5G Device End-to-End Solutions

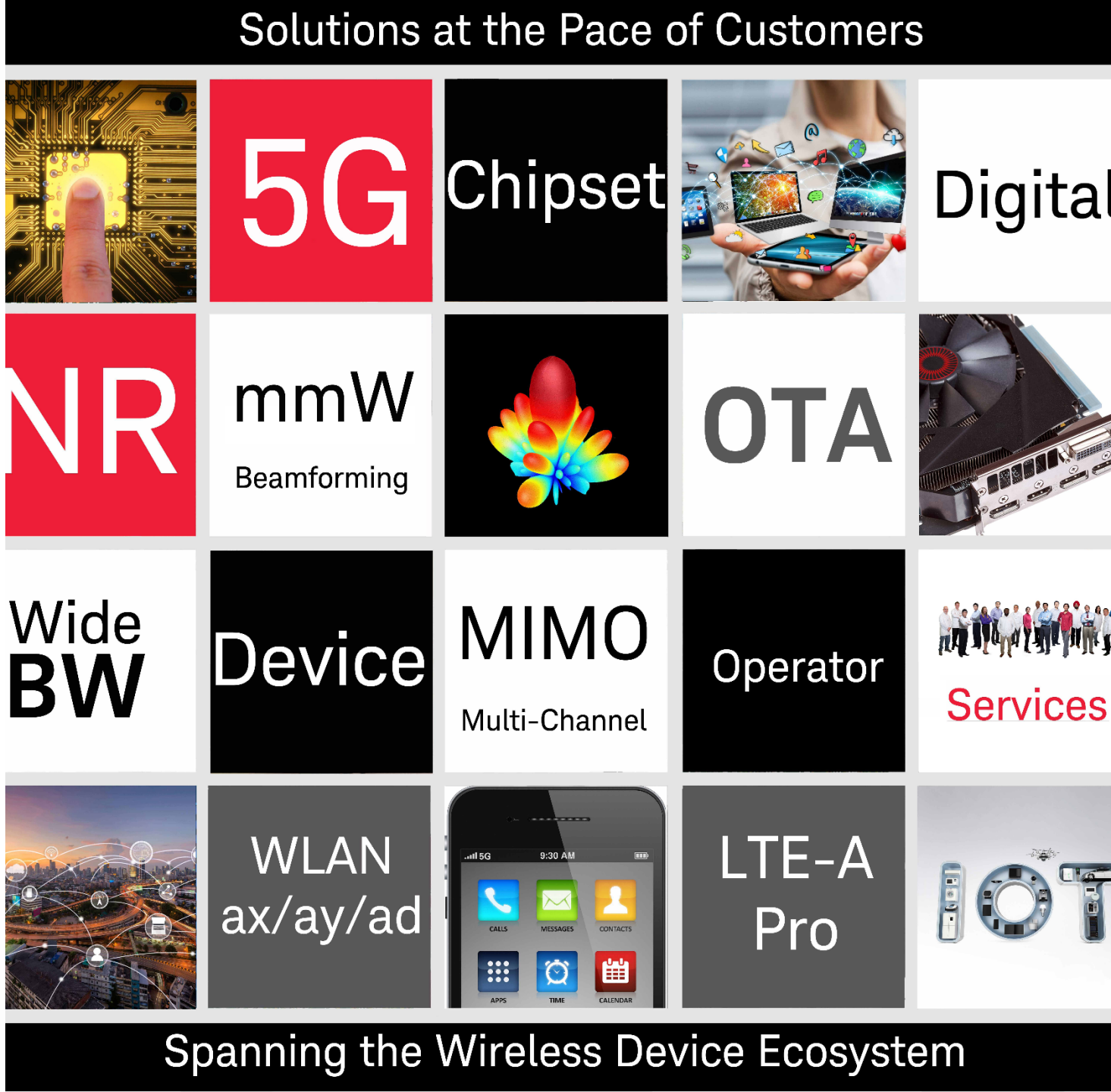
(Network, Channel Emulation & mmWave OTA Solutions)

