

Optimize 5G Device MFG

Keysight Technologies

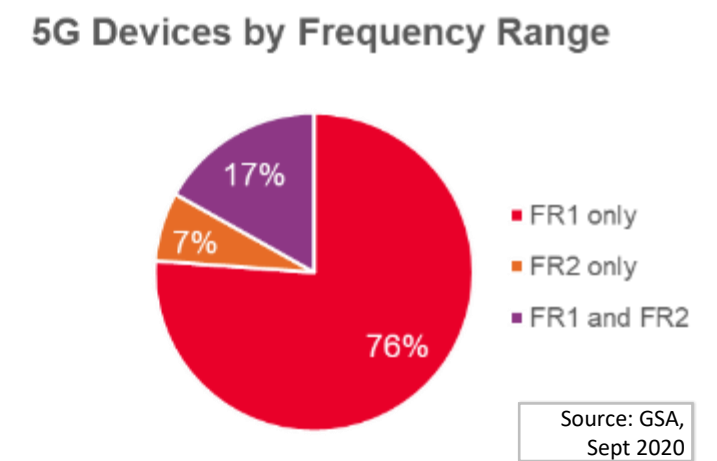
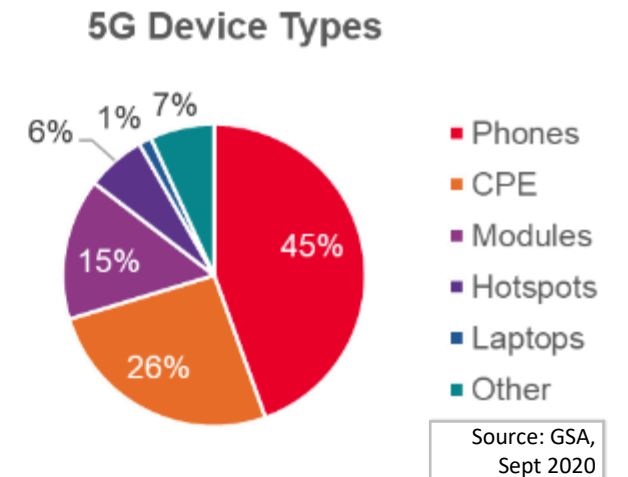
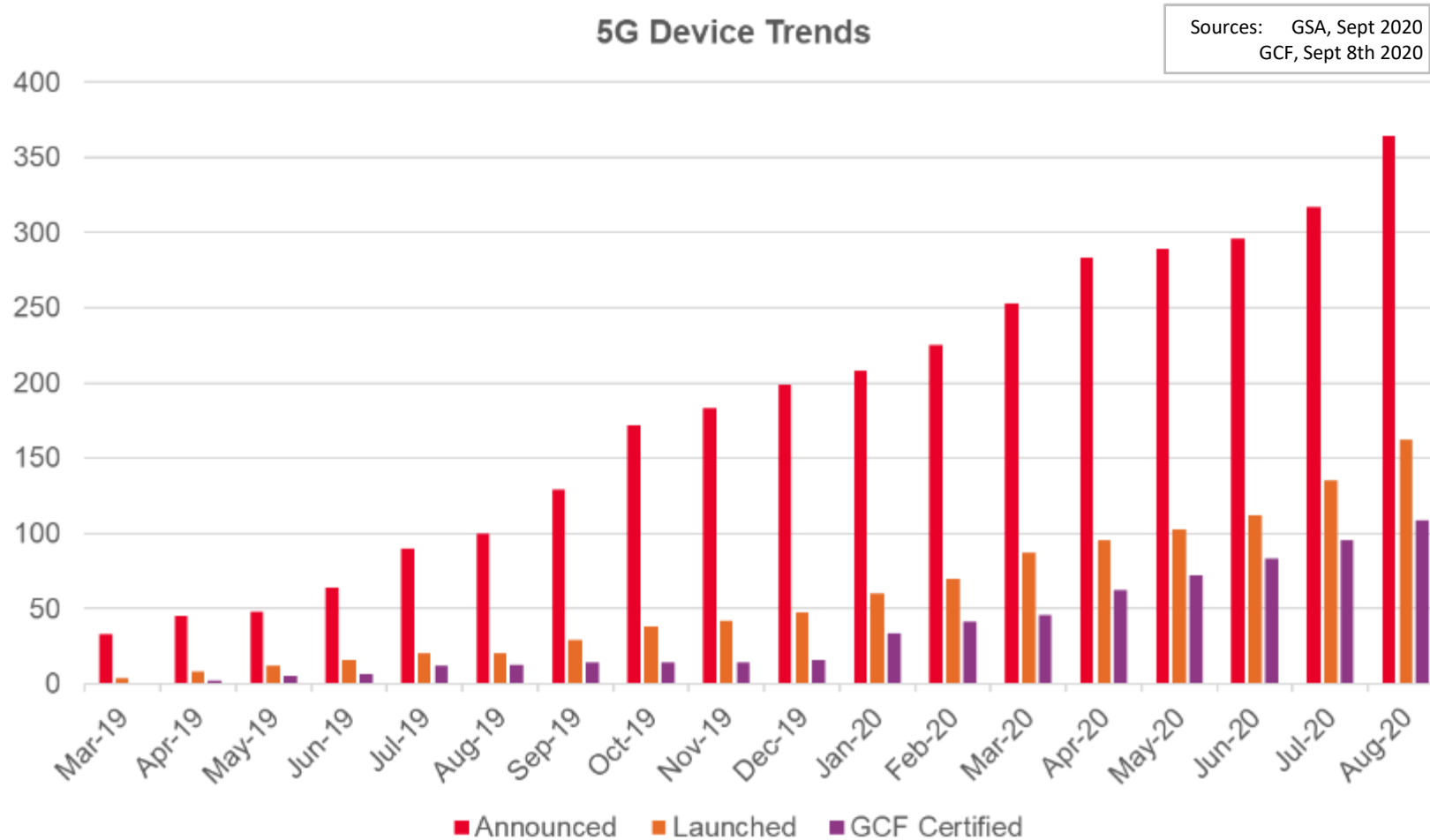
2020.12.22

