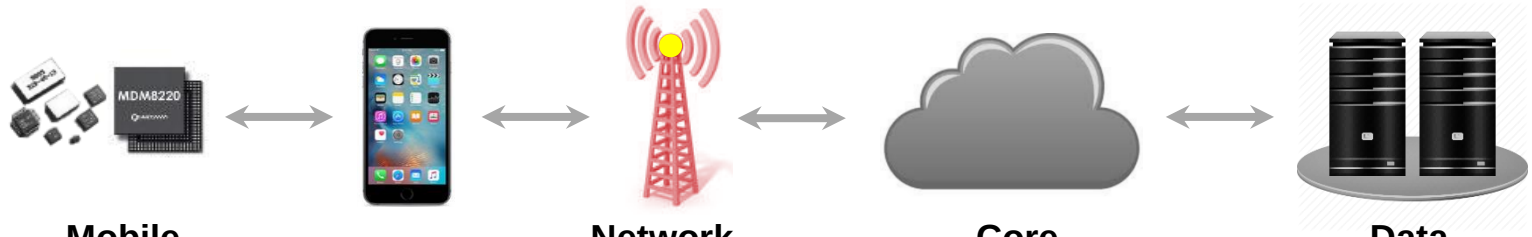
Keysight T&M architectures are adopting these same innovations

Keysight Realignment Around Our Customers

Internet Infrastructure Industry Solution Team Focused on 5G Infrastructure

Industry Solution Teams
Focused on Industry-specific Solutions

ICs	Consumers	Operators / NEMs	Enterprises



Mobile Chipsets	Devices	Network Access	Core Network	Data Center
PA / FEM	Smartphones	Base stations	High Capacity Transmission	Servers
Baseband	IoT	Small cells	1G – 400G Fiber	Storage
Power Control	Sensors	Fronthaul (CPRI+)	Coherent optical	Ethernet
MIPI	Applications &	Backhaul	Backbone Switches	Fiber Channel
USB-C	Technologies	DOCSIS	Routers	PCIe

Centers of Excellence

Focused on General-purpose Instruments

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Keysight Corporate Growth Strategies

Growth Strategies

Software-centric solutions | Organic R&D investments | Strategic M&A

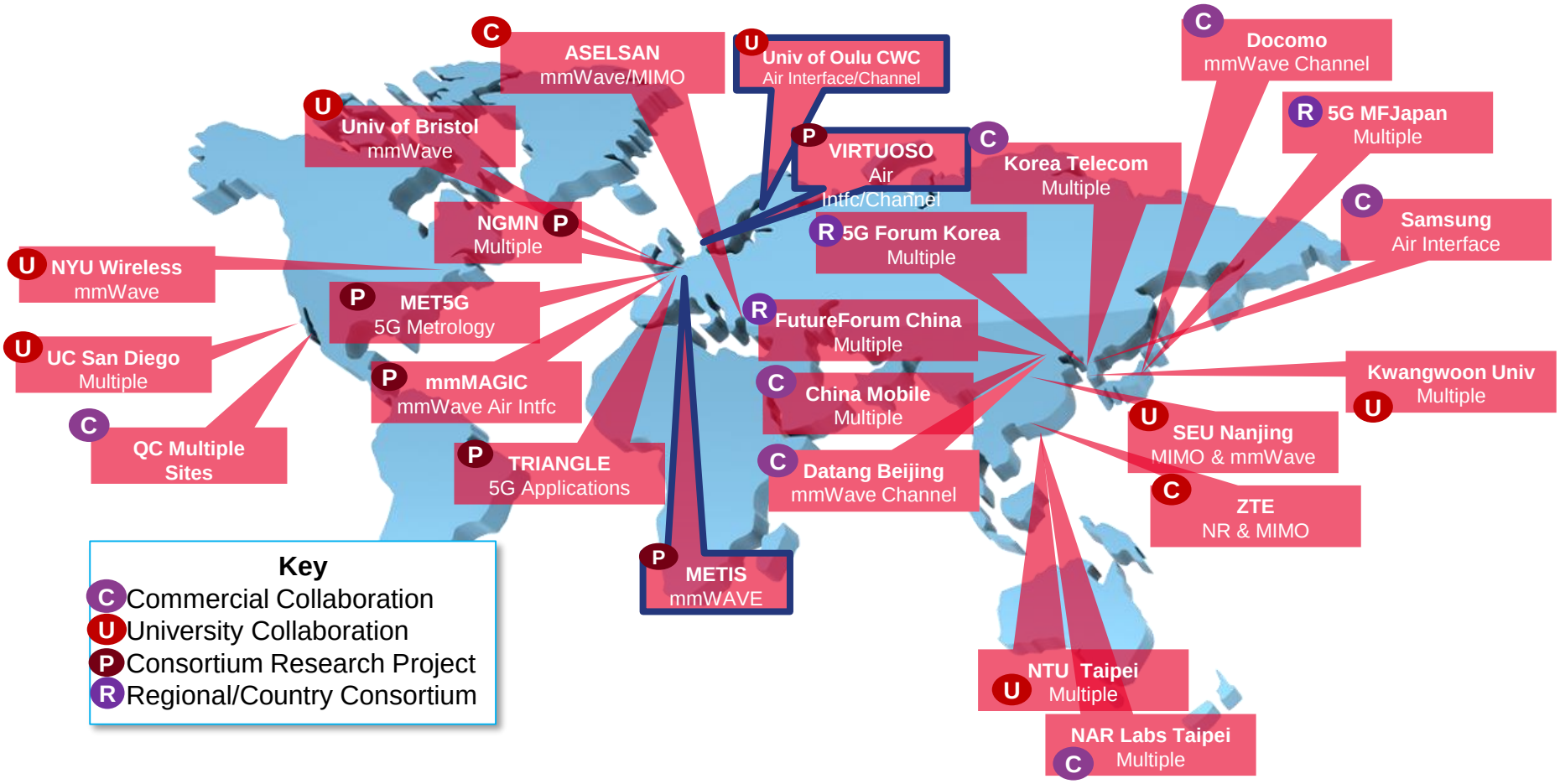
Be first in 5G wireless

Expand leadership in T&M software

Grow services business

Extend into network test and visibility

Keysight's 5G Global Engagements (public-only)



Keysight standard strategy

- **Role of a test vendor in RAN meetings**:
  - Look after testability and accuracy requirements feasibility
  - Provide guidance on measurement methodology
  - Look after testing coverage covered
  - Minimize test system complexity, cost, testing time
  - Identify test system requirements to anticipate test system availability

- **Keysight standards strategy:**
  Spearhead 5G standardization activities by increasing **participation** and **contributions** in 3GPP Forum in tandem with the increasing work load and acceleration of 3GPP standards.