SE / Keysight Technologies	2018.04.27
Seung-Youl, Heo	

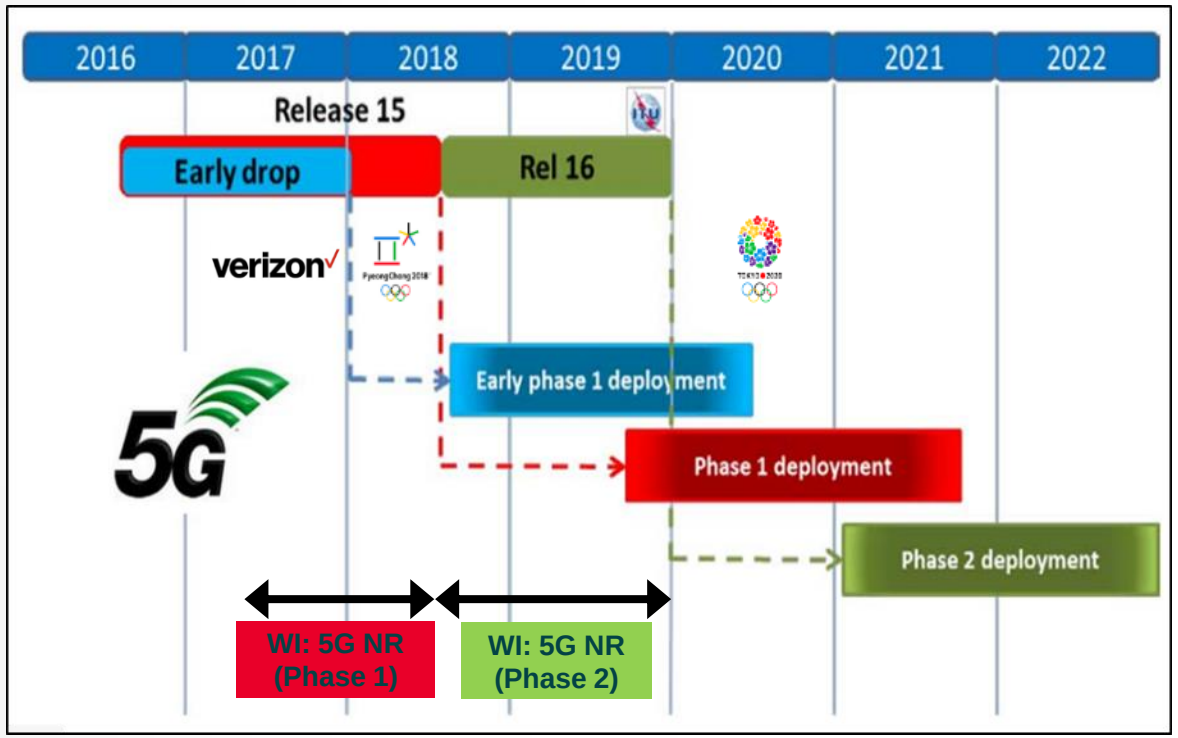
KEYSIGHT TECHNOLOGIES

Agenda

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



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

- "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	• Below 6GHz: 5, 10, 15, 20, 25, 40, 50, 60, 80, **100MHz** • Above 6GHz: 50, 100, 200, **400MHz**	100 MHz
Maximum CCs	**16** (allowed BW and CCs combinations TBD)	8
Numerology (subcarrier spacing)	• Below 6GHz: Data 15k, 30k, 60k & Sync. 15k, 30k • Above 6GHz: Data 60k, 120k & Sync. 120k, 240k	5x15 kHz (75 kHz) (i.e. 5x LTE)
Waveform	CP-OFDM for DL CP-OFDM **+ DFT-s-OFDM for UL**	CP-OFDM for DL and UL
Subcarriers	Variable (maximum is **3300 requiring an 4096 FFT**)	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	**8 for DL and 4 for UL**	2x2
Duplexing	FDD, static TDD, dynamic TDD	Dynamic TDD
Use Cases	eMBB, **URLLC**	eMBB

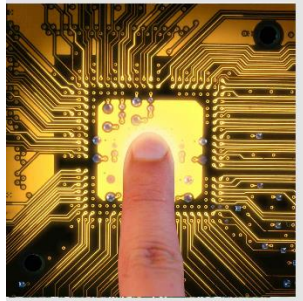
Device Challenges

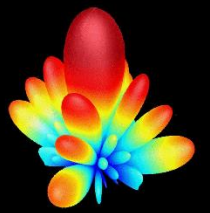
A DYNAMIC INDUSTRY

- **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

KEYSIGHT TECHNOLOGIES

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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  - **Channel Emulator**
  - **OTA Chamber**
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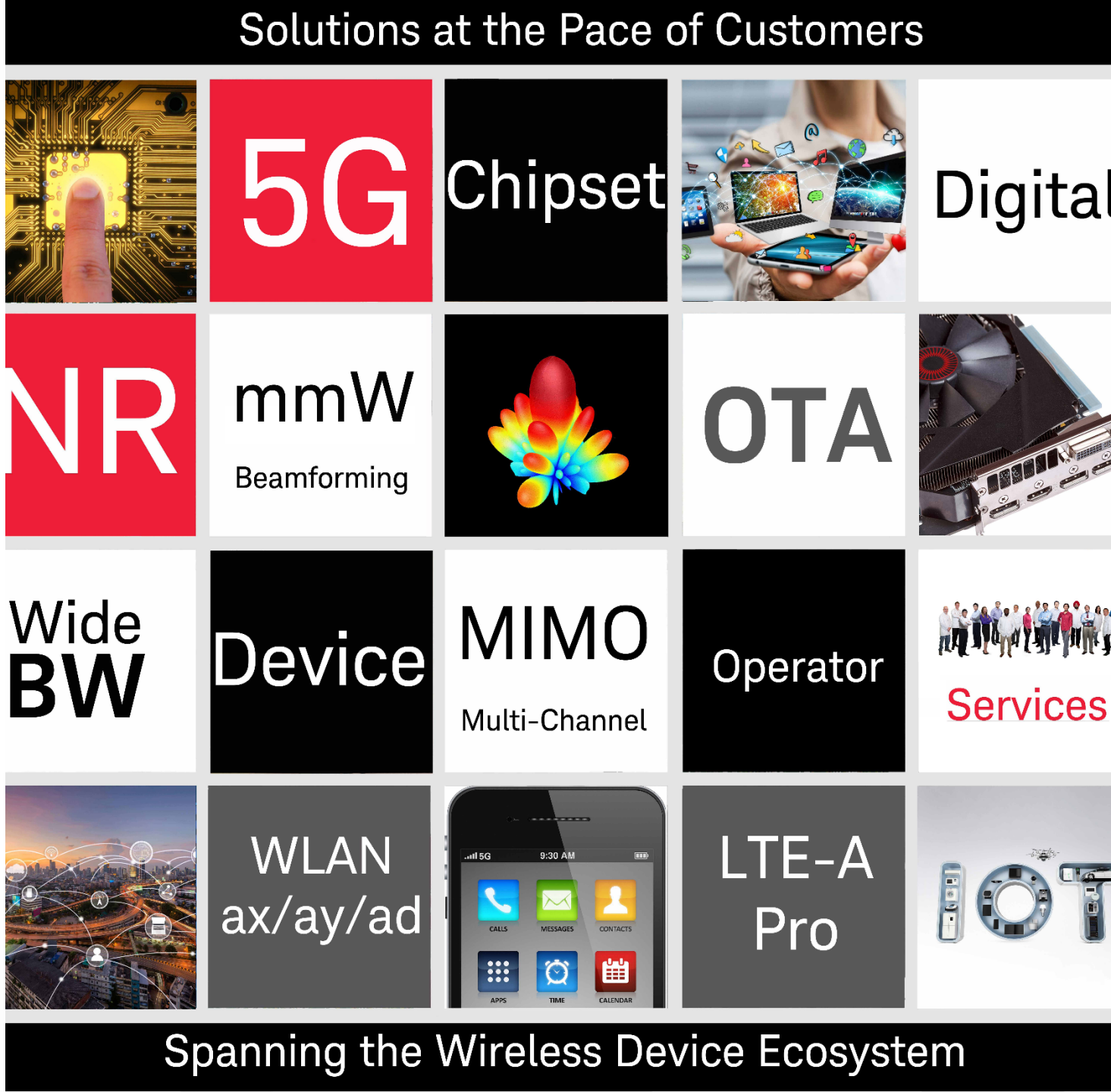