Dannis Yu



5G Devices Trend

SOURCES: GSA & GCF BY SEPTEMBER 2020



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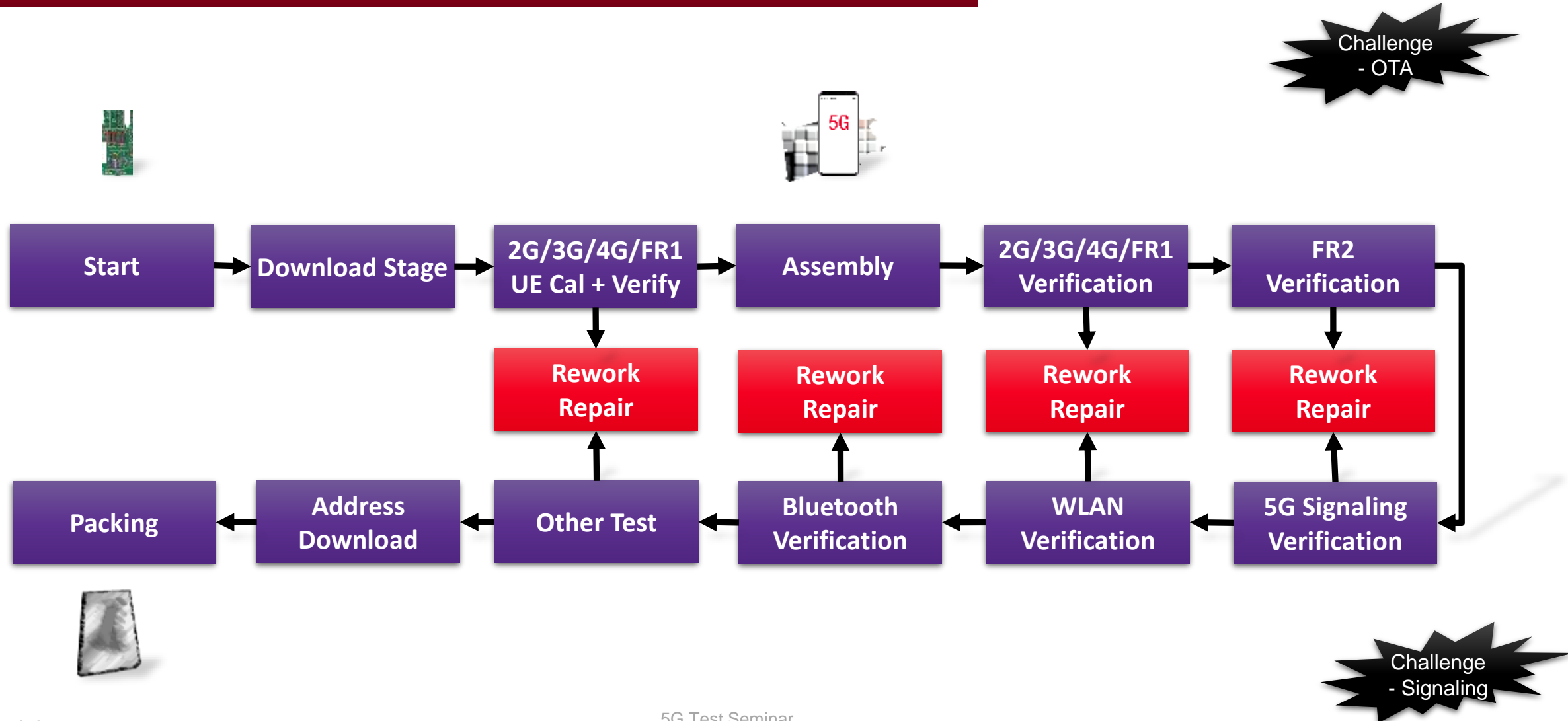
KEY CHALLENGES

- **Quickly deploy new 5G production lines**
 - Leverage work across workflow stages
 - Utilize industry proven solutions



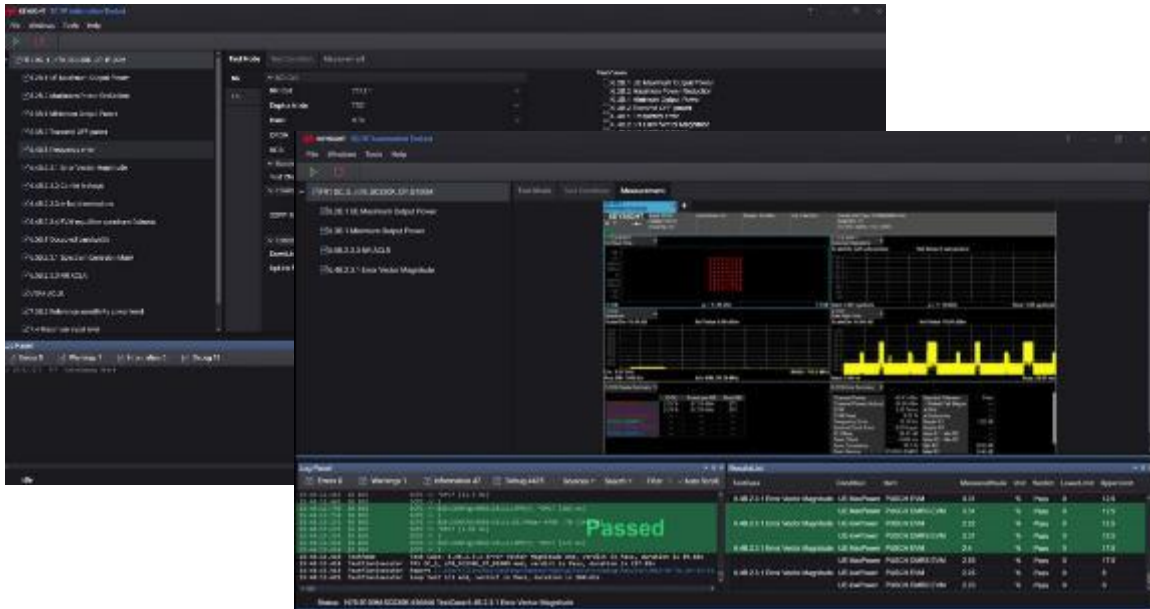
Leverage work across workflow stages

STAGES MAY BE MERGED OR FURTHER SPLIT



Leverage work across workflow stages

SIGNALING TEST FOR DEVICE MANUFACTURING TEST



S8702A RF Automation Toolset extends the capabilities with **UXM 5G** from R&D to Manufacturing by providing:

- An intuitive and easy-to-use graphical user interface for creating, configuring and running test campaigns
- A suite of fully-automated signaling RF Transmitter and Receiver tests
- Optimized test execution times, enabling rapid inspection of the RF performance of 5G NR devices
- A report generator to summarize the results of test campaigns
- Support for LTE, NSA and SA modes in the same network emulator, providing a small footprint benchtop solution for production



5G Test Seminar

Utilize industry proven solutions

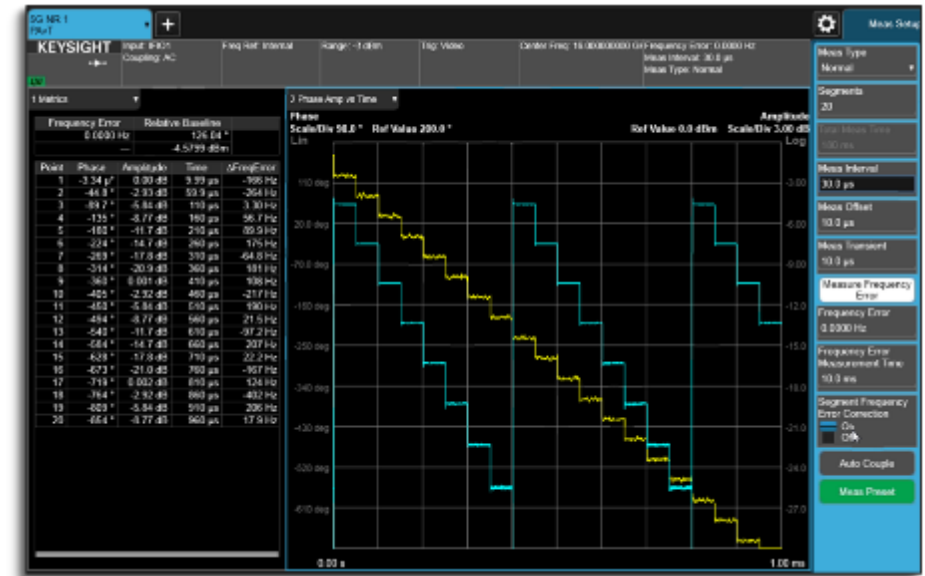
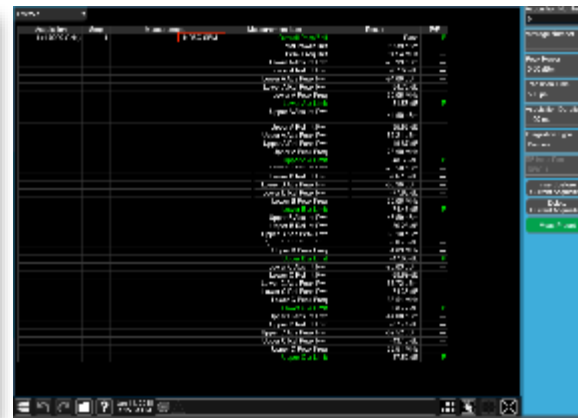
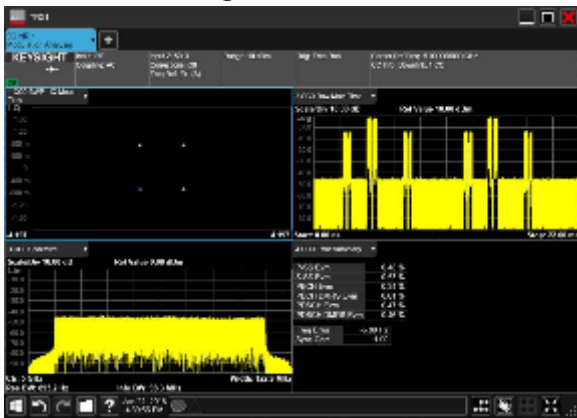
ALIGNMENT WITH R&D & CHIPSET

