

# 5G Device End-to-End Solutions

(Network, Channel Emulation & mmWave OTA Solutions)

*SE / Keysight Technologies*

*2018.04.27*

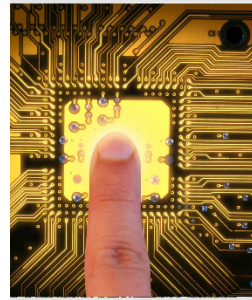
*Seung-Youl, Heo*



# Agenda

- 3GPP Summary
- Solution in Keysight
  - Network Emulator
  - Channel Emulator
  - Chamber
- Summary

## Solutions at the Pace of Customers



# 5G

## Chipset

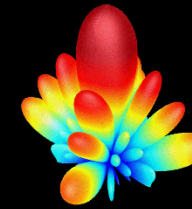


## Digital

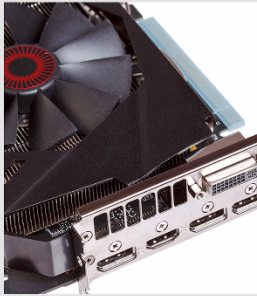


## mmW

Beamforming



## OTA



## Wide BW

## Device

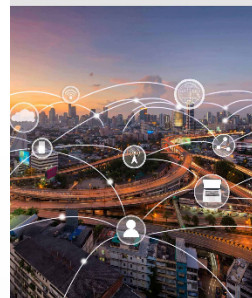
## MIMO

Multi-Channel

## Operator



## Services



## WLAN

ax/ay/ad

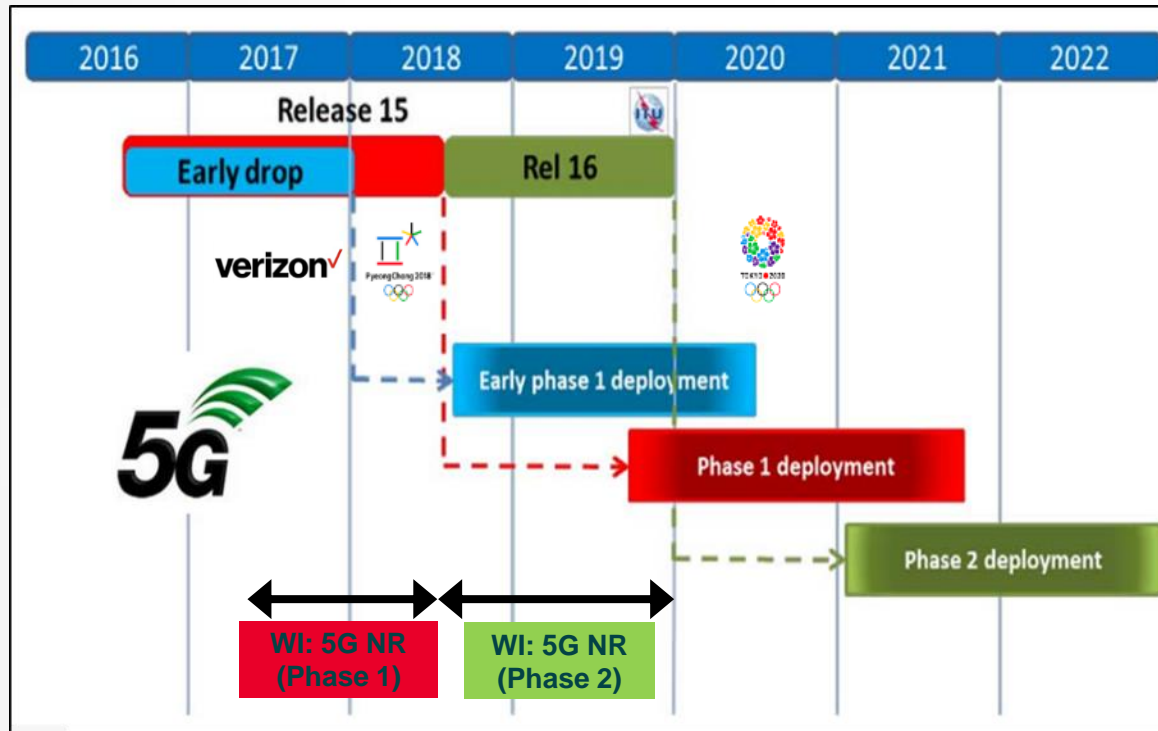


## LTE-A Pro



## Spanning the Wireless Device Ecosystem

# 3GPP NR Roadmap



Source: 3GPP activity towards IMT-2020 [http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Documents/S02-1\\_3GPP%20IMT-2020.pdf](http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Documents/S02-1_3GPP%20IMT-2020.pdf)

- “Early drop” of Release 15 (Dec 2017) to support emerging market needs
  - NR Non Stand-Alone (NSA)
  - Uses 4G Core Network (EPC)
    - LTE eNB always acts as a master
    - NR gNB always acts as a slave
- Release 15 (aka Phase I, by June 2018)
  - First phase of expected deployments in 2020
  - 5G core network
  - NR Stand-Alone (SA), eLTE Stand Alone and NSA combinations
- Release 16 (aka Phase II, by Dec 2019)

# 3GPP NR Phase 1 summary

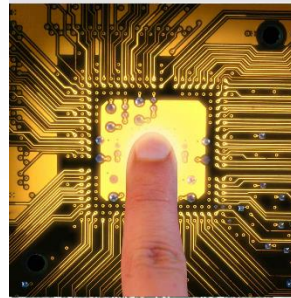
	New Radio Phase-I Rel 15	Verizon Wireless Pre-5G
Frequency Bands	Both below 6GHz and above 6GHz from 6GHz to 52.6GHz	28GHz
Bandwidth	<ul style="list-style-type: none"> <li>Below 6GHz: 5, 10, 15, 20, 25, 40, 50, 60, 80, <b>100MHz</b></li> <li>Above 6GHz: 50, 100, 200, <b>400MHz</b></li> </ul>	100 MHz
Maximum CCs	<b>16</b> (allowed BW and CCs combinations TBD)	8
Numerology (subcarrier spacing)	<ul style="list-style-type: none"> <li>Below 6GHz: Data 15k, 30k, 60k &amp; Sync. 15k, 30k</li> <li>Above 6GHz: Data 60k, 120k &amp; Sync. 120k, 240k</li> </ul>	5x15 kHz (75 kHz) (i.e. 5x LTE)
Waveform	CP-OFDM for DL CP-OFDM + <b><u>DFT-s-OFDM for UL</u></b>	CP-OFDM for DL and UL
Subcarriers	Variable (maximum is <b><u>3300 requiring an 4096 FFT</u></b> )	1200 (2048 FFT)
Subframe length	1 ms (the slot/mini-slot are the scheduling units)	200 μs (this is the scheduling unit)
Slot length	7 or 14 symbols for ≤ 60 kHz 14 symbols for > 60 kHz Less symbols for a mini-slot	7 symbols 100 μs
Channel coding	NR Polar Codes (control); NR LDPC (data)	V5G TBCC (control); V5G LDPC (data)
Initial access	Beamforming with and without DL/UL reciprocity	Beamforming with DL/UL reciprocity
MIMO	<b><u>8 for DL and 4 for UL</u></b>	2x2
Duplexing	FDD, static TDD, dynamic TDD	Dynamic TDD
Use Cases	eMBB, <b><u>URLLC</u></b>	eMBB