5G NE Platform Hardware

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

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

*available

5G Device Acceptance

- Protocol Conformance
- RF/ RRM Conformance
- Carrier Acceptance

Network Emulator

Channel Emulator

mmWave OTA Solutions

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

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

5G Protocol R&D Toolset

KEY FEATURES

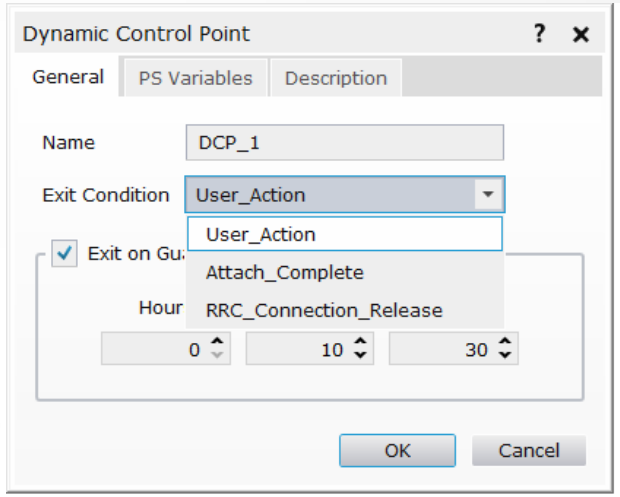
- Earliest availability of new 5G features
- Replicate desired network behavior whilst reducing test complexity with Built-in Protocol State Machine and Dynamic Control Points
- L1/L2 parameter change without programming
- Flexible automation and logging
- Results viewer