Common measurement science required

- **Same 5G NR Measurement Application for Keysight HW platforms**
 - N/V9085EM0E X-Series 5G NR Measurement Application on various HW platforms
 - Shared Demodulation Algorithm Library
- **Same 5G NR Signal Generation for Keysight HW platforms**
 - N7631C Signal Studio waveform license available on various platforms
 - Shared Signal Generation IP

Integrated into Chipset Vendor's Tool Required

- **Qualified by Chipset Specific Tool**
- **Support Chipset Specific Testing**
 - Sequence Analyzer Mode support Fast-Cal and Verification test
 - Single capture, multiple measurement (List Mode)
 - In-parallel capturing & measurement with multithreads support



Optimize 5G Device M

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- **Efficiently ramp to high volume**
 - Optimize test plans for speed
 - Customize scripts, automate efficiently and debug



Optimize test plans for speed

FROM 3GPP TS 38.521 TEST SPECIFICATION

Manufacturing Test

- ✓ Maximum power
- ✓ Minimum power
- ✓ Frequency error
- ✓ EVM
- ✓ Carrier leakage
- ✓ EVM equalizer spectrum flatness
- ✓ OBW
- ✓ SEM
- ✓ ACLR
- ✓ Rx tests require signaling for throughput measurement
- ✓

A subset of tests designed to optimize for production verification and cost of test