# Device Challenges

A DYNAMIC INDUSTRY

- **Solve** tough 5G NR design challenges at sub-6 GHz and mm-wave
- **Keep pace** with rapidly evolving standards and market requirements
- **Accelerate** time to market for new 5G devices
- **Be ready** for new test requirements and set-ups
- **Profitably monetize** and accelerate ROI

Solutions at the Pace of Customers



5G

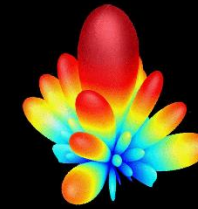
Chipset



Digital

NR

mmW  
Beamforming



OTA



Wide  
BW

Device

MIMO  
Multi-Channel

Operator



Services



WLAN  
ax/ay/ad



LTE-A  
Pro



Spanning the Wireless Device Ecosystem

# 5G Device End-to-End Solutions

## R&D CHALLENGES



### Early protocol development while keeping up with evolving 5G standards

- Progress stack and gain insights to optimize performance
- Customize scripts, automate efficiently, and debug quickly
- Leverage work across workflow stages, stay current with standards cost effectively



### More RF bands, wider bandwidths, and beamforming

- Wideband calibration and verification
- New waveforms, flexible numerology
- Beamforming & beam management
- More band combination complexity



### Support for sustained maximum E2E Data Throughput, meet power consumption goals

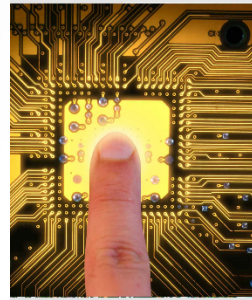
- Stress test the device at maximum E2E data throughput
- Benchmark battery life performance for different 5G use cases

Sub-6 GHz and mmWave - Conducted and OTA

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# 5G

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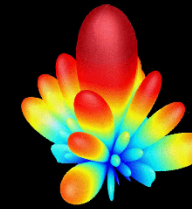


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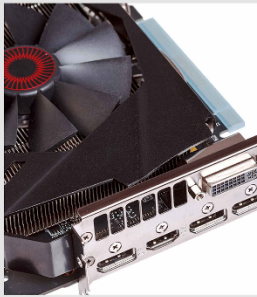


## mmW

Beamforming



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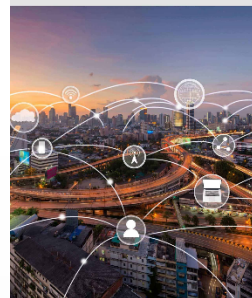
## MIMO

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## WLAN

ax/ay/ad



## LTE-A Pro



## Spanning the Wireless Device Ecosystem

# 5G NE Platform Hardware

## KEY BUILDING BLOCKS



### UXM 5G Wireless Test Platform (E7515B)

- <6GHz Frequency range
- Scalable bandwidth 8Tx/4Rx @800MHz, 4Tx/2Rx @1600MHz
- Integrated RFIO + Internal fading
- Support for RF, IF, Host and BBIQ interfaces
- Support for 10GbE connectivity

# 5G Device End-To-End Solutions

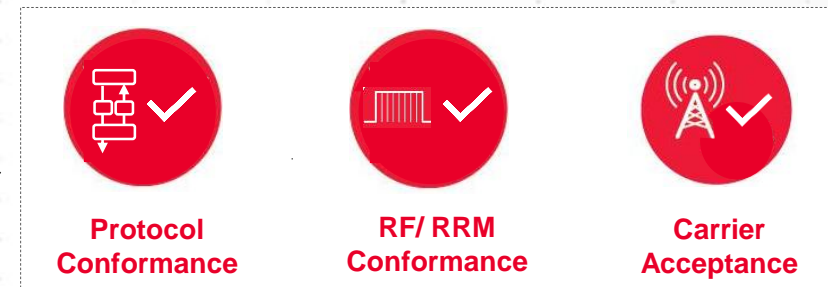
## PORTFOLIO

### 5G Interactive R&D



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### 5G Device Acceptance



Interactive 5G stack  
and tools with common  
scripting engine

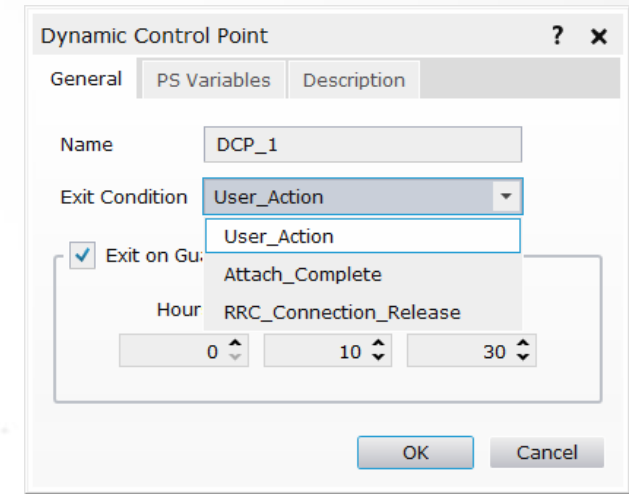
Common measurement science,  
logging  
and automation



# Replicate network behaviour

## 5G PROTOCOL R&D TOOLSET

- Built-in Protocol State Machine and Dynamic Control Points simulates a “Live Network”
- Allows for interactive testing where the behaviour of a device can be investigated in an easy manner to facilitate debugging



Line	Time	Id	Direction	Details
1				Script Details [NR5G_LTE_PSCellAdd]
2				SIM Information [Explicitly defined]
3	00:00.00			5G User Prompt [Activate NR5G Cell]
4	00:00.00	NR-Cell A		Activate NR5G Cell [NR-Cell A :DL Power = -80 dBm/75kHz]
5	00:00.00	N-Cell A		5G DYNAMIC CONTROL POINT [Continue after User Action]
6	00:00.00			5G User Prompt [Start NR5GUEDemonstrator.exe]
7	00:05.00	E-Cell A		Activate LTE Cell
8	00:00.00	E-Cell A	SS --> MS	RRC Connection Reconfiguration
9	00:00.00			5G User Prompt [Wait, Press Ok to Exit]

# Modify network behaviour easily

## 5G PROTOCOL R&D TOOLSET

- Allow dynamic L1/L2 parameters changes without the need for programming
- Very useful in early development testing of prototypes

The screenshot displays the 'DL Scheduling' configuration window. At the top, there are tabs for 'General', 'DL Scheduling', and 'UL Scheduling'. The 'DL Scheduling' tab is active. The interface includes a 'Resource Allocation Type' dropdown set to 'Fixed' and a 'Transmission Mode' dropdown set to 'TM1'. Below this is a 'Resource Block Allocation' table with columns for RBs 0-100 and rows for RB groups (RB0-24, RB25-48, RB49-74, RB75-99). The table shows a grid of blue and white cells representing resource allocation. Below the table are various configuration parameters:

- xPDSCH Start Symbol: Symbol 2
- xPDSCH Stop Symbol: Symbol 12
- xPUCCH Resource Index: 0
- DL PCRS: No PCRS
- UCI Request Configuration (Using xPUCCH - DCI B1/B2): Request Type: None
- CSI-RS/BRRS OFDM Symbol Index: 0
- CSI-RS/BRRS Transmission Timing: 1
- CSI-RS/BRRS Process Indicator: Process 0
- Beam Switch Indication:
- Fixed MCS Index:  MCS Index: 9
- DL MMIO Fixed Rank:  Rank: Rank 1
- HARQ Auto Ack:
- Scrambling Code Id: 0
- Allocation Mode Configuration: Resource Allocation Mode: Normal
- Trigger One Shot Allocation:
- Antenna Ports Configuration: Single Layer Transmission: 1 Layer - Port 8
- Two Layer Transmission: 2 Layers - Ports 8, 9
- xPDCCH Search Space Configuration: DCI Allocation Mode: Dynamic
- Search Space Index: 0
- Aggregation Level: 2
- Ofdm Symbol Index: Dynamic

# 5G logging

## 5G PROTOCOL R&D TOOLSET

- Displays all layers of the protocol stack (PHY/MAC/RLC/RRC/PDCP)
- Filtering allows the user to view the data of interest
- Advanced search facilities and bookmarks make debugging easier
- User friendly as all information needed is available in one view

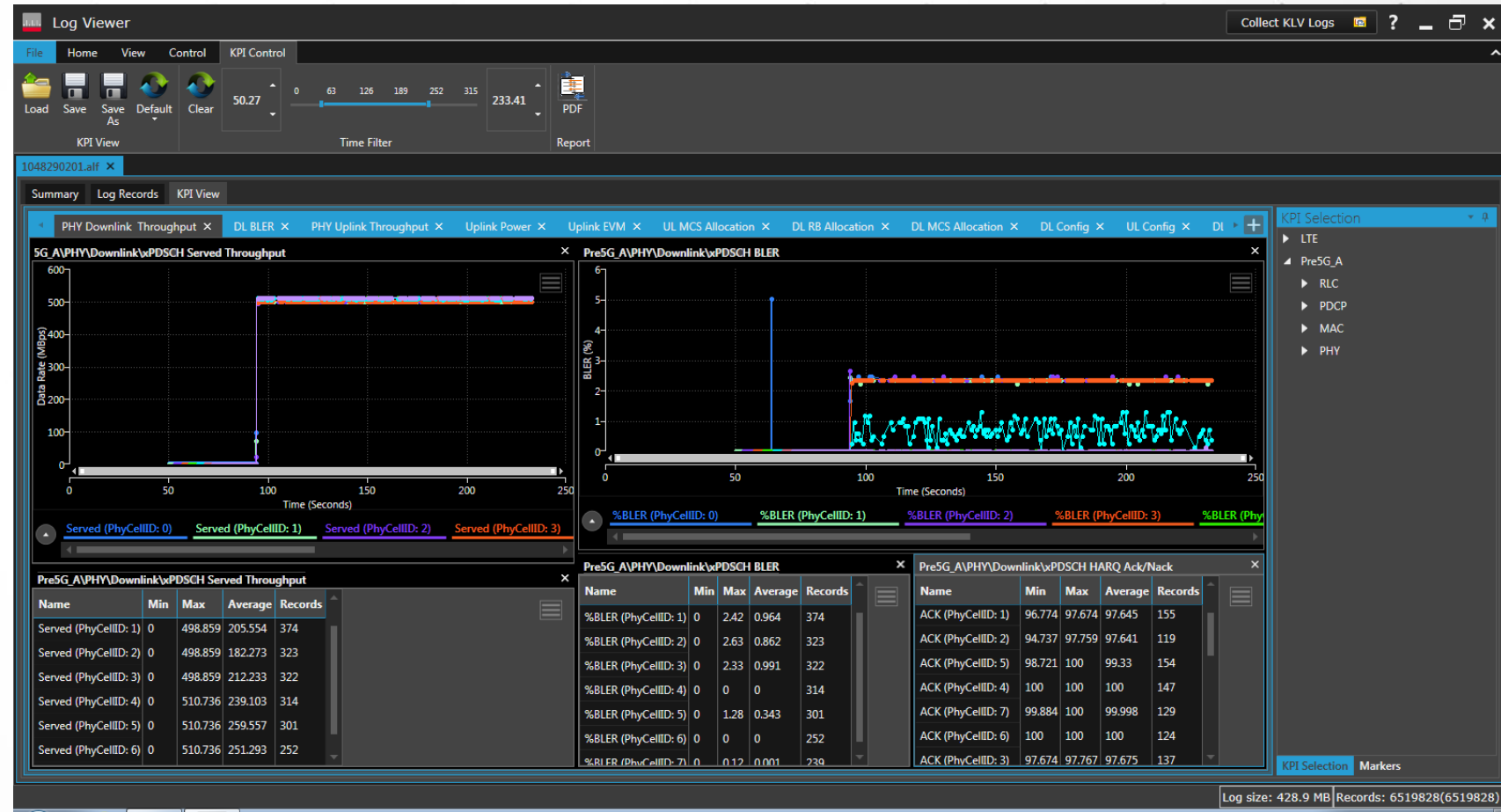
The screenshot displays the Log Viewer application interface. The main window shows a table of log records with columns for Index, Icons, Protocol, Record, Source, Destination, Summary, and Frame. A record at index 66389 is highlighted, showing a BCCH-BCH-Message from Protocol 3GPP. The right-hand side of the interface provides a detailed view of the selected record, including a Summary (MasterInformationBlock), Overview (Protocol: RRC, Version: R15 Jan 2018, Record: BCCH-BCH-Message), and Fields (BCCH-BCH-Message, message, dl-Bandwidth: n6, phich-Config, phich-Duration: normal, phich-Resource: oneSixth, systemFrameNumber: 00000000, schedulingInfoSIB1-BR-r13: 0, spare: 00000). A Hex view of the message data is also visible, showing the address 00000000 and the data 00 00 00. The bottom status bar indicates a log size of 8.3 MB and 1223 records.