- In Q2/Q3, Keysight has contributed number of papers in 3GPP RAN#4 as listed below:-
  - **R4-1705350**: “Provisional measurement uncertainty values for UE RF baseline test method
  - **R4-1705394**: “Simplification of baseline method for off-axis measurements of beamlocked UEs”
  - **R4-1705834**: “Baseline RRM and demod measurement system considerations and channel models”
  - **R4-1705838**: “Simplified sectorized MPAC for RRM/Demodulation Setup”
  - **R4-1705831**: “Metrics for RRM/Demodulation Measurement Setup”
  - **R4-1705830**: “Proposal to base NR demod requirements on variable MCS/rank rather than FRC”

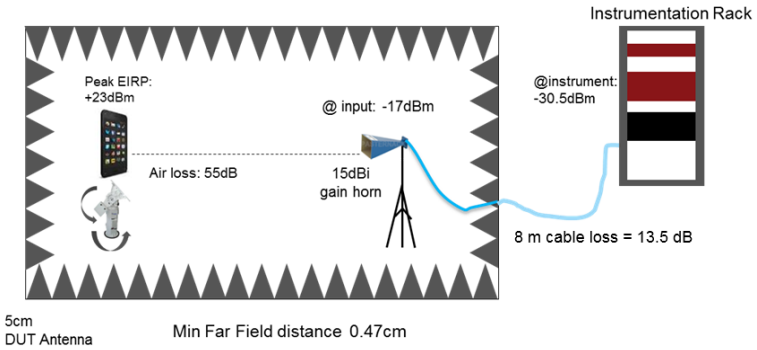
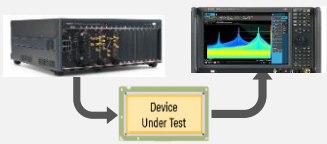
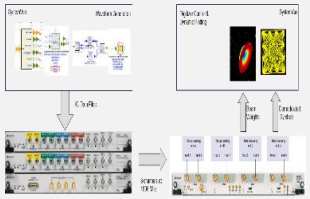
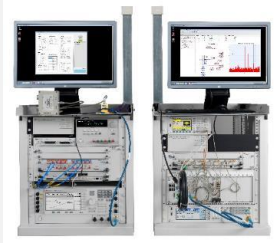


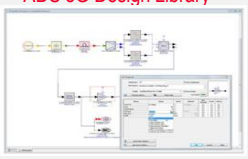
Fig.1 OTA setup for D=5cm for 28GHz

Keysight Test Solutions for 5G

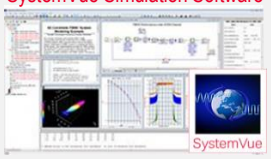
Pave your way from early research to commercialization

Wideband RF/µW/mmWave Generation & Analysis	Wideband mmWave Analysis	NES – Protocol, RF and Functional	Massive MIMO	Channel Sounding
5G Waveform Generation & Analysis Testbed Reference Solution 40GHz Signal Generation Up to 110 GHz Signal Analysis 	**E-Band Signal Analysis Reference Solution** 	**Network Emulation, Protocol, Analysis, Automation RF Tool** 	**Real-time Beamforming Signal Generation & Analysis** 	**Channel Sounding Reference Solution** 

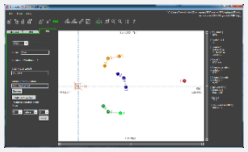
ADS 5G Design Library



SystemVue Simulation Software

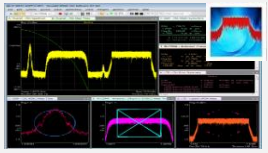


5G Channel Emulation



Signal Studio Software

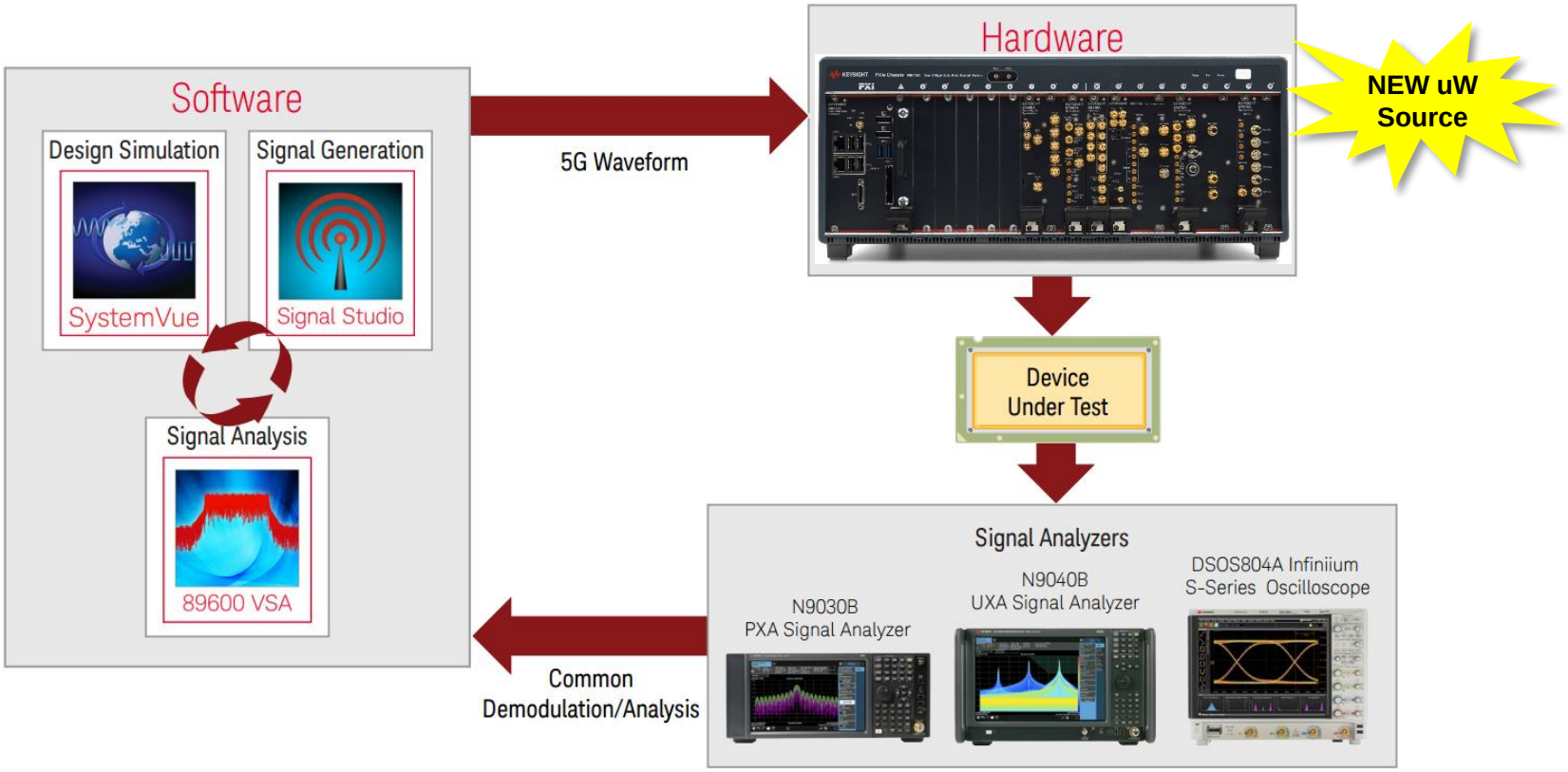
89600 VSA Software



5G Flexible Testbed for waveform Generation & Analysis

Flexibility is needed in three key areas of 5G research and early testing:

- Generating and analyzing new waveforms
- Supporting a wide range of modulation bandwidths, from several MHz to a few GHz
- Supporting a wide range of frequency bands, from RF to microwave to millimeter-wave



SA Frequency range : 3Hz ~ 110GHz and Analysis Bandwidth : 1 GHz (5GHz w/OSC)

SG Frequency range : 250KHz ~ 44GHz and Bandwidth : 2 GHz

Keysight's Modular Testbed Platform for 5G

Scalable **Flexible** **Upgradable**

Microwave Signal Generator Instrument M9383A- Analog and Vector

Performance

- **Performance class**
  Analog and Vector Signal Generator
- **Multi-module Instrument**: **M9383A**