6.3.3.8	Transmit power time mask for consecutive slot or local subslot transmission and short subslot transmission boundaries	140	6.3A.1.5.2	Test applicability	177	6.3A.4.2.3.5	
6.3.3.9	Transmit power time mask for consecutive short subslot transmission boundaries	140	6.3A.1.5.3	Minimum conformance requirements	177	6.3A.4.2.3.6	
6.3.4	Power control	140	6.3A.1.5.4	Test description	177	6.3A.4.2.3.7	
6.3.4.1	General	140	6.3A.1.5.5	Test requirement	178	6.3A.4.2.3.8	
6.3.4.2	Absolute power tolerance	140	6.3A.1.6	Minimum output power for CA (FUL CA)	179	6.3A.4.2.3.9	
6.3.4.2.1	Test purpose	140	6.3A.1.6.1	Test purpose	179	6.3A.4.2.4	
6.3.4.2.2	Test applicability	140	6.3A.1.6.2	Test applicability	179	6.3A.4.2.4.1	
6.3.4.2.3	Minimum conformance requirements	140	6.3A.1.6.3	Minimum conformance requirements	179	6.3A.4.2.4.2	
6.3.4.2.4	Test description	140	6.3A.1.6.4	Test description	179	6.3A.4.2.4.3	
6.3.4.2.5	Initial condition	140	6.3A.1.6.5	Test requirement	180	6.3A.4.2.4.4	
6.3.4.2.6	Message content	140	6.3A.1.7	Minimum output power for CA (SUL CA)	181	6.3A.4.2.4.4.1	
6.3.4.2.7	Test purpose	140	6.3A.1.7.1	Test purpose	181	6.3A.4.2.4.5	
6.3.4.2.8	Test applicability	140	6.3A.1.7.2	Test applicability	181	6.3A.4.2.5	
6.3.4.2.9	Minimum conformance requirements	140	6.3A.1.7.3	Minimum conformance requirements	181	6.3A.4.2.5.1	
6.3.4.2.10	Test description	140	6.3A.1.7.4	Test description	181	6.3A.4.2.5.2	
6.3.4.2.11	Initial condition	140	6.3A.1.7.5	Test requirement	181	6.3A.4.2.5.3	
6.3.4.2.12	Message content	140	6.3A.2	Transmit OFF power for CA	182	6.3A.4.2.5.4	
6.3.4.2.13	Test purpose	140	6.3A.2.1	Minimum conformance requirements	183	6.3A.4.2.5.4.1	
6.3.4.2.14	Test applicability	140	6.3A.2.2	Transmit OFF power for CA (SUL CA)	183	6.3A.4.2.5.5	
6.3.4.2.15	Minimum conformance requirements	140	6.3A.2.3	Transmit OFF power for CA (FUL CA)	185	6.3A.4.2.6	
6.3.4.2.16	Test description	140	6.3A.3	Transmit ON/OFF time mask for CA (FUL CA)	186	6.3A.4.2.6.1	
6.3.4.2.17	Initial condition	140	6.3A.3.1	Minimum conformance requirements	187	6.3A.4.2.6.1.1	
6.3.4.2.18	Message content	140	6.3A.3.2	Transmit ON/OFF time mask for CA (SUL CA)	187	6.3A.4.2.6.1.2	
6.3.4.2.19	Test purpose	140	6.3A.4.1	Power control for CA	187	6.3A.4.2.6.1.3	
6.3.4.2.20	Test applicability	140	6.3A.4.1.1	General	190	6.3A.4.2.6.1.4	
6.3.4.2.21	Minimum conformance requirements	140	6.3A.4.1.2	Absolute power tolerance for CA	190	6.3A.4.2.6.1.5	
