5G New Radio Challenges and Redefining Test

JULY 12TH, 2018

5G New Radio Solutions
Keysight Technologies

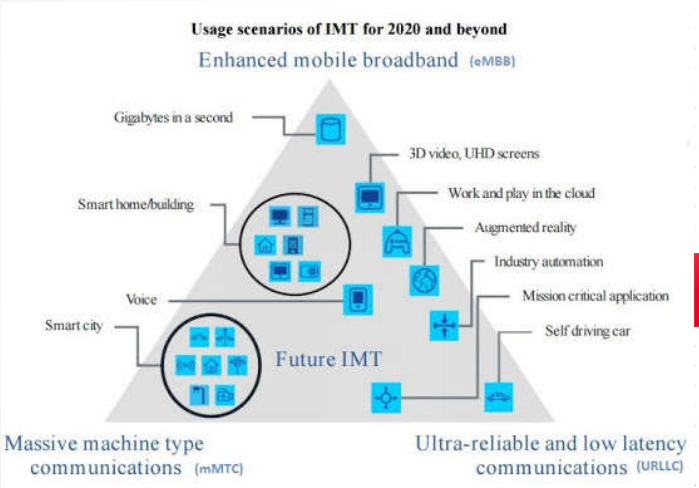
Agenda

- 5G Market Trends
- 5G New Radio Specification and Implications
- New Measurement Challenges and Redefining Test
- Summary

Market Trends

5G Use Cases and Goals

AGGRESSIVE GOALS



- 100X Data Rates
- 1000X Capacity
- 100X Densification
- 1ms Latency
- Reliability 99.999%
- 100X Energy Efficiency

Source: ITU Recommendation 09/2015

New Business Challenges

IT'S A RACE TO BE FIRST IN 5G

- Aggressive timelines
- Capture new business models
- Keep mmWave cost under control
- Lower cost per bit
- Intense competition

5G New Radio Release 15

A BROAD RANGE OF NEW SERVICES AND CONNECTIVITY

Enhanced Mobile Broadband (eMBB)

- All data, all the time
- 2 billion people on social media
- 10-20 Gbps peak data rates

Ultra Reliability and Low Latency (URLLC)

- Ultra high-reliability
- Ultra-responsive
- <1 ms air interface latency
- 5 ms E2E latency

Massive Machine Communication (mMTC)

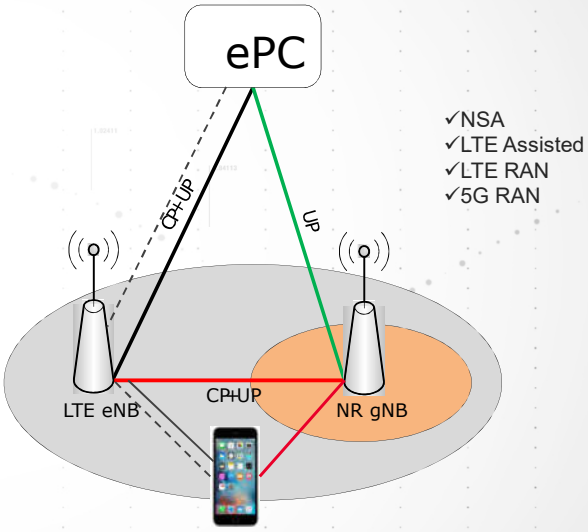
- 30 billion "things" connected
- Low cost, low energy
- 10^5 to 10^6 per km2
- 10-year battery life

Courtesy of METIS: 2014

Rel. 15 (Dec 2017)

How Will 5G Goals Be Achieved?