Index	Icons	Protocol	Record	Source	Destination	Summary	Frame
66369	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->ULFrequency = 1950	
66370	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->ULEarfcn = 18300	
66373	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->DLFrequency = 2140	
66374	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->DLEarfcn = 300	
66375	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->PhysicalLayerCellIdentity	
66376	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->PhysicalLayerCellIdentity	
66377	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->TimingOffset = 0	
66378	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->AntennaCount = 1	
66379	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->NumAntennaElements =	
66380	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->AntennaMapping = ANTI	
66381	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->Enabled = VARIANT_TRU	
66382	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->EtwPrimaryNotificationE	
66383	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->EtwSecondaryNotificatio	
66389	→	RRC	BCCH-BCH-Message	\\Protocol\3GPP\		MasterInformationBlock	
66390	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->Macs->Mac [1]->SIs->MI	
66393	→	RRC	BCCH-DL-SCH-Message	\\Protocol\3GPP\		systemInformationBlockType1	
66394	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->Macs->Mac [1]->SIs->SII	
66397	→	RRC	BCCH-DL-SCH-Message	\\Protocol\3GPP\		systemInformation	
66398	→	Developers AP	Property Set	\\Test Control\De		E-Cell A->Macs->Mac [1]->SIs->SI	
66401	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->Signals->AddNew(Signal	
66403	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->Signals->AddNew(Signal	
66405	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->Signals->AddNew(Signal	
66407	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->Signals->AddNew(Signal	
66408	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->PhysicalChannels->AddN	
66409	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->PhysicalChannels->AddN	
66410	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->TransportChannels->Add	
66411	→	Developers AP	Method Called	\\Test Control\De		E-Cell A->TransportChannels->Rch	

# Results viewer

## 5G R&D PROTOCOL TOOLSET

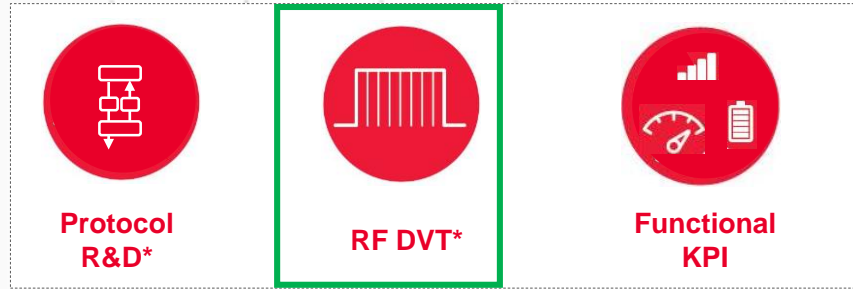
- Customised view with multiple graphs
- Enhanced debugging as relationship between various KPIs such as data rate and BLER can easily be seen graphically
- Link from graph to relevant location in the log to facilitate debugging
- Report generation to share results with other teams



# 5G Device End-To-End Solutions

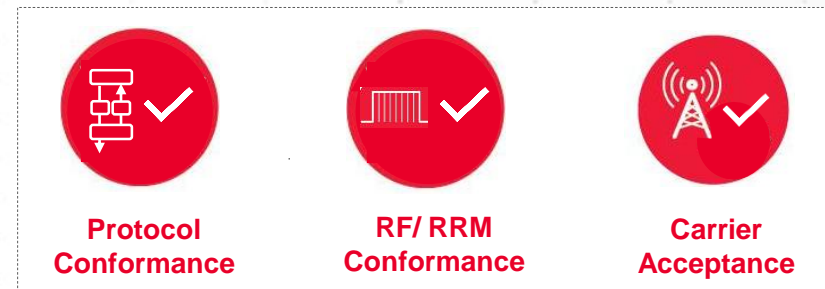
## PORTFOLIO

### 5G Interactive R&D

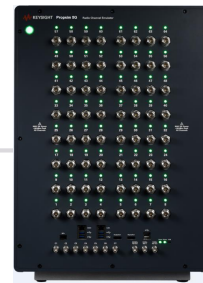


\*available

### 5G Device Acceptance



Network Emulator



Channel Emulator



mmWave OTA Solutions

Interactive 5G stack  
and tools with common  
scripting engine

Common measurement science,  
logging  
and automation

# 5G RF DVT Toolset

## KEY FEATURES

- 5G NR support
- RF Test Application
- Automation & Scripting
- Pre-conformance ready
- Traceability to conformance

The screenshot displays the Keysight Test Automation Platform interface. At the top, there is a menu bar with 'File', 'Settings', 'Tools', and 'Help'. Below it, the 'Test Plan' is identified as '5G\_Tests.TapPlan'. A table lists the test steps:

Step Name	Verdict	Duration	Step Type
Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power	Pass		Wireless Test - 5G \ 3GPP \ 6.2.2 UE Maximum Output Power
Wireless Test - 5G - RF Parametrics.Sensitivity	Pass		Wireless Test - 5G \ RF Parametrics \ Sensitivity
Wireless Test - 5G - RF Parametrics.Transmit Signal Quality	Pass		Wireless Test - 5G \ RF Parametrics \ Transmit Signal Quality

An 'External Test Plan Parameters' dialog box is open, showing a table of parameters:

External Name	Value	Test Step \ Property
Band	1	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ Band
DL Channel Bandwidth	20 MHz	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ DL Channel Bandwidth
Like 3GPP	<input type="checkbox"/>	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ Like 3GPP
Test Environment	<input checked="" type="checkbox"/>	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ Test Environment
Test Frequency	<input checked="" type="checkbox"/>	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ Test Frequency
UL RB Number	1	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ UL RB Number
UL RB Start Position	0	Wireless Test - 5G - 3GPP.6.2.2 UE Maximum Output Power \ UL RB Start Position

The main interface shows three measurement views (VMA 1, VMA 2, VMA 3) and a summary table. VMA 1 shows a constellation diagram. VMA 2 shows an RF Envelope plot with a mean power of 16.05 dBm. VMA 3 shows an Occupied Bandwidth plot with a value of 89.143 MHz. The summary table is as follows:

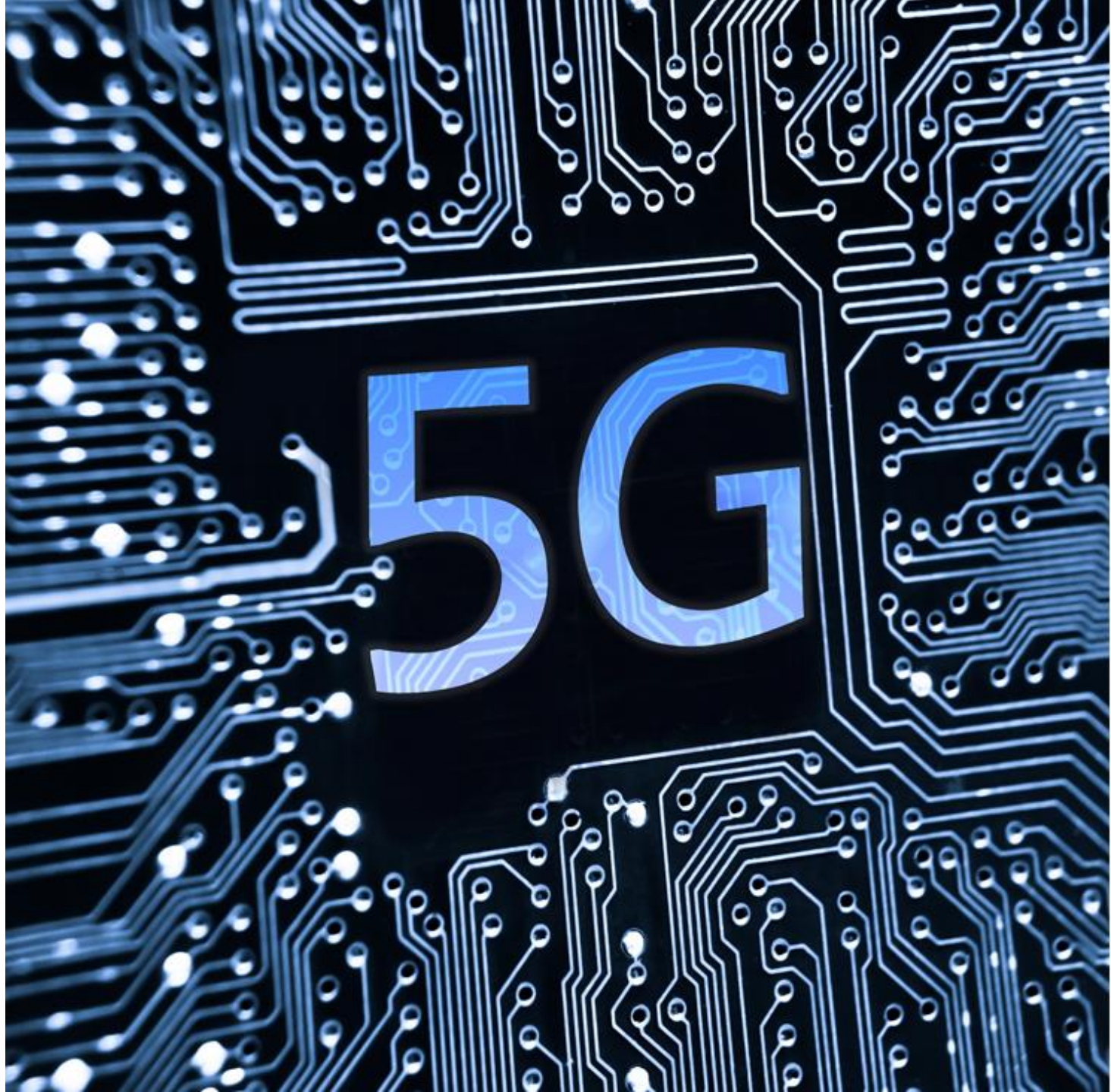
Metric	Value
EVMMER	2.63%
EVMPeak	10.57%
PilotEvm	1.00%
DataEvm	2.73%

Additional metrics shown include: Occupied Bandwidth: 89.143 MHz, Total Power: 24.9 dBm, % of OBW Power: 99.00%. The interface also includes a 'Log' window showing 'Errors 0' and a 'Meas Setup' panel on the right with various configuration options.

# 5G NR support

## 5G RF DVT TOOLSET

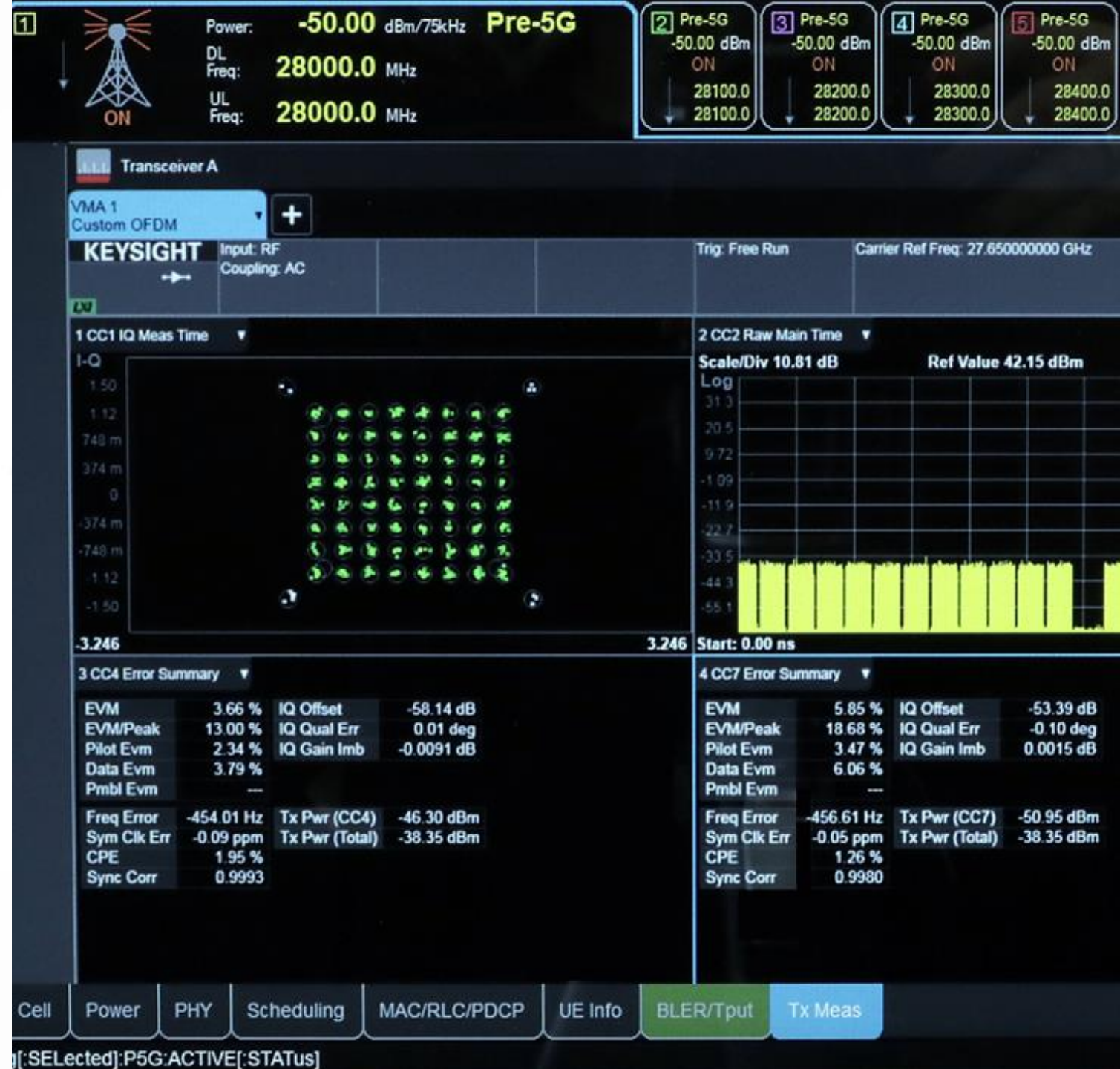
- Sub-6GHz and mmWave
- Deployed standalone or with LTE anchor
- Flexible numerology
- High directivity phase-array antennas and beamforming
- OTA test challenges



# RF Test Application

## 5G RF DVT TOOLSET

- Flexible manual testing
- On-a-call UL RF measurements
- Common Keysight measurement science through X-Apps
- Automate test set up Keysight 5G Interactive tools



# Automation & Scripting

## 5G RF DVT TOOLSET

- Automate complete test set up include device and mmWave OTA measurements
- Test cases scripting with Keysight measurement tools or customized test steps
- Examples
  - Initial Access
  - Beam Management
  - Downlink Channels demodulation
  - UE reporting
  - Total Radiated Power (TRP)