KEYSIGHT TECHNOLOGIES

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



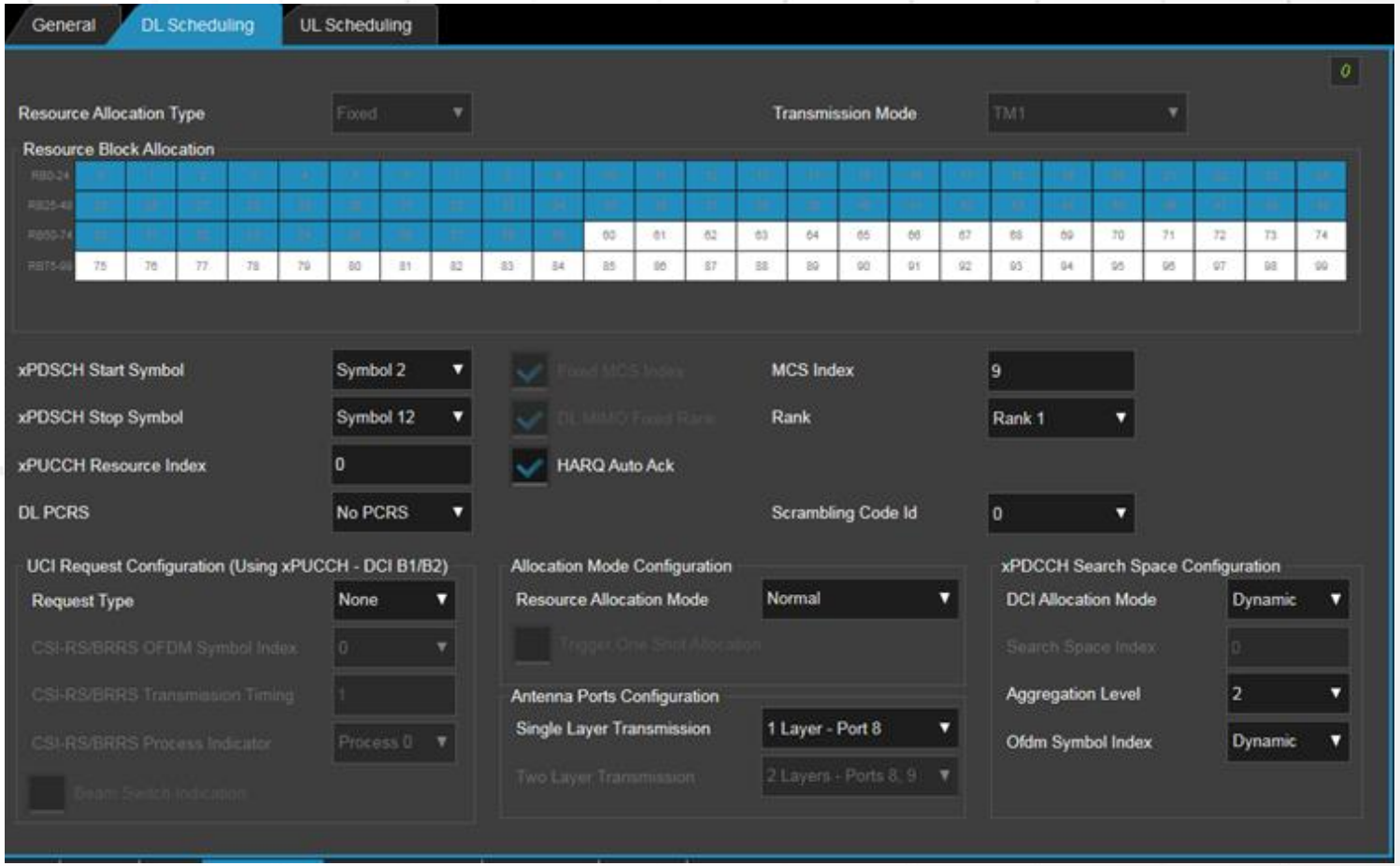
Script

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

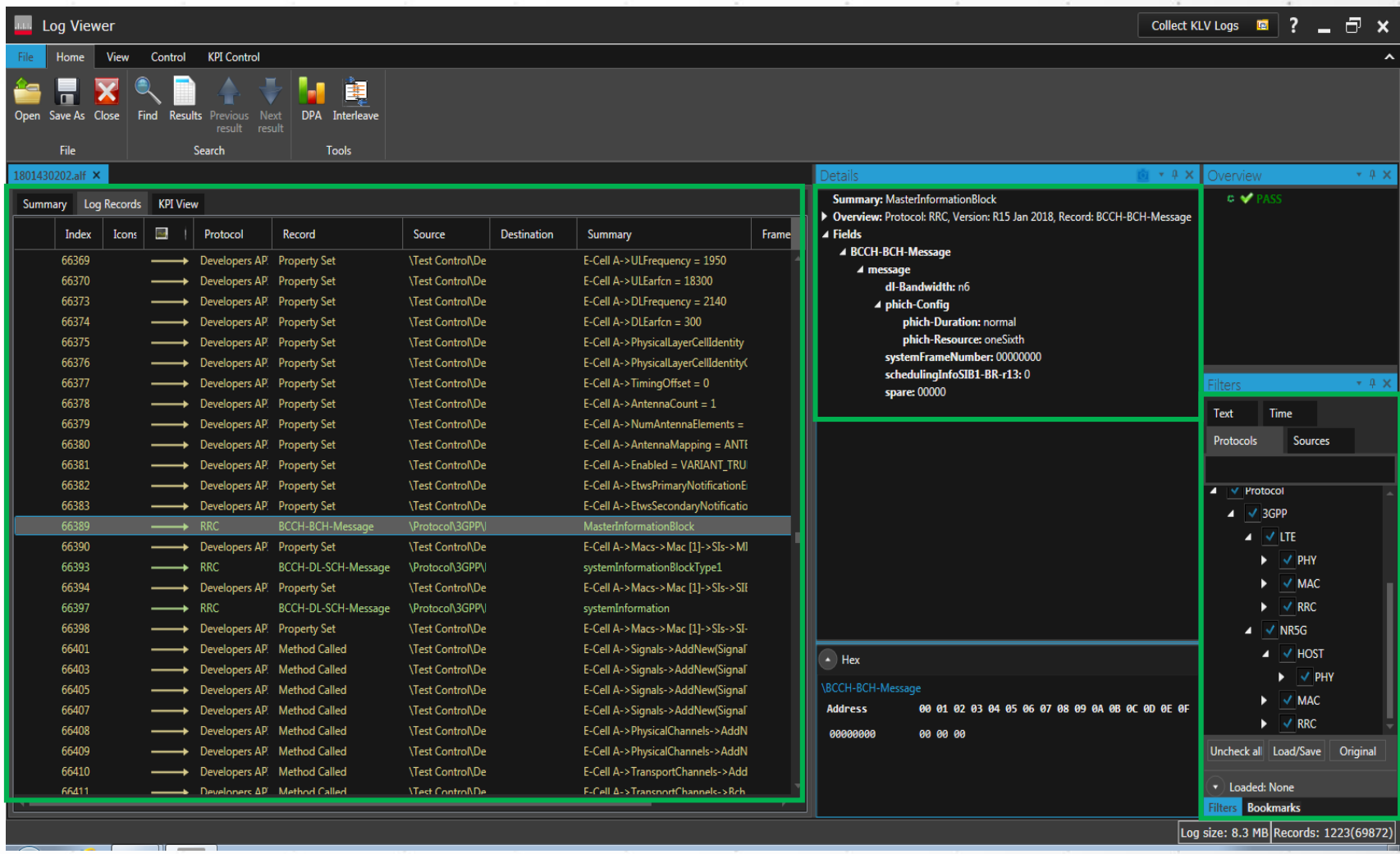
- Allow dynamic L1/L2 parameters changes without the need for programming
- Very useful in early development testing of prototypes