6.3.4.2.22	Test description	140	6.3A.4.1.3	Minimum conformance requirements	190	6.3A.4.2.6.5	
6.3.4.2.23	Initial condition	140	6.3A.4.1.4	Absolute power tolerance for CA (SUL CA)	190	6.3A.4.2.7	
6.3.4.2.24	Message content	140	6.3A.4.1.5	Test purpose	190	6.3A.4.2.7.1	
6.3A.4.2.25	Test applicability	191	6.3A.4.1.6	Minimum conformance requirements	191	6.3A.4.2.7.2	
6.3A.4.2.26	Test description	191	6.3A.4.1.7	Test description	191	6.3A.4.2.7.3	
6.3A.4.2.27	Initial condition	191	6.3A.4.1.8	Test requirement	191	6.3A.4.2.7.4	
6.3A.4.2.28	Message content	191	6.3A.4.2.1	Test purpose	192	6.3A.4.2.7.4.1	
6.3A.4.2.29	Test applicability	192	6.3A.4.2.2	Absolute power tolerance for CA (FUL CA)	195	6.3A.4.2.7.5	
6.3A.4.2.30	Test description	192	6.3A.4.2.3	Test purpose	195	6.3D	Carrier
6.3A.4.2.31	Initial condition	192	6.3A.4.2.4	Test applicability	195	6.3D.1	Bandwidth
6.3A.4.2.32	Message content	192	6.3A.4.2.5	Minimum conformance requirements	195	6.3D.2	Transmit
6.3A.4.2.33	Test purpose	192	6.3A.4.2.6	Test description	195	6.3D.3	Transmit
6.3A.4.2.34	Test applicability	192	6.3A.4.2.7	Test description	195	6.3D.3.1	Carrier
6.3A.4.2.35	Minimum conformance requirements	192	6.3A.4.2.8	Test description	195	6.3D.3.2	Carrier
6.3A.4.2.36	Test description	192	6.3A.4.2.9	Test requirement	195	6.3D.3.2.1	Carrier
6.3A.4.2.37	Initial condition	192	6.3A.4.3	Test description	195	6.3D.3.3	Carrier
6.3A.4.2.38	Message content	192	6.3A.4.3.1	Test description	195	6.3D.3.3.1	Carrier
6.3A.4.2.39	Test purpose	192	6.3A.4.3.2	Test description	195	6.3D.3.4	Carrier
6.3A.4.2.40	Test applicability	192	6.3A.4.3.3	Test description	195	6.3D.3.4.1	Carrier
6.3A.4.2.41	Minimum conformance requirements	192	6.3A.4.3.4	Test description	195	6.3D.3.4.2	Carrier
6.3A.4.2.42	Test description	192	6.3A.4.3.5	Test description	195	6.3D.3.4.3	Carrier
6.3A.4.2.43	Initial condition	192	6.3A.4.3.6	Test description	195	6.3D.3.4.4	Carrier
6.3A.4.2.44	Message content	192	6.3A.4.3.7	Test description	195	6.3D.3.4.5	Carrier
6.3A.4.2.45	Test purpose	192	6.3A.4.3.8	Test description	195	6.3D.3.4.6	Carrier
6.3A.4.2.46	Test applicability	192	6.3A.4.3.9	Test description	195	6.3D.3.4.7	Carrier
6.3A.4.2.47	Minimum conformance requirements	192	6.3A.4.3.10	Test description	195	6.3D.3.4.8	Carrier
6.3A.4.2.48	Test description	192	6.3A.4.3.11	Test description	195	6.3D.3.4.9	Carrier
6.3A.4.2.49	Initial condition	192	6.3A.4.3.12	Test description	195	6.3D.3.4.10	Carrier
6.3A.4.2.50	Message content	192	6.3A.4.3.13	Test description	195	6.3D.3.4.11	Carrier