Scalability

- **Highly configurable/scalable:**

Analog:

- 1 MHz to 20 or 44 GHz Frequency Coverage
- High Output Power & Low Phase Noise

Vector:

- 1 MHz to 20 or 44 GHz Frequency Coverage
- Multiple Enhance Phase Noise levels
- 1 GHz Modulation BW with 1% EVM at 28 GHz

Upgradability

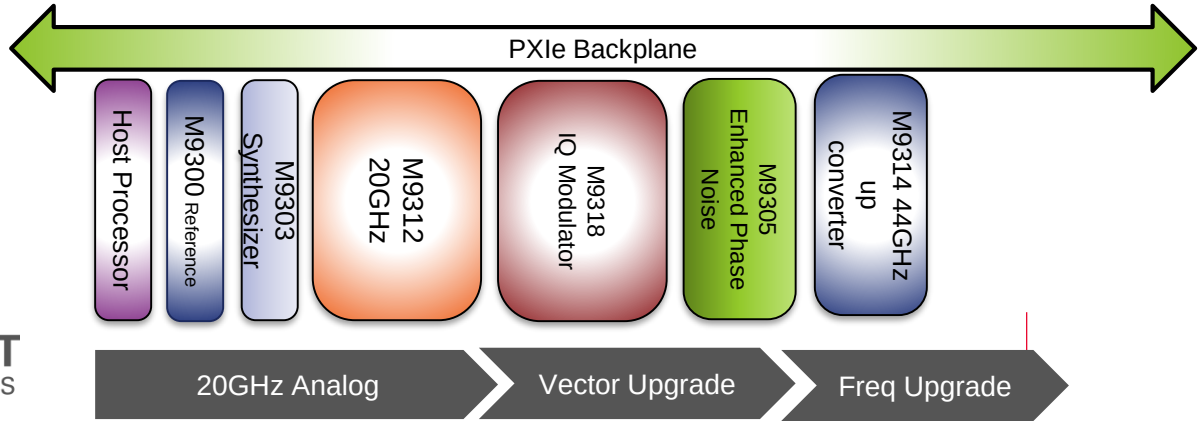
- **Industry's most upgradeable Source**
- **In-Chassis Orderability (MS9000A)**

New M9383A PXI VSG for 5G

Target for R&D, DVT and Mfg

- Frequency Range: 1 MHz to **44 GHz**
- Amplitude Range: -90 to **+ 7 dBm** (40 GHz)
- Amplitude Accuracy:
  - ± 1.0 dB (Pout > -90 dBm; Fc ≥ 2 GHz)
- Tuning Speed:
  - **~150 us** (list mode)
  - ~10 us within IF BW (list mode)
- Internal modulation BW: up to **1 GHz**
  - Real-time channel corrections
  - Arbitrary Re-Sampling
- EVM @ 28 GHz 1 GHz BW **1.0%**
- **Scalable, flexible, upgradable**

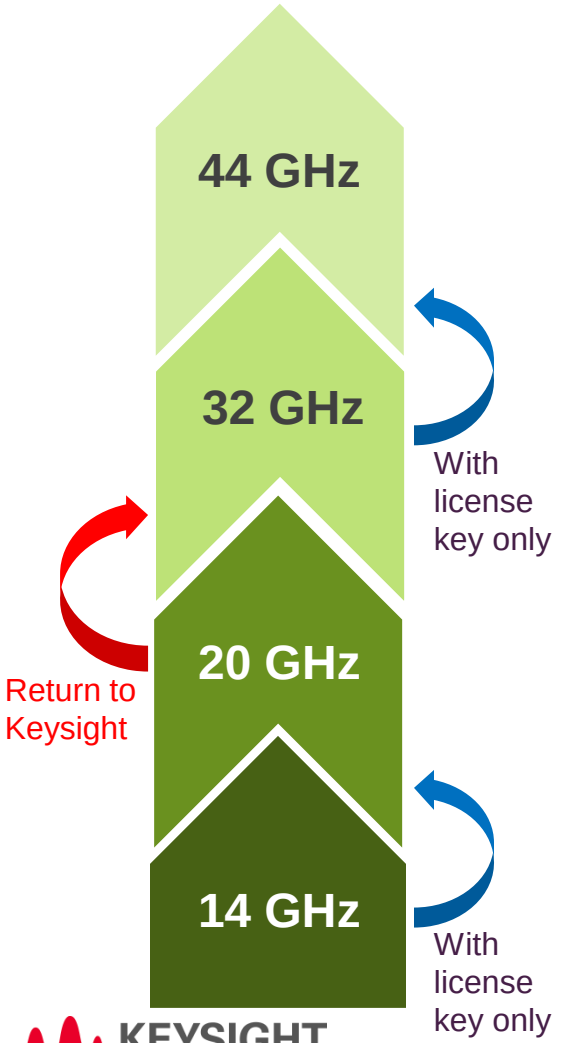
5G Requirements
- 28/39 GHz
- 1 GHz BW
- 1% EVM



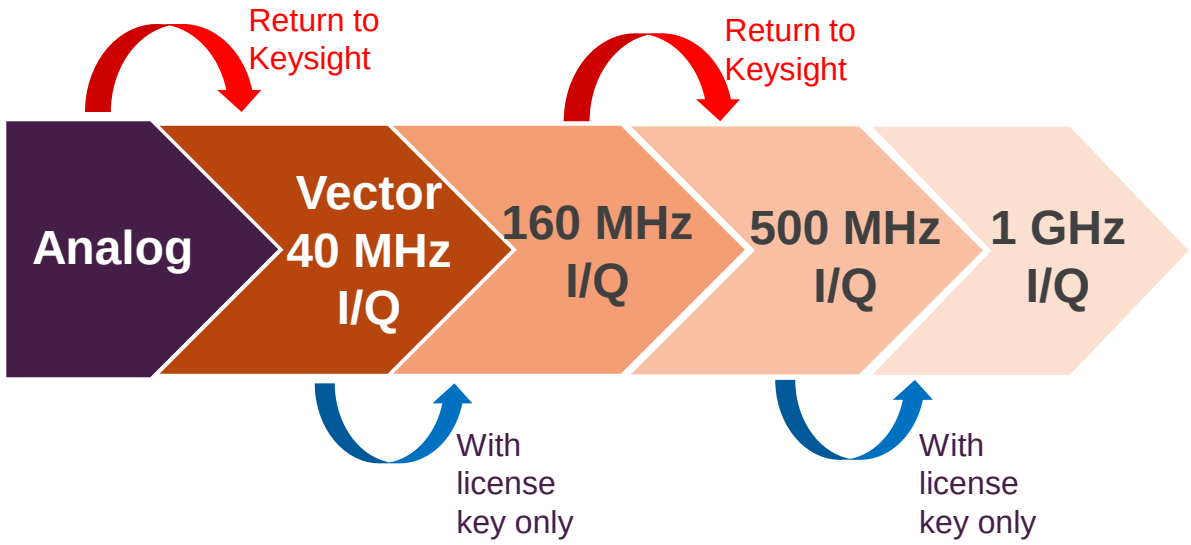
Industry's best upgradeability

Upgradability

- Frequency upgrades



- Bandwidth upgrades



(Compare to ESG, PSG, MXG, UXG with upgrade by trade-in!)