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



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

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Protocol R&D*

RF DVT*

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Network Emulator

Channel Emulator

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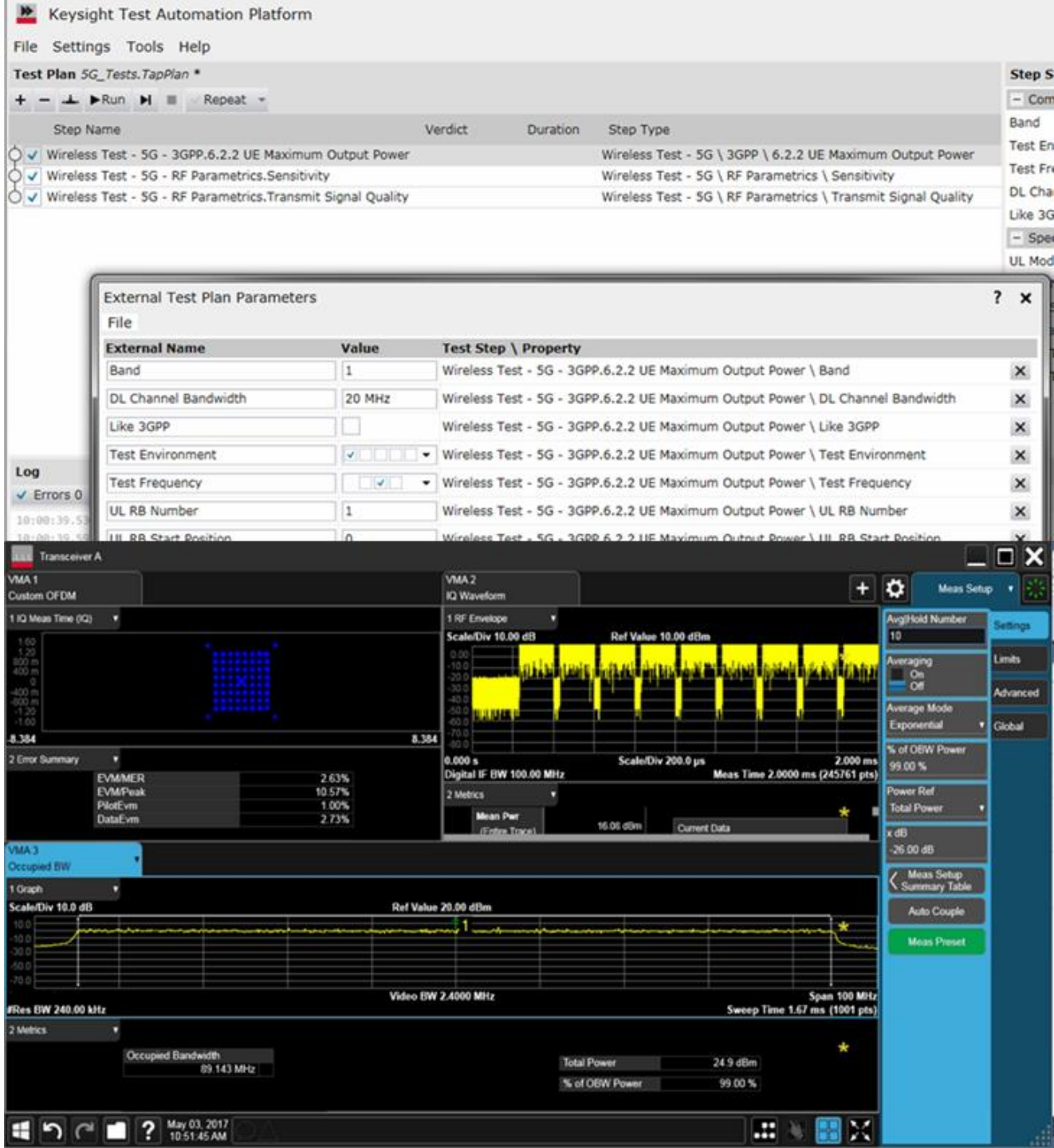
5G RF DVT Toolset