3GPP TS 38.521-2 v16.3.0 (2020-03)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NR;
User Equipment (UE) conformance specification;
Radio transmission and reception;
Part 2: Range 2 Standalone
(Release 16)



Optimize 5G Device MFG

KEY CHALLENGES

- Quickly deploy new 5G production lines
 - Leverage work across workflow stages
 - Utilize industry proven solutions
- Efficiently ramp to high volume
 - Optimize test plans for speed
 - Customize scripts, automate efficiently and debug quickly
- **Test FR2 over the air**
 - Rapidly adopt and deploy new radiated test techniques
 - Minimize costs due to more floor space, higher frequency and bandwidth, and longer test times
 - Accurately compensate for loss with system calibration

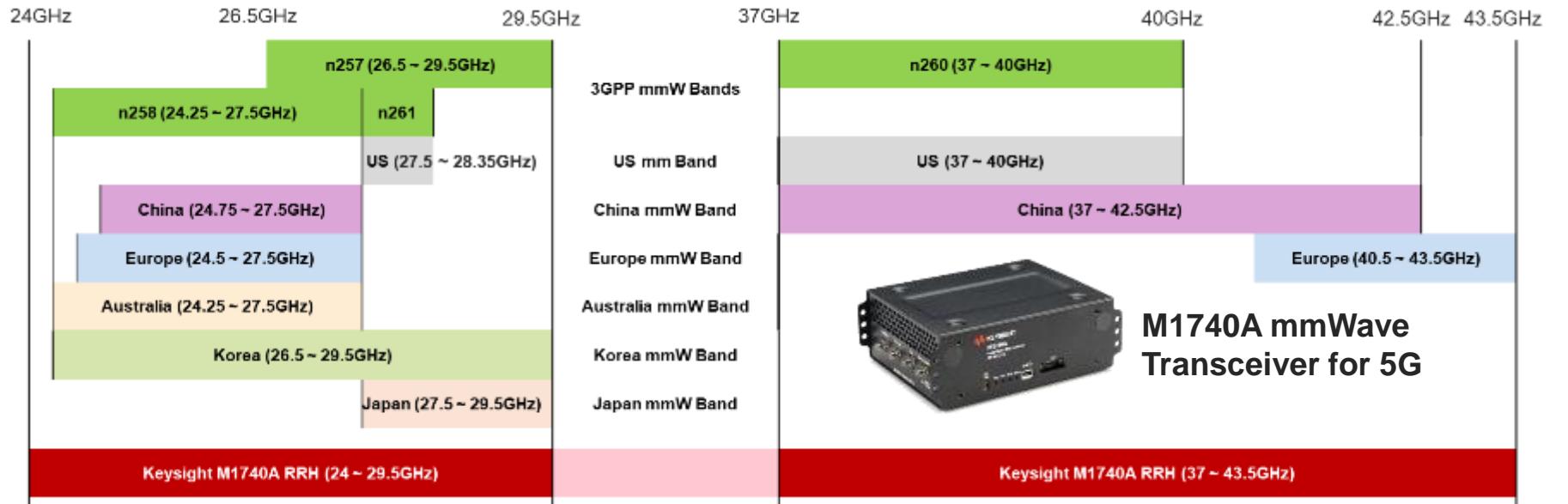
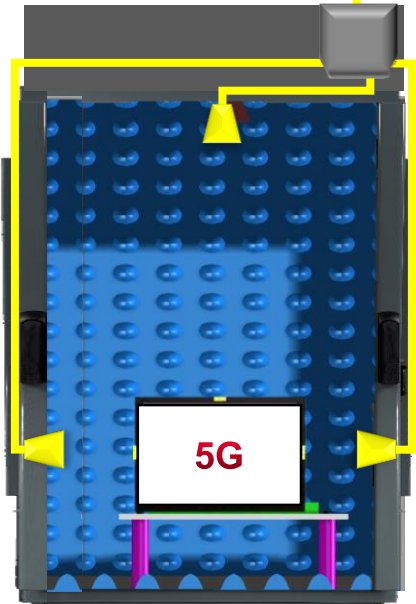
Test FR2 over the air