KEYSIGHT TECHNOLOGIES

5G Testbed Solution Roadmap

Ready for 5G R&D, DVT, & early manufacturing

NEW uW Source

Modular 5G testbed Demonstrator

Analyzer

Source

1% EVM

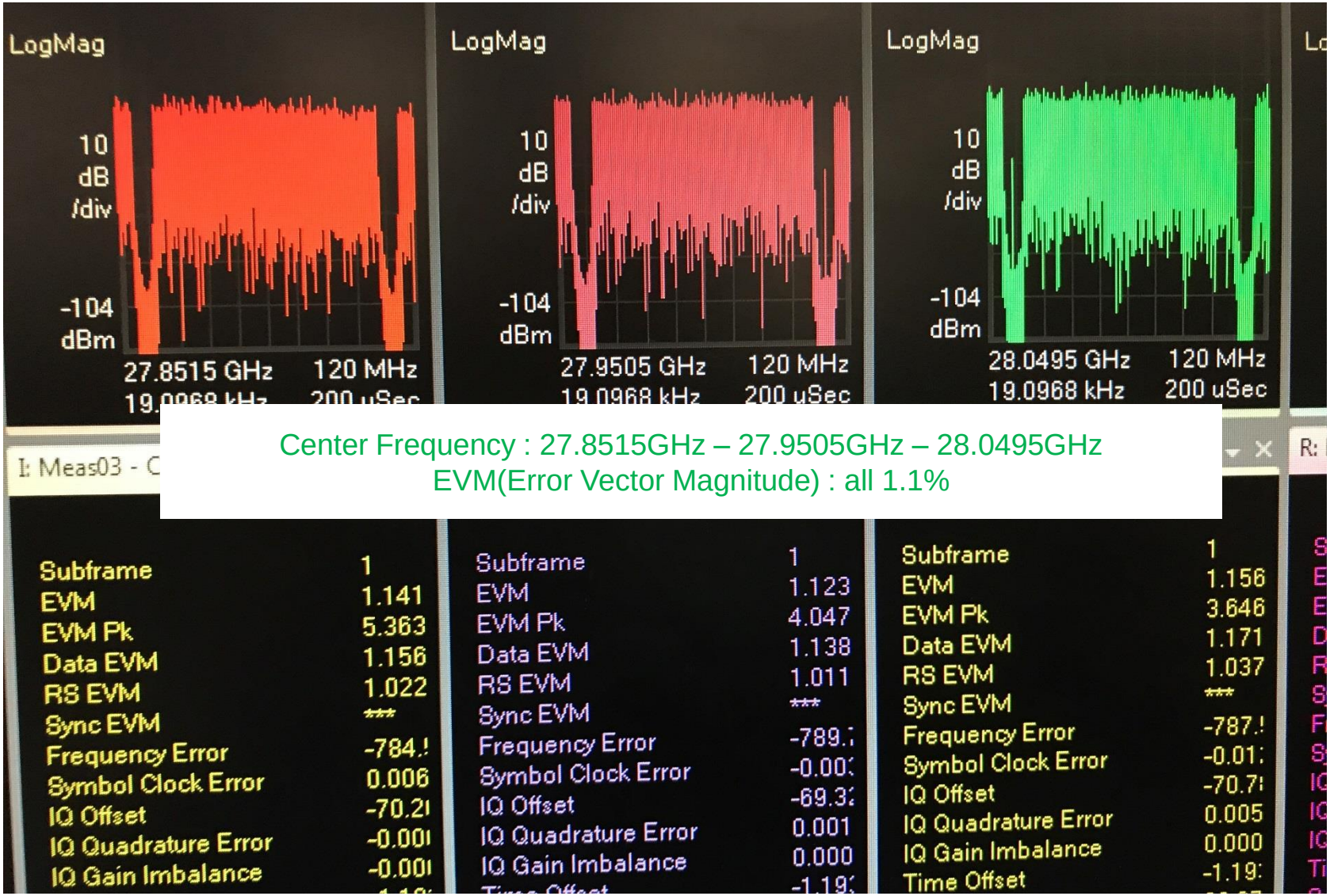
SS/SA in one Chassis

PXI uW source

PXI uW analyzer

Results: 28 GHz Verizon pre-5G (8CC x 100MHz)

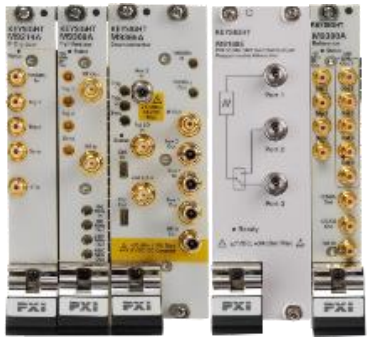
Results: 28 GHz Verizon pre-5G (8CC x 100MHz)



M9393A + M9203A: 50 GHz VSA with 1 GHz BW

New flexible analyzer solution, 9 kHz to 50 GHz

- M9393A VSA is world's fastest in mmW PXI
  - Opt F27 + FRX covers 3.6 to 50 GHz tuning range
  - M9169E mech. switch/attenuator to control range (*no preamp*)
  - Opt WB1 provides 1 GHz wide IF output at ~550 MHz
  - ACP ~55 dB CW, ~49 dB for 16QAM 28 GHz 200 MHz BW
- M9203A Digitizer 12-bit 1-/2-chan 3.2 GSa/s
  - Interleave mode at 3.2 GSa/s captures full 1 GHz BW
  - Opt SA0 provides recommended bundle for SA uses
  - SFDR 55 dB nom
- 89600 VSA plus "VSA Input Control" demo app
  - 89600 VSA SW controls both RF front end and M9203A
  - "VSA Input Control" applet coordinates & simplifies set-up; provides "family cal" files to improve IF flatness
  - EVM 2-4% (typ family cal); potential to improve with custom cal