KEY FEATURES

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

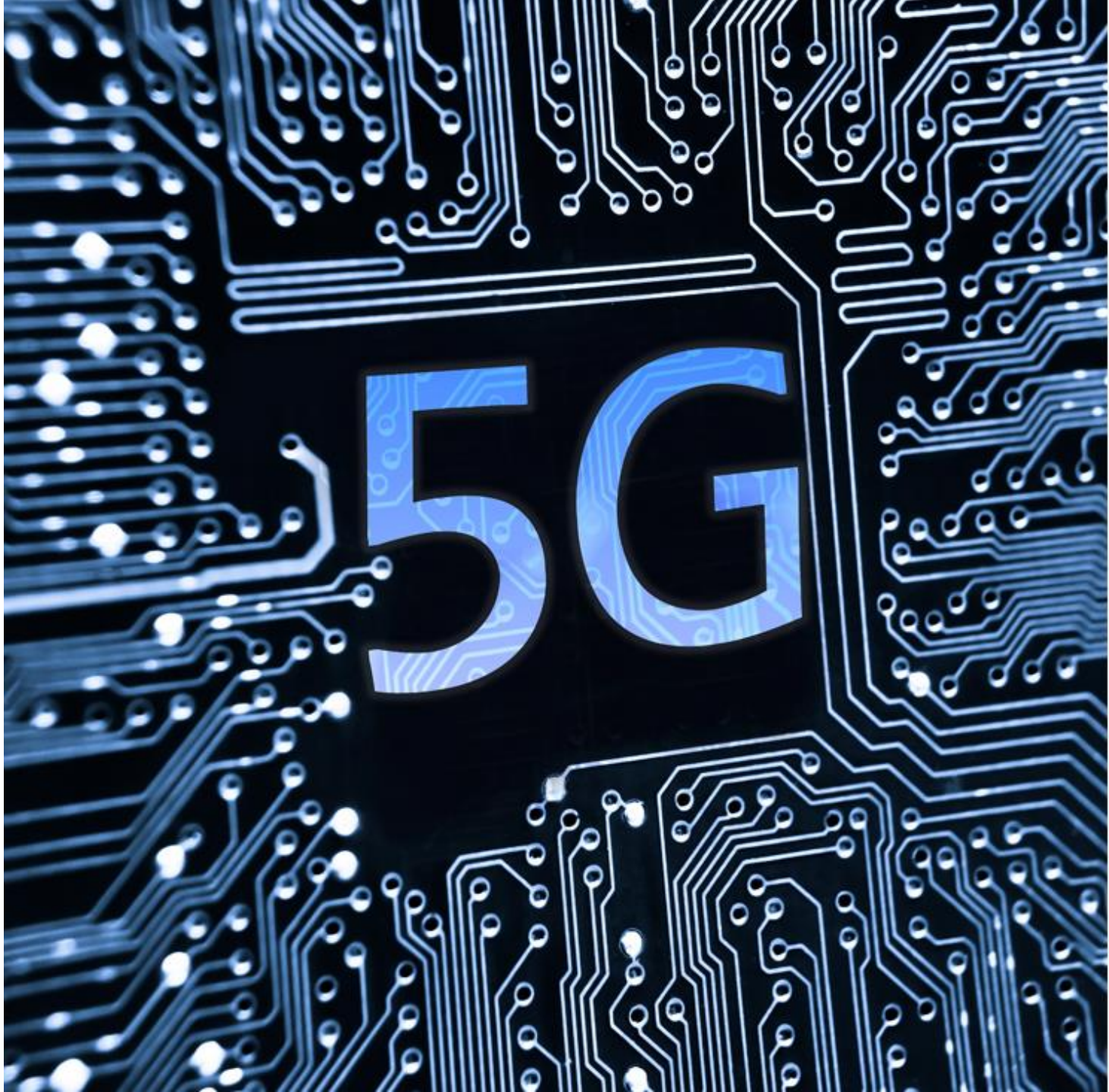


KEYSIGHT TECHNOLOGIES

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

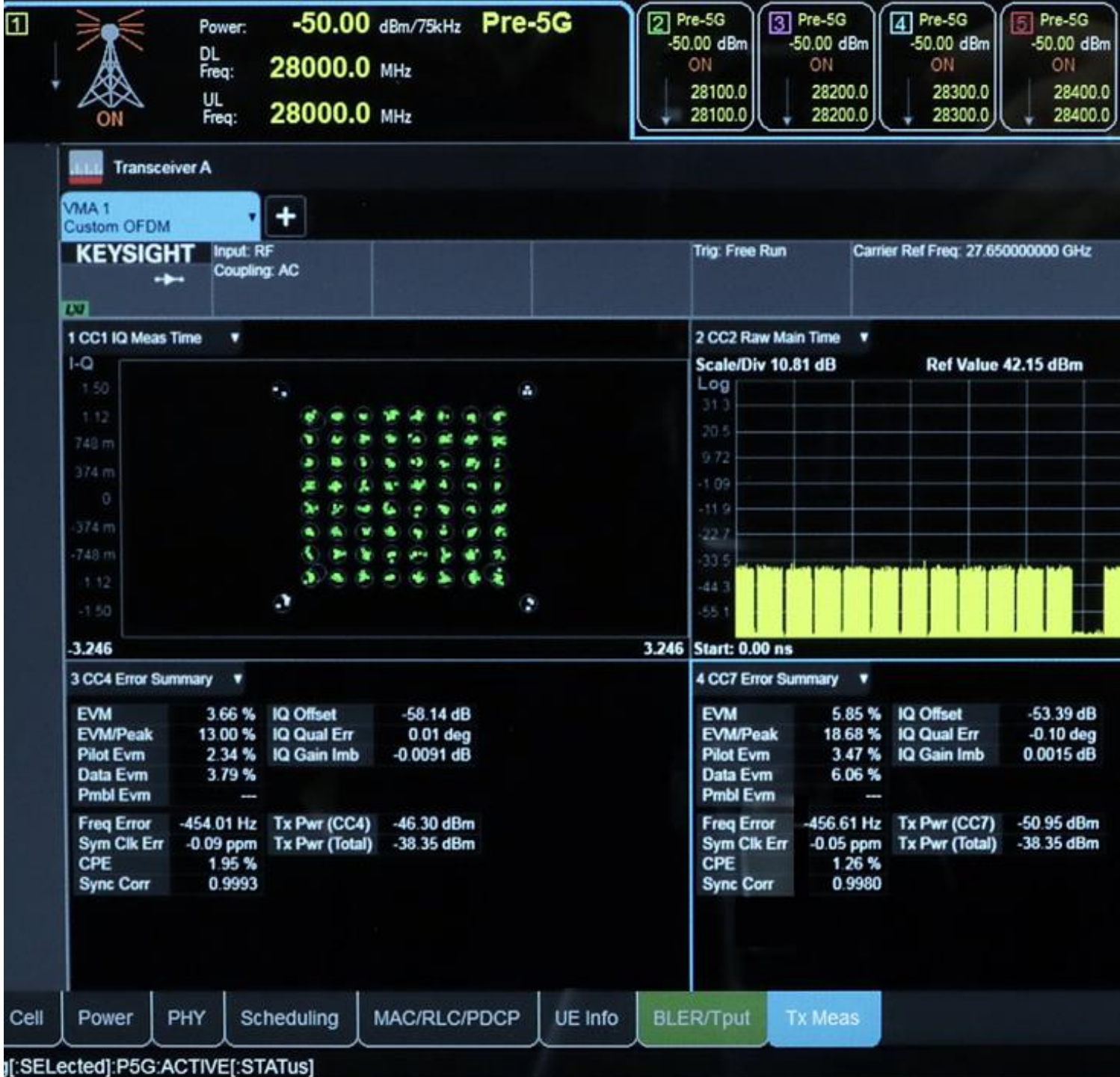


KEYSIGHT TECHNOLOGIES

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

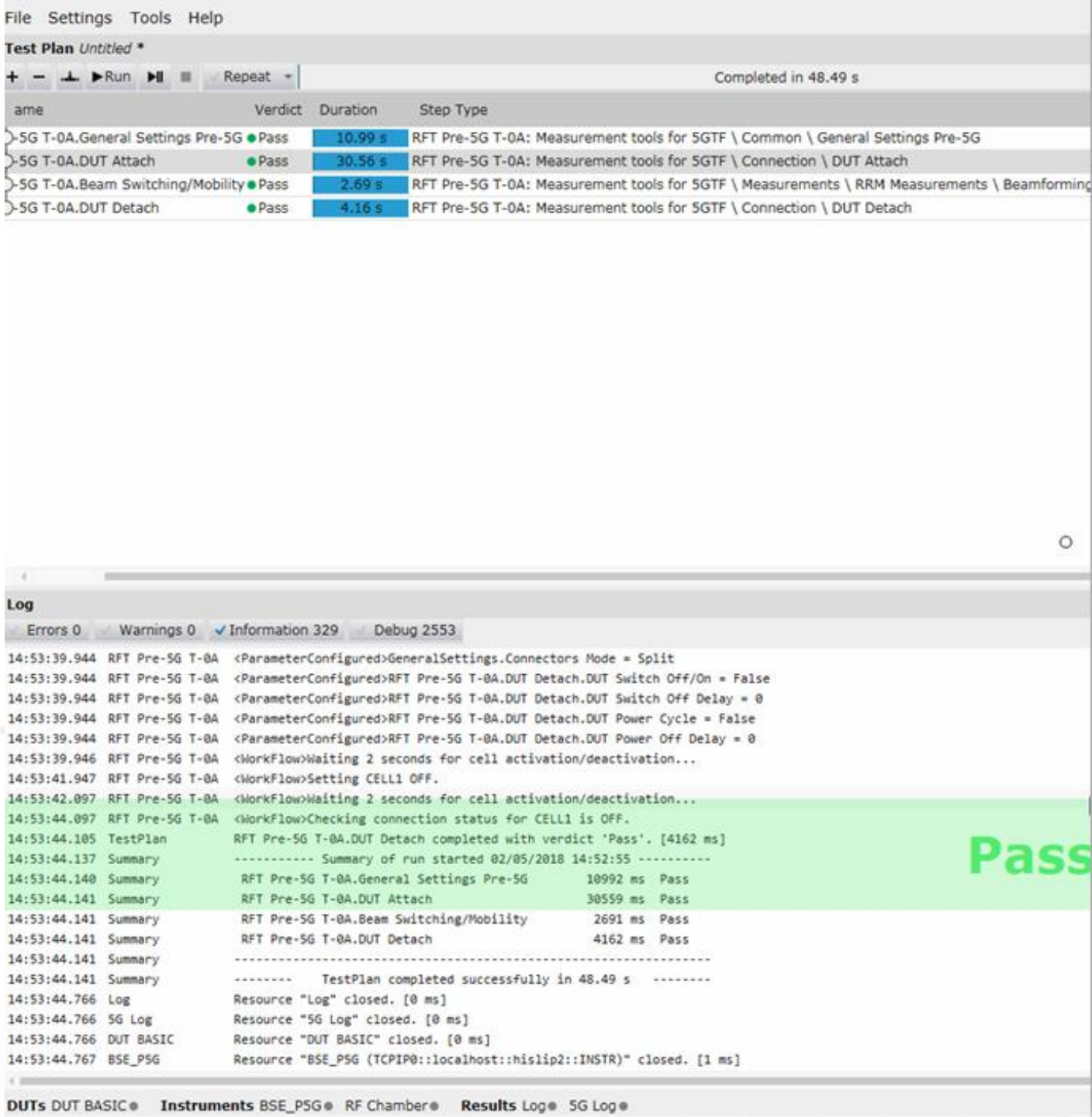


KEYSIGHT TECHNOLOGIES

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)



KEYSIGHT TECHNOLOGIES

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

Protocol R&D*

RF DVT*

Functional KPI

5G Device Acceptance

Protocol Conformance

RF/ RRM Conformance

Carrier Acceptance

*available

Network Emulator

Channel Emulator

mmWave OTA Solutions

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

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

5G Functional KPI

5G NES

COMING SOON