File Settings Tools Help

Test Plan Untitled \*

+ - Run Repeat Completed in 48.49 s

ame	Verdict	Duration	Step Type
5G T-0A.General Settings Pre-5G	Pass	10.99 s	RFT Pre-5G T-0A: Measurement tools for 5GTF \ Common \ General Settings Pre-5G
5G T-0A.DUT Attach	Pass	30.56 s	RFT Pre-5G T-0A: Measurement tools for 5GTF \ Connection \ DUT Attach
5G T-0A.Beam Switching/Mobility	Pass	2.69 s	RFT Pre-5G T-0A: Measurement tools for 5GTF \ Measurements \ RRM Measurements \ Beamforming
5G T-0A.DUT Detach	Pass	4.16 s	RFT Pre-5G T-0A: Measurement tools for 5GTF \ Connection \ DUT Detach

Log

Errors 0 Warnings 0 Information 329 Debug 2553

```
14:53:39.944 RFT Pre-5G T-0A <ParameterConfigured>GeneralSettings.Connectors Mode = Split
14:53:39.944 RFT Pre-5G T-0A <ParameterConfigured>RFT Pre-5G T-0A.DUT Detach.DUT Switch Off/On = False
14:53:39.944 RFT Pre-5G T-0A <ParameterConfigured>RFT Pre-5G T-0A.DUT Detach.DUT Switch Off Delay = 0
14:53:39.944 RFT Pre-5G T-0A <ParameterConfigured>RFT Pre-5G T-0A.DUT Detach.DUT Power Cycle = False
14:53:39.944 RFT Pre-5G T-0A <ParameterConfigured>RFT Pre-5G T-0A.DUT Detach.DUT Power Off Delay = 0
14:53:39.946 RFT Pre-5G T-0A <Workflow>Waiting 2 seconds for cell activation/deactivation...
14:53:41.947 RFT Pre-5G T-0A <Workflow>Setting CELL1 OFF.
14:53:42.097 RFT Pre-5G T-0A <Workflow>Waiting 2 seconds for cell activation/deactivation...
14:53:44.097 RFT Pre-5G T-0A <Workflow>Checking connection status for CELL1 is OFF.
14:53:44.105 TestPlan RFT Pre-5G T-0A.DUT Detach completed with verdict 'Pass'. [4162 ms]
14:53:44.137 Summary ----- Summary of run started 02/05/2018 14:52:55 -----
14:53:44.140 Summary RFT Pre-5G T-0A.General Settings Pre-5G 10992 ms Pass
14:53:44.141 Summary RFT Pre-5G T-0A.DUT Attach 30559 ms Pass
14:53:44.141 Summary RFT Pre-5G T-0A.Beam Switching/Mobility 2691 ms Pass
14:53:44.141 Summary RFT Pre-5G T-0A.DUT Detach 4162 ms Pass
14:53:44.141 Summary ----- TestPlan completed successfully in 48.49 s -----
14:53:44.766 Log Resource "Log" closed. [0 ms]
14:53:44.766 5G Log Resource "5G Log" closed. [0 ms]
14:53:44.766 DUT BASIC Resource "DUT BASIC" closed. [0 ms]
14:53:44.767 BSE_P5G Resource "BSE_P5G (TCP/IP0::localhost::hislip2::INSTR)" closed. [1 ms]
```

DUTs DUT BASIC Instruments BSE\_P5G RF Chamber Results Log 5G Log

Pass

# Pre-conformance ready

## 5G RF DVT TOOLSET

- Run test campaigns for pre-conformance
- Rich environment with sequencer and test campaign management features
- Traceability to Conformance
- Leading participation in industry groups defining Radio Conformance Test (RCT)
- Maximum covering, including support for out of band measurements.



# 5G Device End-To-End Solutions

## PORTFOLIO

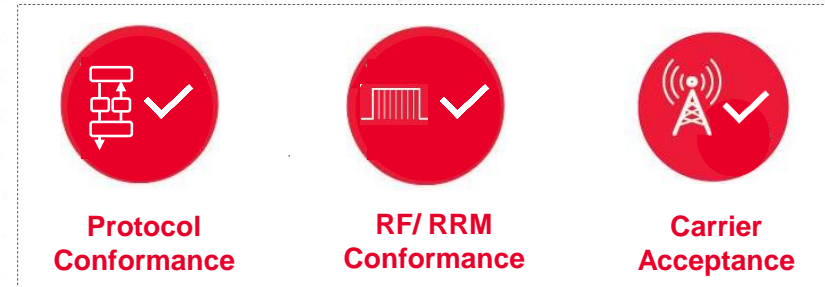
### 5G Interactive R&D



*\*available*



### 5G Device Acceptance



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

**Common measurement science,  
logging  
and automation**

# 5G Functional KPI

## 5G NES

- Easy to use GUI enables complex tests without the need to define protocol scripts
- Network configurations optimized to measure device performance
  - Throughput, Battery life, Beam management
- Flexible automation, including use of external measurement equipment
- Simple Test case development
- Use results viewer for off line analysis

COMING SOON



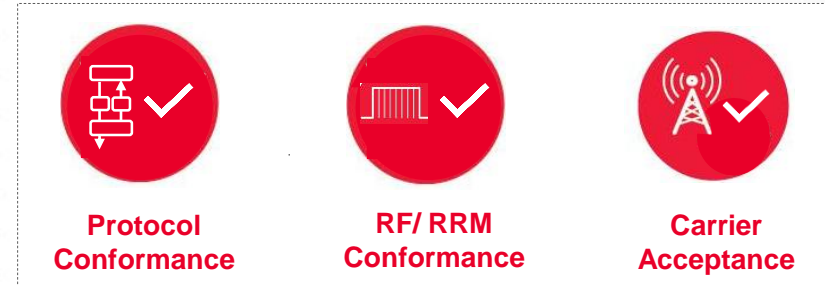
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## PORTFOLIO

### 5G Interactive R&D



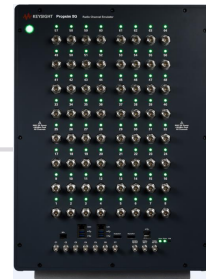
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Network Emulator