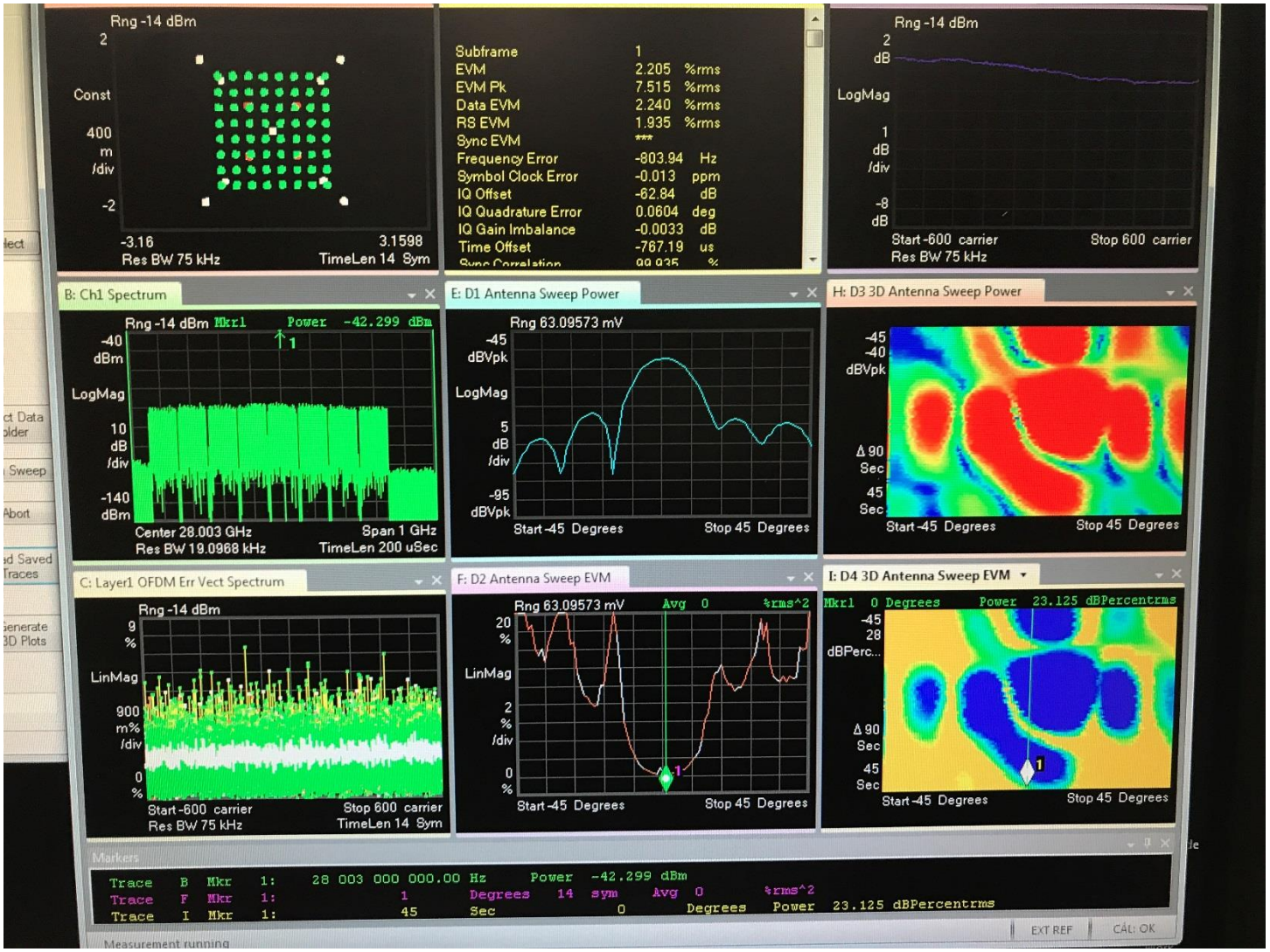


* M9203A may be export controlled.

IMS June 2017 – Keysight Testbed Demo

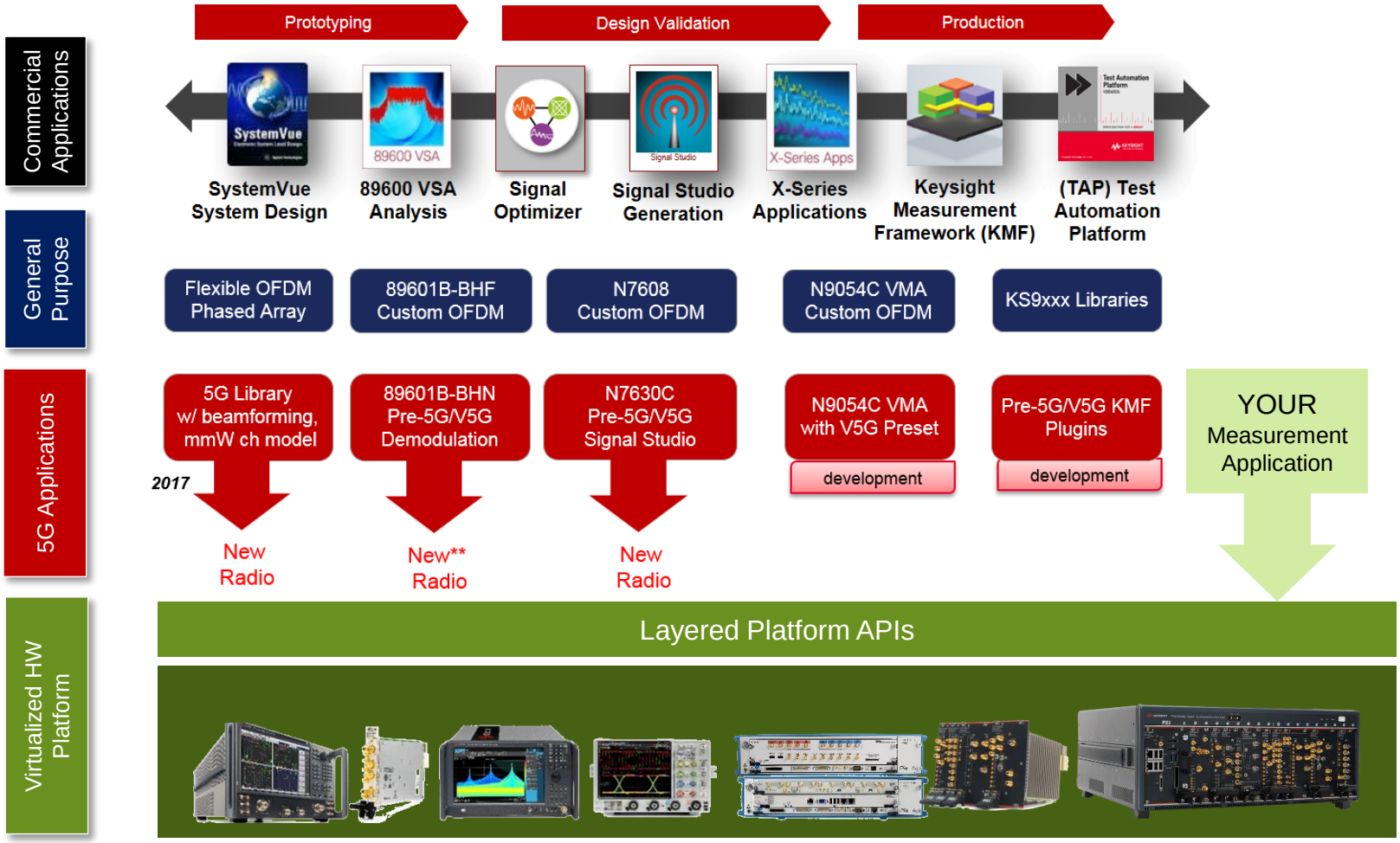
IMS June 2017 – Keysight Testbed Demo

IMS June 2017 – Keysight Testbed Demo



Software Solution Framework

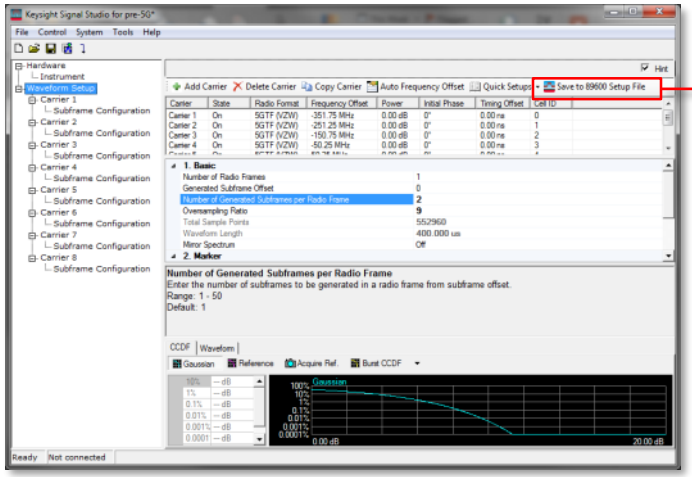
Driving to faster transitions from R&D to DVT to MFG