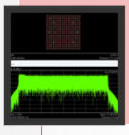
- Phased approach, first step is 3GPP Radio Layer Specification
- 5G network will initially work in non-standalone, then standalone mode
- 5G network will use a unified air interface concept
  - Sub-6 GHz
  - New mmWave Spectrum
  - Licensed and unlicensed spectrum
  - NSA mode and coexistence



5G New Radio Specification and Implications

3GPP Release 15 Specification

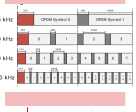
INITIAL RELEASE DEC 2017, FINAL RELEASE LATER 2018



Waveform & Modulation

CP-OFDM (UL/DL): QPSK, 16QAM, 64QAM and 256QAM

DFT-s-OFDM (UL): π/2-BPSK, 16QAM, 64QAM and 256QAM



Flexible Numerology

15 kHz*2^{n} Sub-carrier spacing

1ms subframe

10 ms Frame

Extended Cyclic Prefix

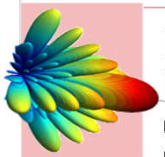
New Spectrum

Sub-6 GHz up to 52.6 GHz

Up to 400 MHz Bandwidth

Up to 16 Component Carriers

Bandwidth Parts enables multiplexing of services



Massive MIMO & Beamforming Access

Up to 8x8 MIMO

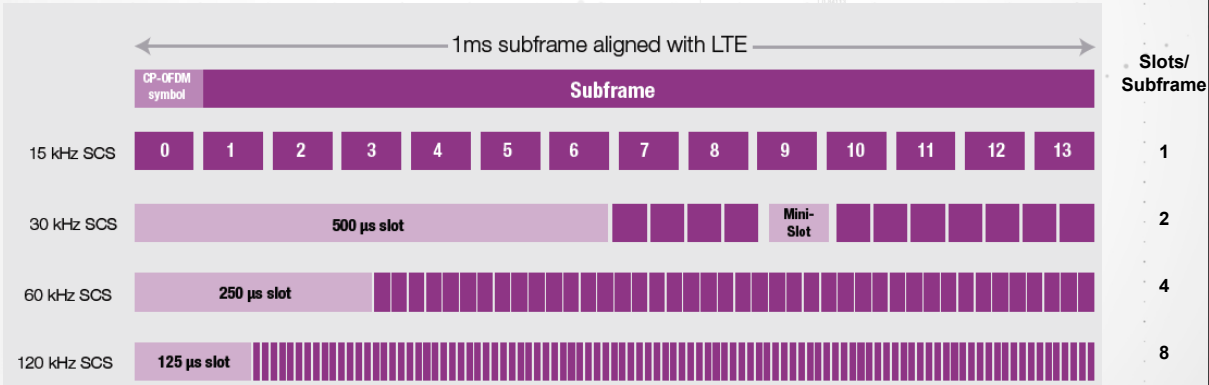
Much greater # antennas on gNB than UE

Beamsweeping

Flexible Numerology

EXPLOSION OF TEST CASES

- 15 kHz*2^{n} sub-carrier spacing
- 10 ms frame, 1 ms subframe
- Slot based scheduling – 14 OFDM symbols
- A slot can be uplink, downlink, or flexible
- New mini-slots can be 2, 4, or 7 OFDM symbols and can start immediately



Expansion into mmWave Spectrum

BOTH COMMERCIAL AND INDUSTRIAL ADOPTION INTO MMWAVE

0.6 GHz | 2.5 GHz | 3.4 - 3.8 GHz | 4.4 – 4.9 GHz | ISM | 28 GHz | 39 GHz | . . . | 64 -71 GHz 71 – 76 GHz

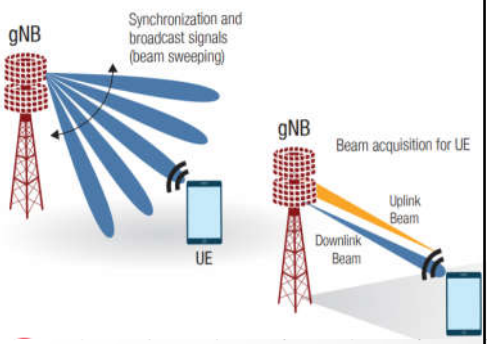
							
Application	5G	Secure Link	Short-range	Automotive	Backhaul	5G	Next-Gen
Frequency	•<6 GHz •28/39 GHz	•50 GHz	•60 GHz (11ad)	•60GHz •70 GHz	•71-76 GHz •81-86 GHz	•64-71 GHz •71-76 GHz •100 GHz	•>100 GHz
Bandwidth	<2 GHz?		2 GHz	>2 GHz	5 GHz?		