Channel Emulator



mmWave OTA Solutions

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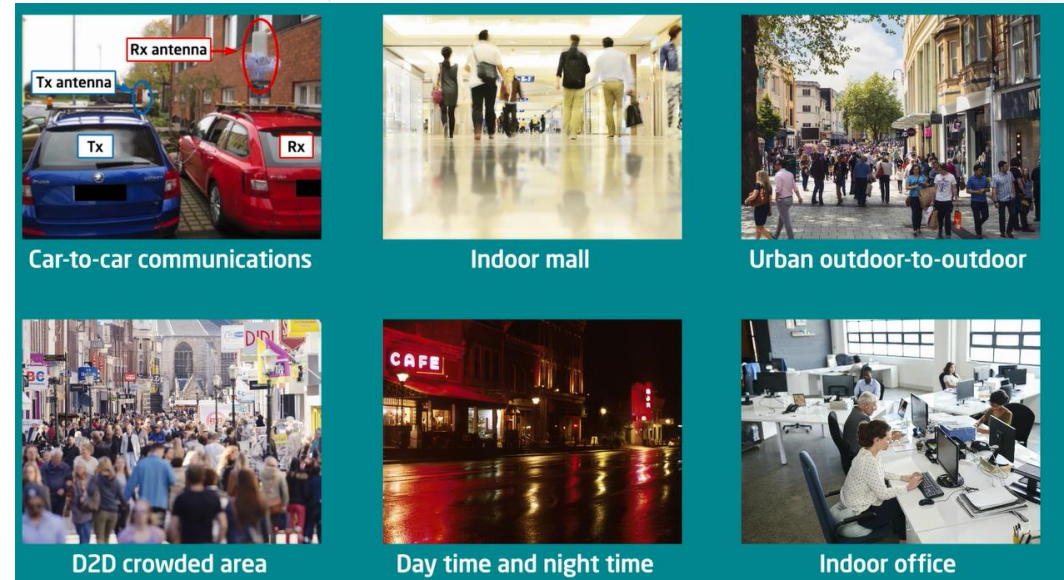
Common measurement science, logging and automation

# 5G Channel Emulation

## KEY PERFORMANCE INDICATORS

- Beam management testing under real world propagation conditions and 3GPP reference channel models (TR38.901)
- Beam Acquisition metrics
- Mobility Beam change and Handover
- Data Throughput, peak, average
- Latency
- Stability

Realistic Test environment in lab for 5G Device End-To-End testing



# 5G Channel Emulation Solutions

## 5G DEVICE END-TO-END SOLUTIONS

### Challenges

#### 5G Channel Modeling

- Complex modeling science

#### 5G Channel Emulation

- Realtime channel emulation
- Wide Bandwidths 100/200/400MHz
- CA 8CC/12CC/16CC
- Network Emulator and Real gNB support (NV-IOT)
- mmW OTA solutions

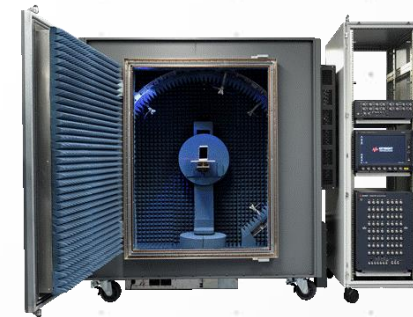
### Solutions

#### Propsim GCM 5G Tools

- Channel Modeling Science ready & proven

#### Propsim 5G Channel Emulation solutions

- Realtime very low insertion delay
- BW 100/200/400MHz up to 1.2GHz
- CA up to 12CC (1.2GHz)
- UXM 5G support validated with gNB
- Complete mmWave OTA solutions



# 5G Channel Emulation

## KEY FEATURES

### General

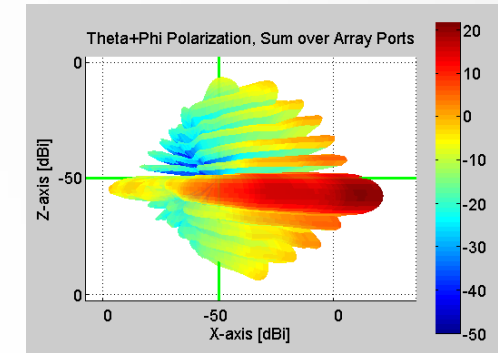
- Supported 5G NR Carrier BWs 5...100/200/400MHz. NSA and SA.
- RF range SUB6GHz, HIGH IF 6-12GHz and mmW 24-43.5GHz
- 5G NR Carrier Aggregation schemes 8CC up to 16CC supported
- MIMO 8x8bi, 16x8bi, 64x8bi etc. MU-MIMO
- Comprehensive 3GPP 5G NR channel modeling (TR38.901) with PropSim 3D Geometric Channel Modeling Tool (GCM).

### 5G Device Testing

- UXM 5G based Sub-6 GHz RF cabled and OTA testing in multi probe chamber
- UXM 5G based mmW OTA solutions single probe to 3D multi-probe
- real gNB based solutions for Sub-6 GHz and mmWave OTA (NV-IOT). NSA/SA.

### 5G gNB Testing

- Sub-6 GHz MIMO, 3D/Massive MIMO up to 64/128TRX. NSA/SA. UEE based and real Device-IOT solutions.
- mmWave Hybrid Beamforming OTA testing. Multiprobe chamber configurations. UEE based and real Device-IOT solutions.