Pre-5G Software Solution Leadership

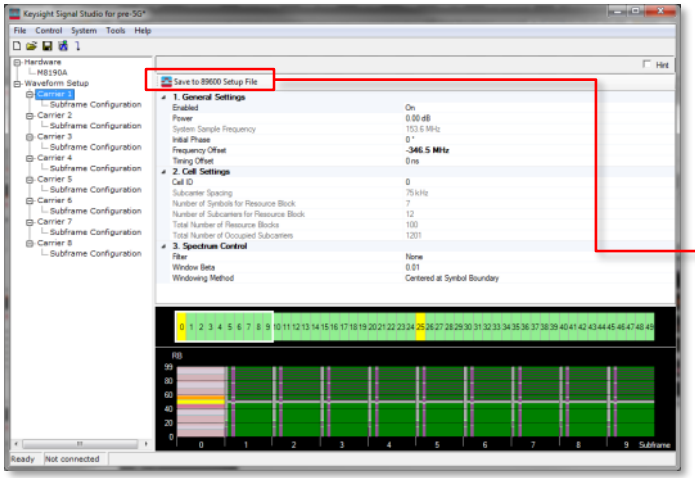
Signal Studio & VSA examples

Export VSA Setup from “Waveform Setup” level



VSA Custom OFDM with multi-measurement
(8 carrier simultaneous measurement)

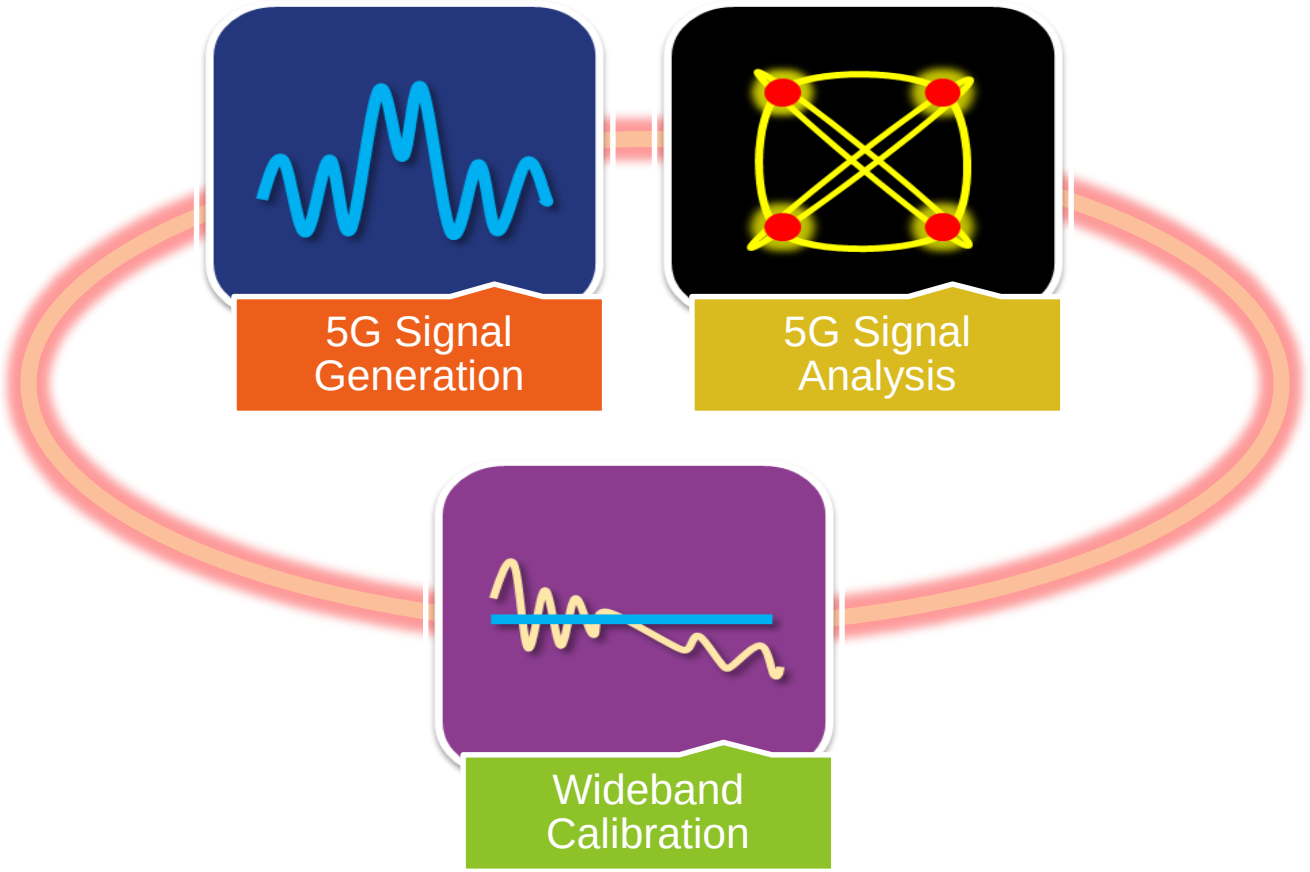
Export VSA Setup from “Carrier” level



VSA Custom OFDM with single carrier measurement
(Note: each carrier requires different setup file)

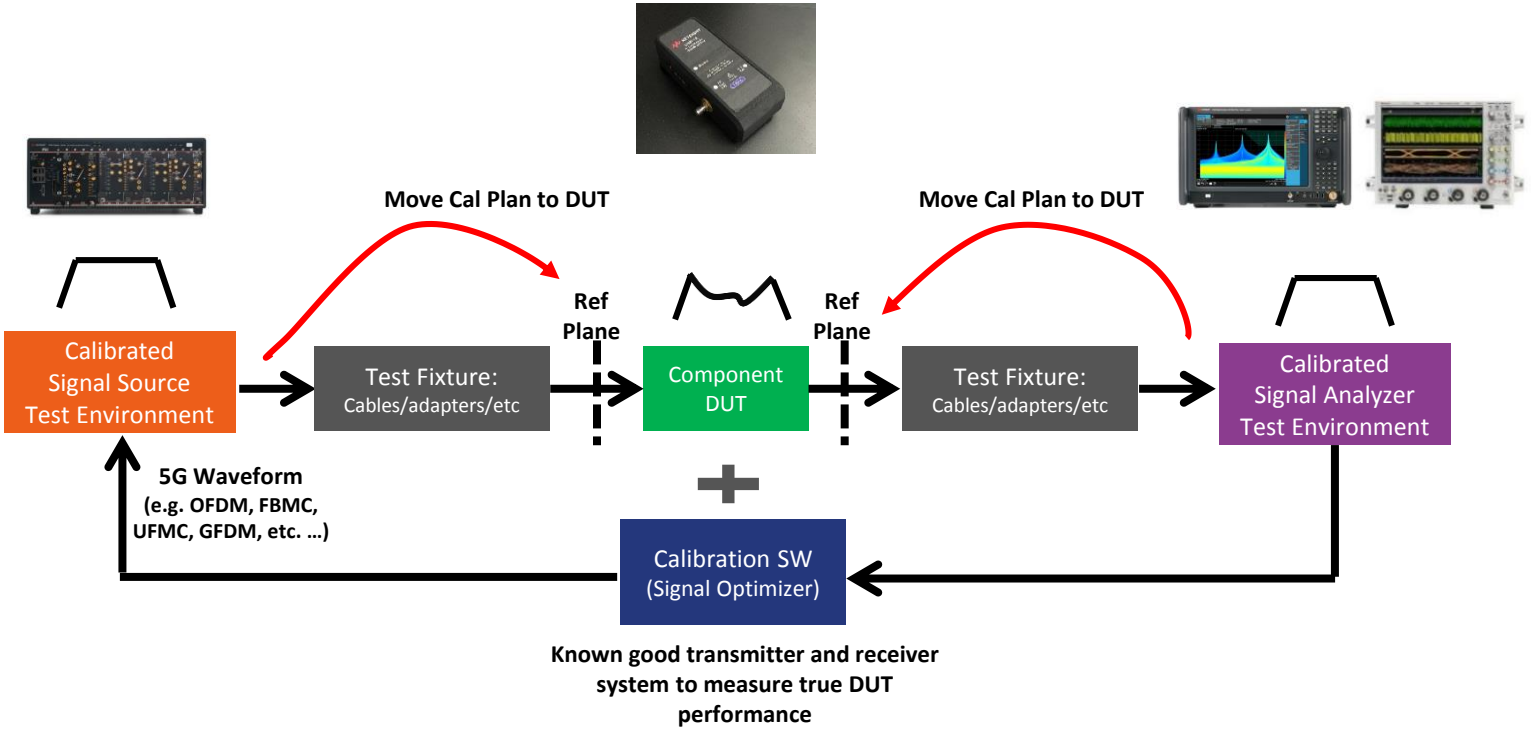
New 5G Software: **Keysight Signal Optimizer**