- 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

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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 Throuhput, 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

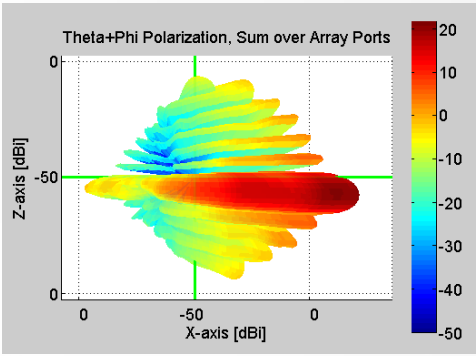
- Supported 5G NR Carrier BWs 5...100/200/400MHz. NSA and SA.
- RF range SUB6GHz, HIGH IF 6-12GHz and mmW 24-43.5GHz
- 5G NR Carrier Aggregation schemes 8CC up to 16CC supported
- MIMO 8x8bi, 16x8bi, 64x8bi etc. MU-MIMO
- Comprehensive 3GPP 5G NR channel modeling (TR38.901) with Propsim 3D Geometric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

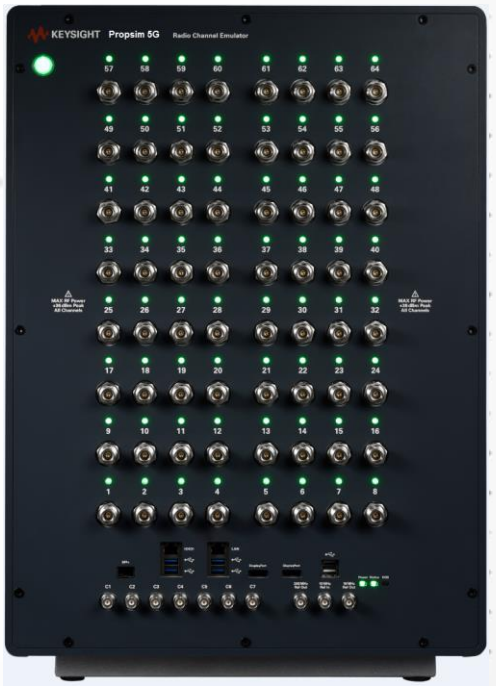
5G Device Testing

- 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.





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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