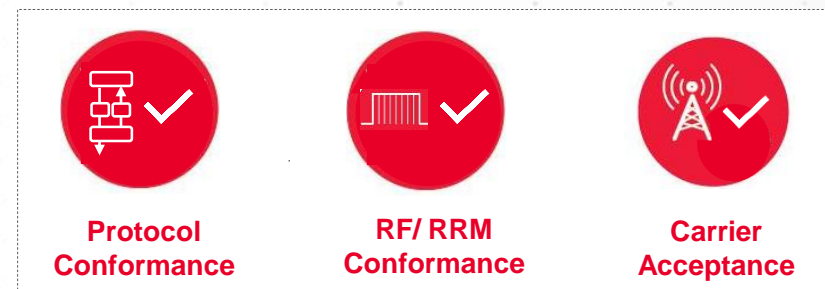
# 5G Device End-To-End Solutions

## PORTFOLIO

### 5G Interactive R&D



### 5G Device Acceptance



\*available



Network Emulator



Channel Emulator



mmWave OTA Solutions

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

**Common measurement science,  
logging  
and automation**

# mmWave OTA Solutions

5G DEVICE END-TO-END SOLUTIONS



RMTC



CATR



3D MPAC

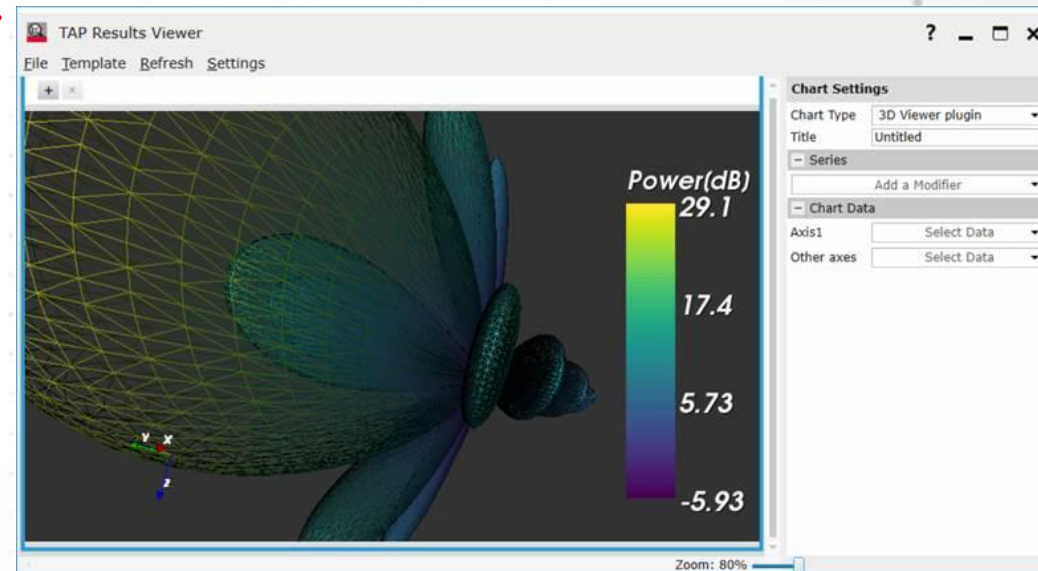
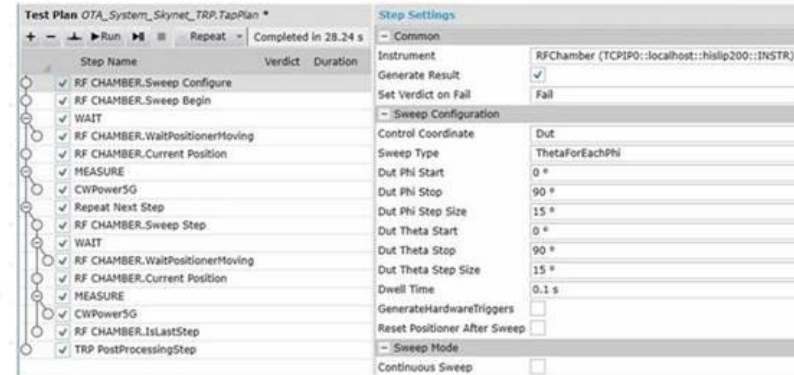
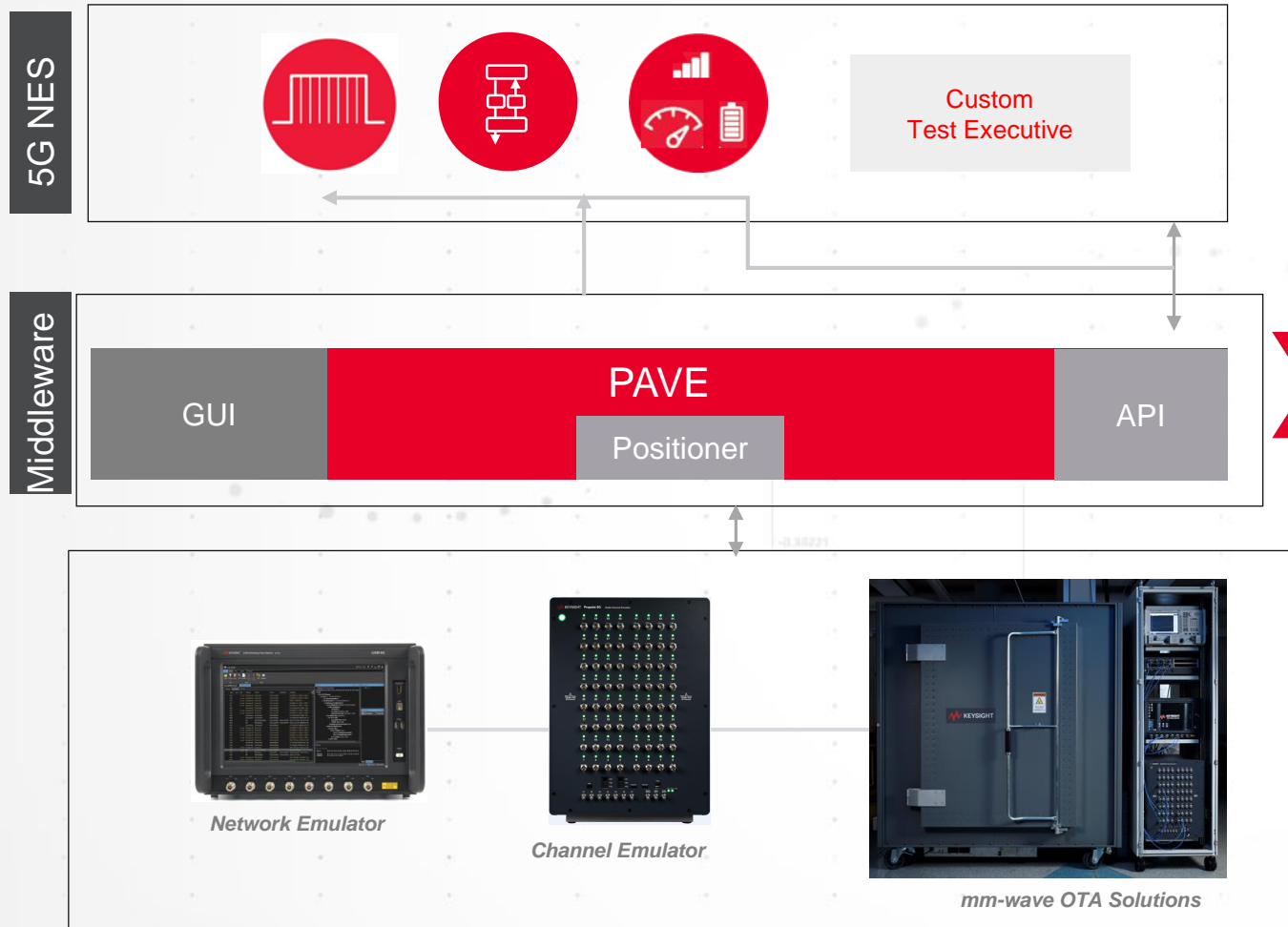
# What are your mm-Wave OTA testing needs?

## 5G DEVICE END-END SOLUTIONS



# Solution Summary – mmWave OTA

## 5G DEVICE END-TO-END SOLUTIONS

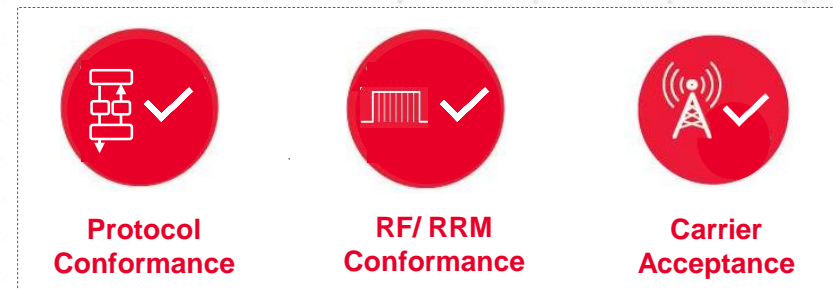


# Summary

## 5G Interactive R&D



## 5G Device Acceptance



*\*available*



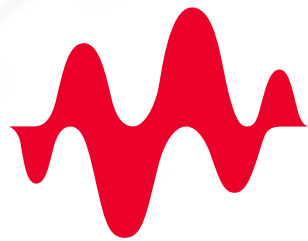
Network Emulator



Channel Emulator



mmWave OTA Solutions



**KEYSIGHT**  
TECHNOLOGIES

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