Country Regulation, Compliance

MIMO under 6 GHz vs. 28/39 GHz

DIFFERENT IMPLEMENTATIONS OF MIMO

	< 6 GHz	mmWave
Deployment Scenario	Macro cells High user mobility	Small cells Low user mobility
MIMO Order	Up to 8x8	Less MIMO order (typically 2x2)
Number of Simultaneous Users	Tens of users Large coverage area	A few users Small coverage area
Main Benefit	Spatial multiplexing "Null-forming" for reduced interference	Beamforming for single user
Channel Characteristics	Rich multipath propagation	A few propagation paths
Spectral Efficiency	High, due to the spatial multiplexing	Lower spectral efficiency (few users, high path loss)



Both sub 6 GHz MIMO and mmWave MIMO will require better beam management and over-the-air validation

5G New Radio Challenges Across the Spectrum

SUB 6 GHZ AND MMWAVE

Sub-6 GHz

eMBB, URLL - Massive MIMO to increase capacity and throughput

Challenges

- 5G NR coexistence with LTE and Wi-Fi
- Multi-mode devices
- Massive MIMO performance
- UE battery life

mmWave

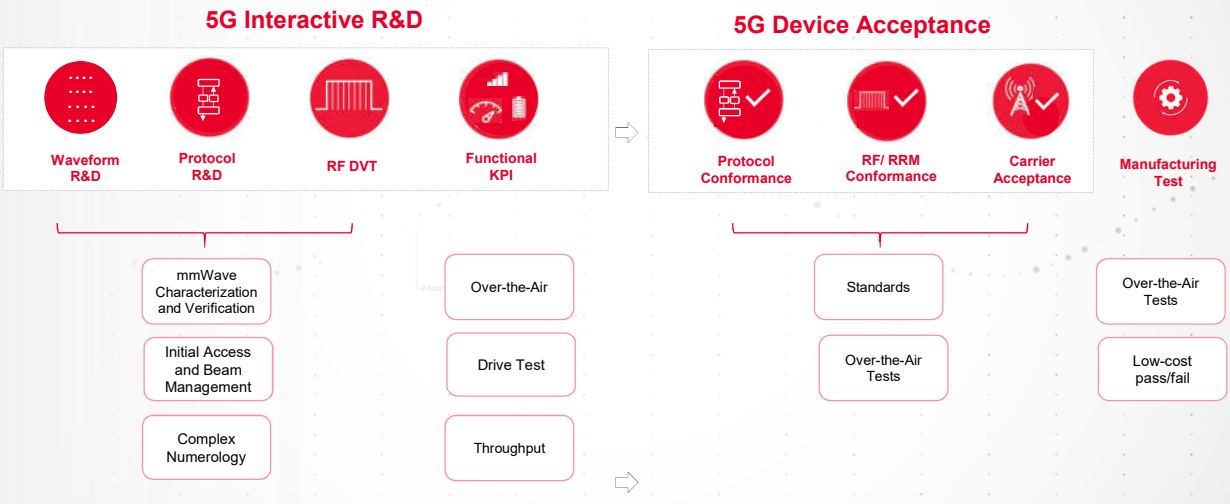
eMBB - Fixed wireless broadband or low mobility

Challenges

- Path loss and blockage @ mmW frequencies
- Wideband signal quality
- Initial access and beam management
- Measurements without connectors
- UE battery life