Build Confidence into your 5G System



Calibrated Tx and Rx Measurement System

How does it work?



See the true performance of device under test!

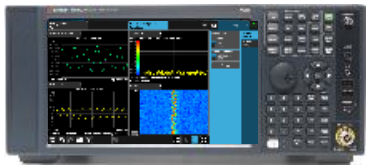
Introducing the **N9041B** UXA Signal Analyzer

Industry's **first integrated 110 GHz** signal analyzer

1st

CXA
Leading low-cost tool

- 9 kHz to 26.5 GHz,
- 25 MHz BW



EXA
Maximum value up to m mWAve

- 10 Hz to 44 GHz
- 40 MHz BW

MXA
Optimum choice for wire less

- 10 Hz to 26.5 GHz
- 160 MHz BW
- Real Time SA

PXA
Benchmark for demandi ng applications

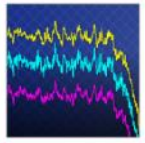
- 3 Hz to 50 GHz,
- 510 MHz BW
- Real Time SA

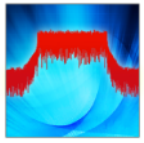
UXA
Wide-open performance

- 3 Hz to 110 GHz*
- 5 GHz BW with external oscil loscope
- 1 GHz internal BW
- Real Time SA – 255 MHz

Download your next insight

X-Series applications
Ready-to-use measurements





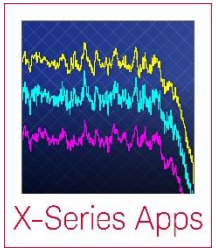
89600 VSA software
Comprehensive demodulation & vector signal analysis

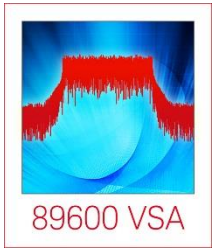
KEYSIGHT TECHNOLOGIES

*50 GHz with N9040B

The **New N9041B** UXA Signal Analyzer, **110 GHz**

- 1st — 3 Hz - **110 GHz** Continuous sweeps
- 1st — **5 GHz BW** (with external oscilloscope)
- 1st — Up to **1 GHz internal** BW
- 1st — **-150 dBm/Hz** DANL up to 110 GHz
- 1st — Dual input **rugged 2.4 mm** connector





1mm connector
3 Hz – 110 GHz

2nd rugged
2.4mm connector
3 Hz – 50 GHz

KEYSIGHT TECHNOLOGIES

5G Testbed Reference Solution

>2 GHz Bandwidth: 50 – 110 GHz

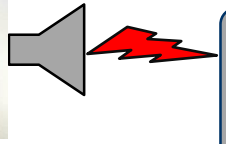
M8195A Wideband AWG
(5 GHz IF Generation)

Waveform

Signal Optimizer (K3101A)

Compact VDI Upconverter
(V, E, W-Bands)

N5183A MXG (LO)

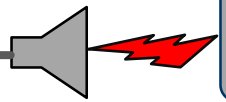


DUT

Digitized Signal

Infiniium Scope

N9041B X-Series Analyser



5 GHz IF

5G Testbeds – Focus on pre-5G and NR market

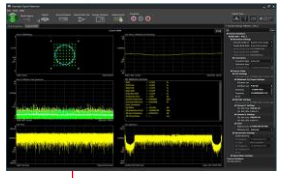
Customer Challenges & Keysight Response

Market Segment	R&D “Explorer” series	DVT “Validator” series	MFG “Producer” series
What is customer looking for?	• Measurement Performance • Ease of Use	• Time to Market • Automation • Measurement Performance • Footprint	• Cost of Test • Footprint • Speed • Price per port
Signal Generation	M9383A PXI VSG AWG+PSG	M9383A PXI VSG AWG+PSG	M9383A PXI VSG
Signal Analysis	N9040B UXA analyzer	M9393A PXI VSA	M9393A PXI VSA N9020B 50GHz MXA
Software	89601B BHN software N7630C Signal Studio K3101A Signal Optimizer	89601B BHN software N7630C Signal Studio K3101A Signal Optimizer	89601B BHN software N7630C Signal Studio









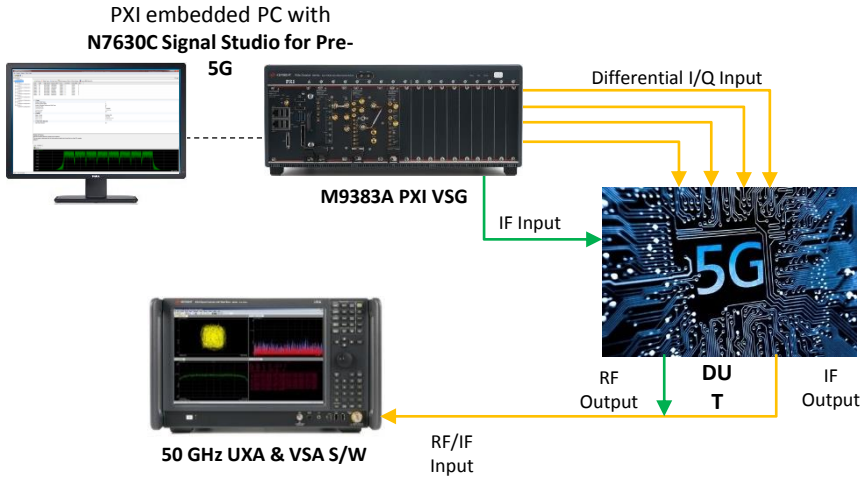
5G Testbed Solution for RFIC Tx/Rx

Pre-5G signal generation and analysis to verify RFIC performance and I/Q calibration

- ✓ Measurement items : Channel Power, ACP, EVM, Frequency, IQ mismatch (Quad error, Gain imbalance, Skew)
- ✓ Features : Testbed & RFIC Calibration for IQ mismatch (Quad error, Gain imbalance, DC/Differential offset)