RF/Antenna

Protocol/Functional Single Link

Beamforming with Clean channel

Mobility and Performance

CATR

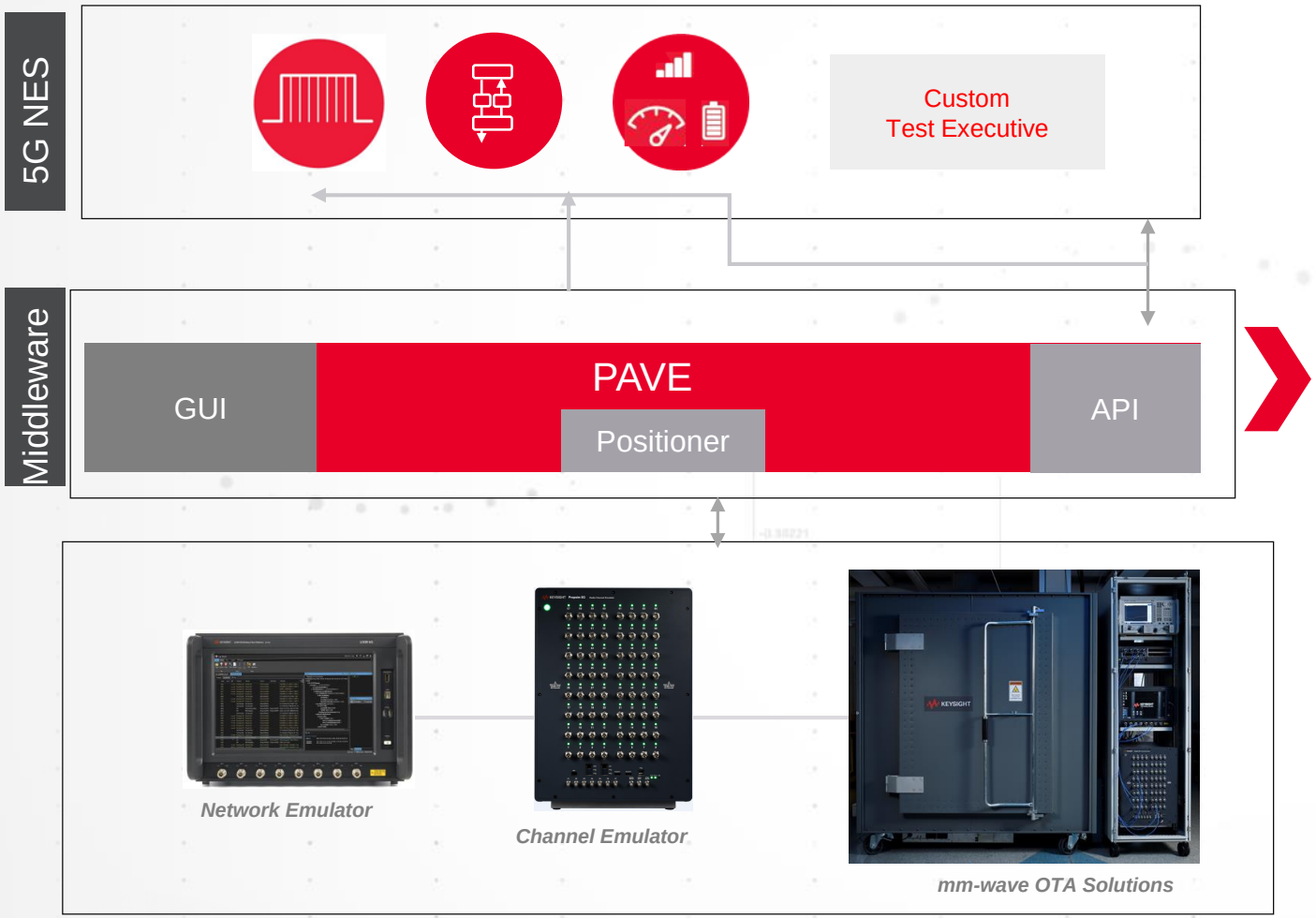
RMTC

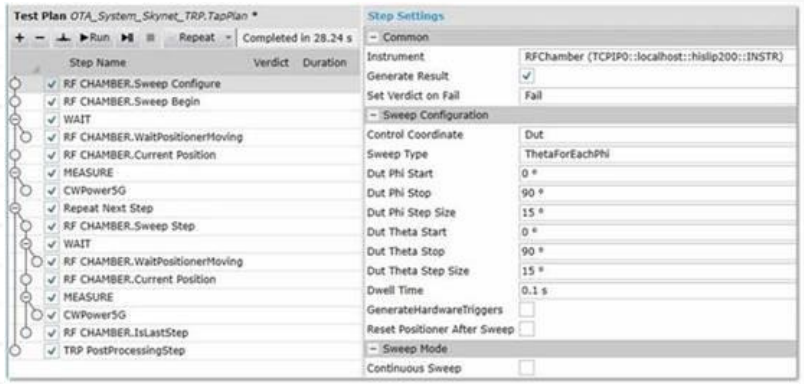
2D MPAC

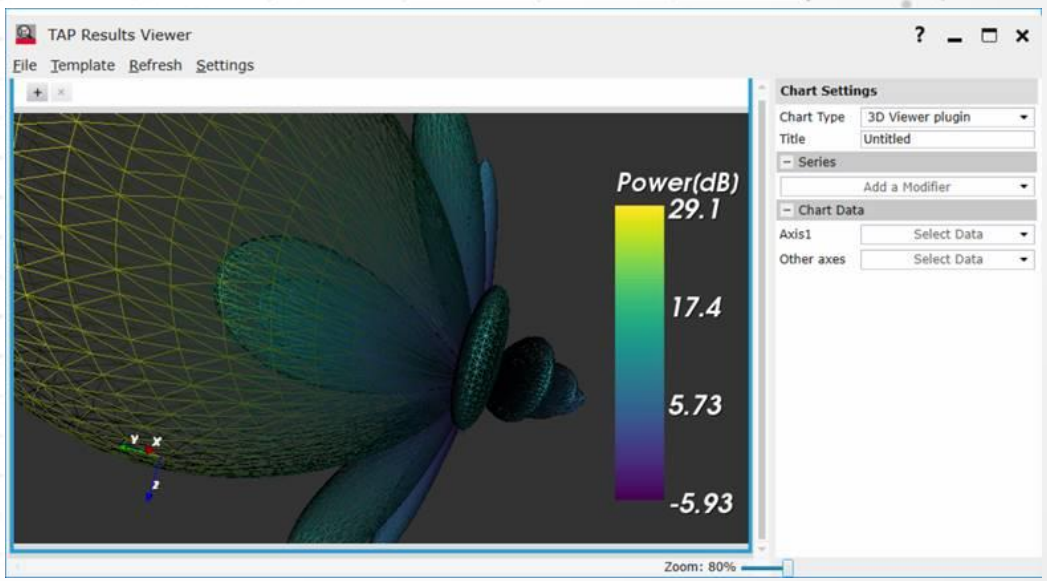
3D MPAC

Solution Summary – mmWave OTA

5G DEVICE END-TO-END SOLUTIONS







Summay

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