5G NR Device Workflow

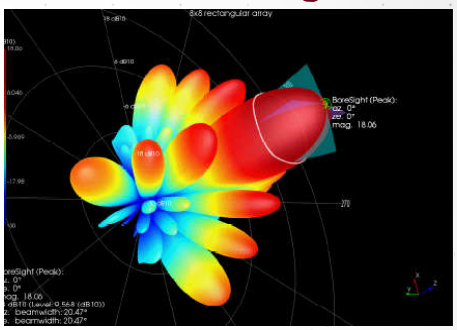
END-TO-END TESTS



Antenna Array for Massive MIMO and Beamforming

Challenge: Understanding MIMO and Beamforming real-world performance including handover and throughput

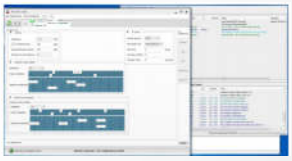
- Beam creation with proper phase and magnitude relationship
- Emulate real-world conditions
- Understanding test cases for different network scenarios



Multi-Channel Source

Channel Emulation

Emulate Network Test Cases

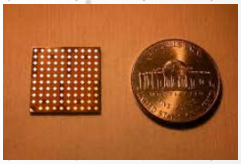


Measurements without Connectors

- Device testing in previous generations (<3GHz) almost exclusively tested using connectors & cables

- Antenna testing slowly being introduced:
  - SISO UE RF Tests (c.2001)
  - Base Station Active Antenna System (AAS) Tests (2016)
  - MIMO UE Performance Tests (2017)

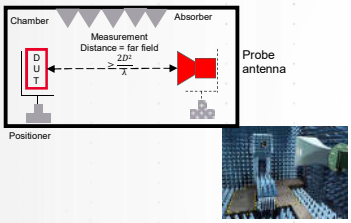
- Introduction of mmW bands for 5G: **A paradigm shift in how devices and systems are tested**



Testing of mmWave 5G devices and systems will be almost exclusively OTA

Common OTA Test Methods

Direct Far Field



- ✓Antenna beam pattern characterization
- ✓Beamforming/beamsteering validation
- ✓RF parametric tests (if S/N high enough)

- × Subject to higher path loss
- × Can get very large & expensive

Compact Ranges

Image courtesy of NSI-MI

- ✓Antenna beam pattern characterization
- ✓Beamforming/beamsteering validation
- ✓RF parametric tests
- ✓Small footprint, Lowest path loss