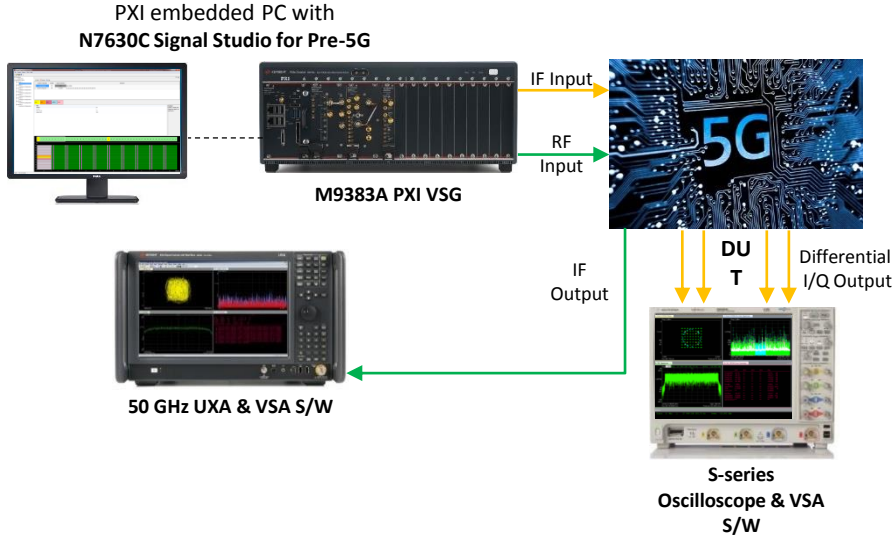
[RFIC **Tx path** Configuration]

- ❖ H/W : M9383A PXI VSG, N9040B UXA
- ❖ S/W : N7630C Signal Studio, 89600 VSA(Option : BHN)



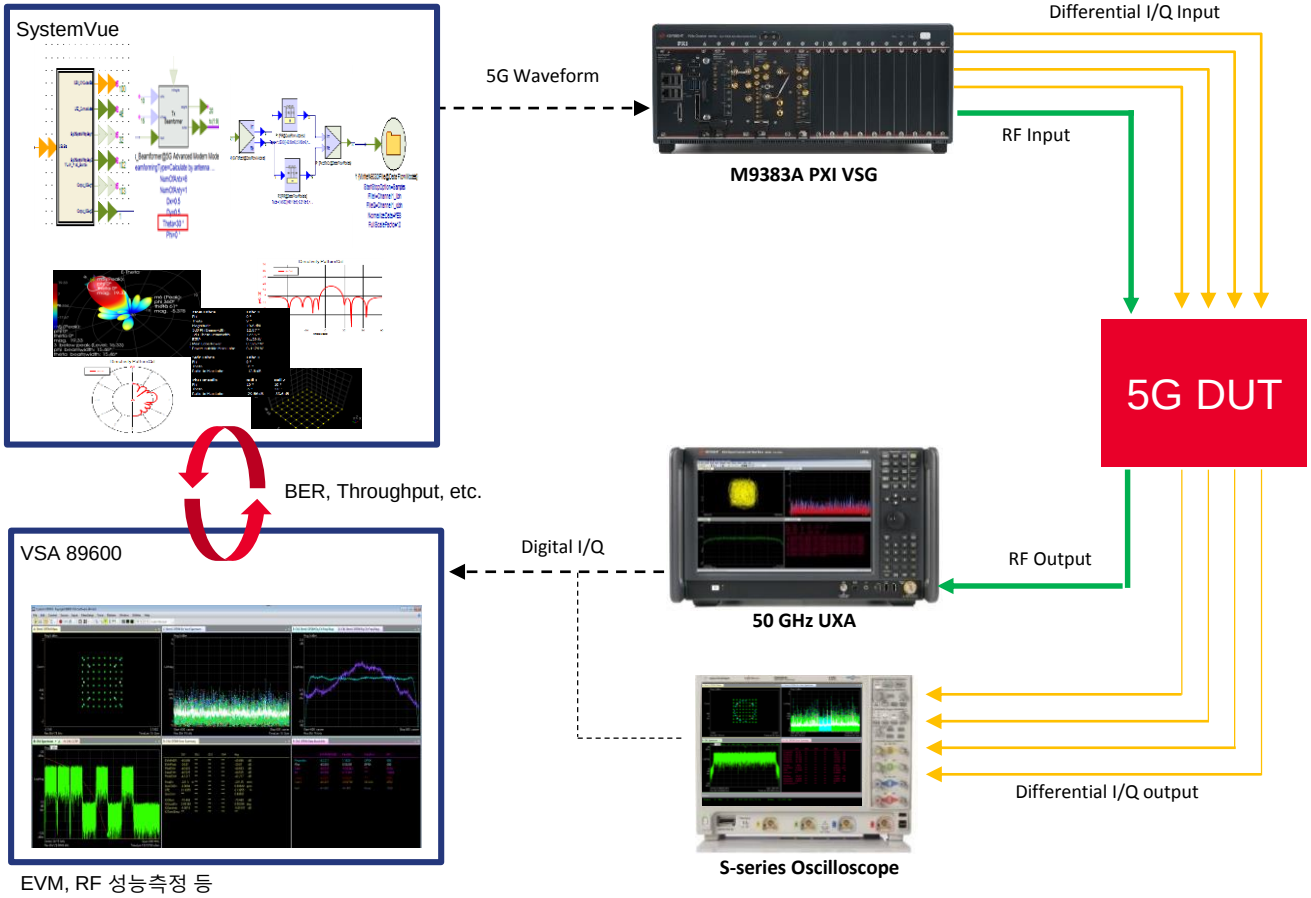
[RFIC **Rx path** Configuration]

- ❖ H/W : M9383A PXI VSG, N9040B UXA, S-series OSC
- ❖ S/W : N7630C Signal Studio, 89600 VSA(Option : BHN)



5G NR(New Radio) 물리계층 설계 및 개발 솔루션

업계 가장 빠른 3GPP NR이 적용되는 SystemVue 시뮬레이션 프로그램과 신호 발생기, 신호 분석기를 이용하여
5G NR의 신호 생성, 분석, BER, Throughput 측정 및 Beam 분석등을 지원하는 솔루션



[SystemVue]

- NR에서 제안한 13가지 OFDM 구성 및 Waveform 생성 지원
- Front-End RF 소자 성능 분석 (EVM, RF Performance, etc..)
- 업계 가장 빠른 3GPP NR 이 적용된 예제 및 라이브러리 제공
- BER, Throughput 측정 지원
- 빔(Beam) 패턴 시뮬레이션 및 분석
- 신호발생기로 직접 다운로드 지원

[M9383A PXI 벡터 신호 발생기]

- 1 MHz ~ 44 GHz 주파수 범위
- 변조대역폭: 최대 1 GHz
- 1% EVM 성능 @ 28GHz, 1GHz BW

[N9040B UXA 벡터 신호 분석기]

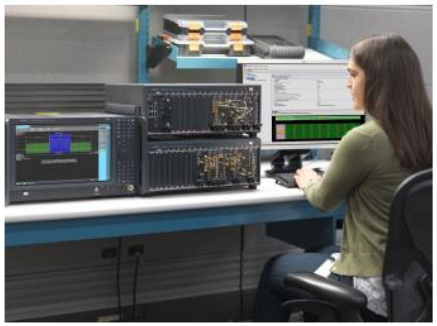
- 3Hz ~ 50 GHz 주파수 범위
- 복조대역폭: 최대 1 GHz
- 89600 VSA SW 지원
- 성상도, EVM, 평탄도 등 측정 지원

[S-series 오실로스코프]

- 500 MHz ~ 8 GHz 분석대역폭
- 4개 채널 지원
- 89600 VSA SW 지원

Keysight Technologies

5G 솔루션 카탈로그



KEYSIGHT TECHNOLOGIES

HARDWARE+SOFTWARE+PEOPLE=5G INSIGHTS

Thank you!