- × Rx spatial field generation not defined

Near-Field Scanning

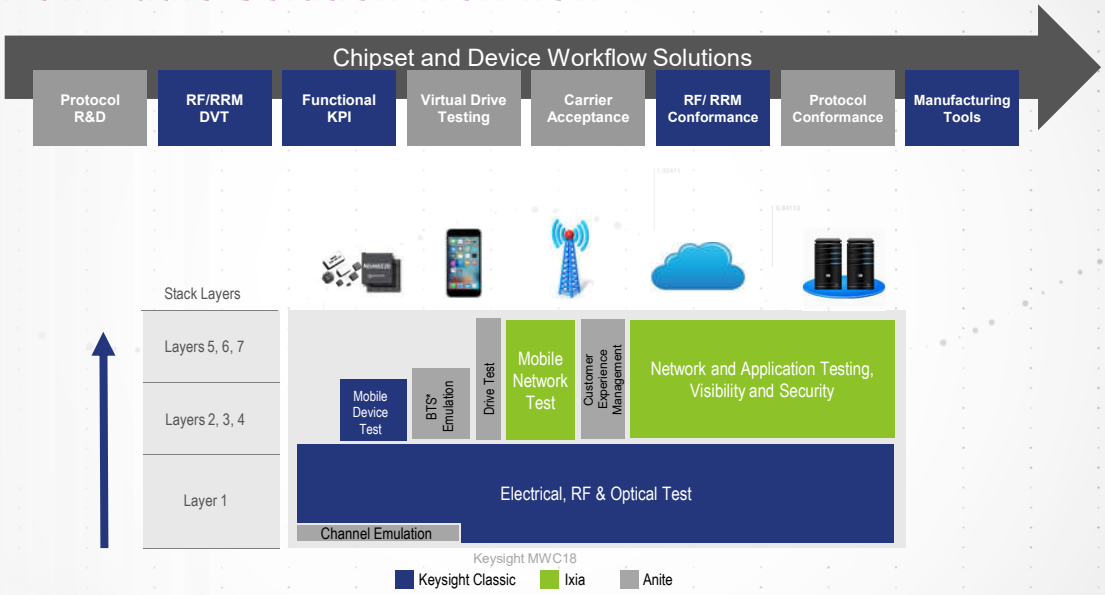
Image courtesy of NSI-MI

- ✓Antenna beam pattern characterization
- ✓Beamforming/beamsteering validation
- ✓RF parametric tests

- × Only on-axis blocking sources possible

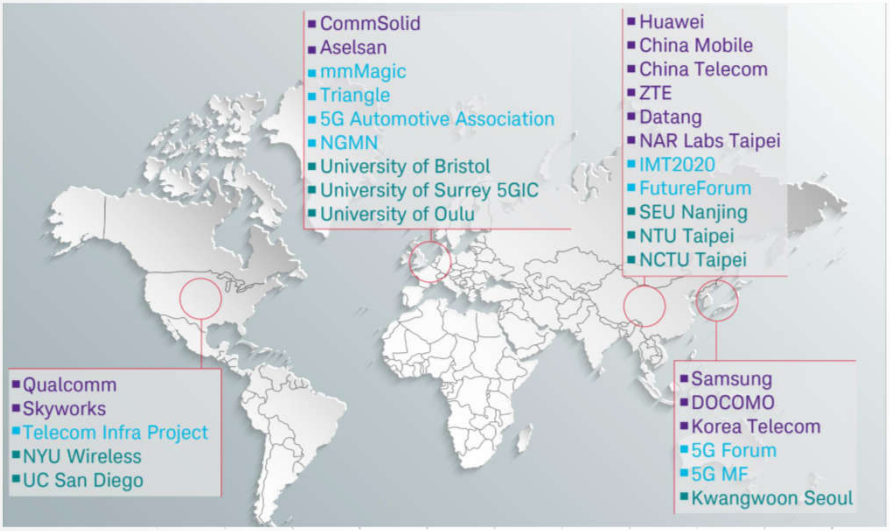
Summary

5G New Radio Solution Workflow



Transforming Your 5G Ideas into Reality

KEYSIGHT 5G PUBLIC COLLABORATIONS



- mmWave
- Massive MIMO
- Beamforming
- NB-IoT
- CRAN
- 5G NR
- 5G TF

Commercial
Consortium
University

5G NR Device Workflow and Redefining Test

END-TO-END TESTS

5G Interactive R&D

Waveform R&D | Protocol R&D | RF DVT | Functional KPI

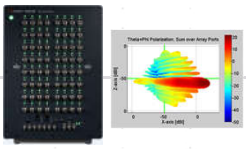
5G Device Acceptance

Protocol Conformance | RF/ RRM Conformance | Carrier Acceptance | Manufacturing Test

Network Analysis

Waveform Testbed

Network Emulator



Channel Emulator

mmWave OTA Solutions

Interactive 5G stack and tools with **common scripting engine**

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

Summary

- 5G NR will exist in both sub-6 GHz and mmWave frequency Bands
- Coexistence, Massive MIMO, Beamforming, OTA measurements will introduced new measurement challenges
- mmWave measurements require proper equipment, cables and adapters, and calibration to ensure accurate measurements
- Leveraging the ecosystem can help you accelerate your designs

Find more measurement tips and tools at
www.keysight.com/find/5G

Master the complexities of 5G New Radio so you can accelerate your 5G designs

Thank You !