MINIMIZE COSTS, FLOOR SPACE & UNCERTAINTIES



Flexible Layout & Minimize mmW Cable Length

- mmWave Transceiver design for FR2 testing
- N-Type Cables between RRH and EXM for flexible layout
- Shortest mmW Cable Fixed between Chamber wall to Horn
- mmW Chamber with mmW Switch supporting UE supporting multiple AiP Modules & Dual Polarization



M1740A mmWave Transceiver for 5G

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- **Verify more RF bands / devices / standards Effectively**
 - More band combination complexity
 - More test points and longer test times
 - More future standard, frequency bands

Verify more devices effectively

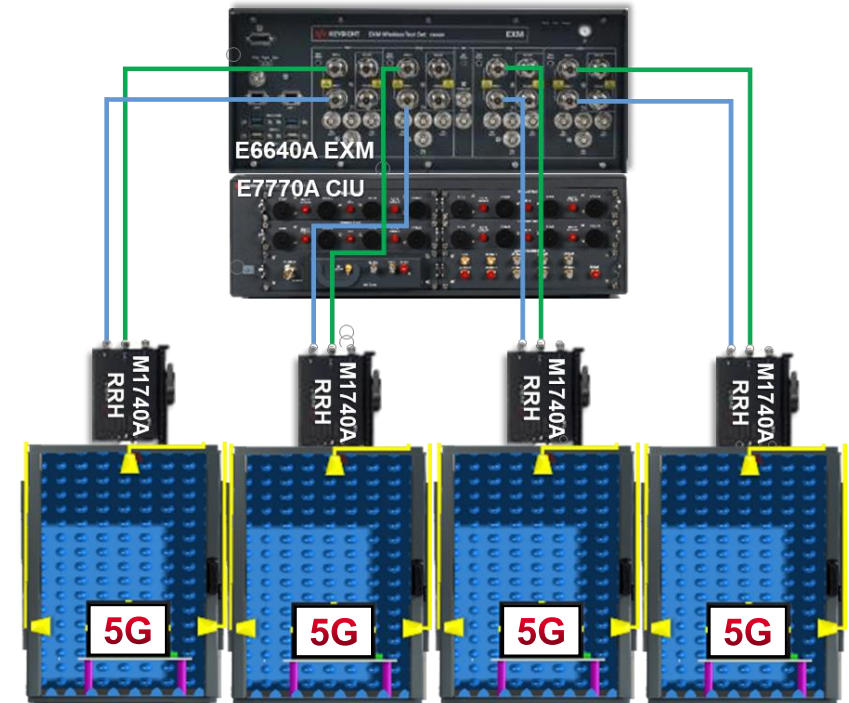
MULTIPLE DEVICES TESTING – MULTI-VSA/VSG

Key Advantages

- ✓ Smaller Footprint with higher port density to increase manufacturing volume per unit area
- ✓ Flexible TRX Port Expansion for future plan

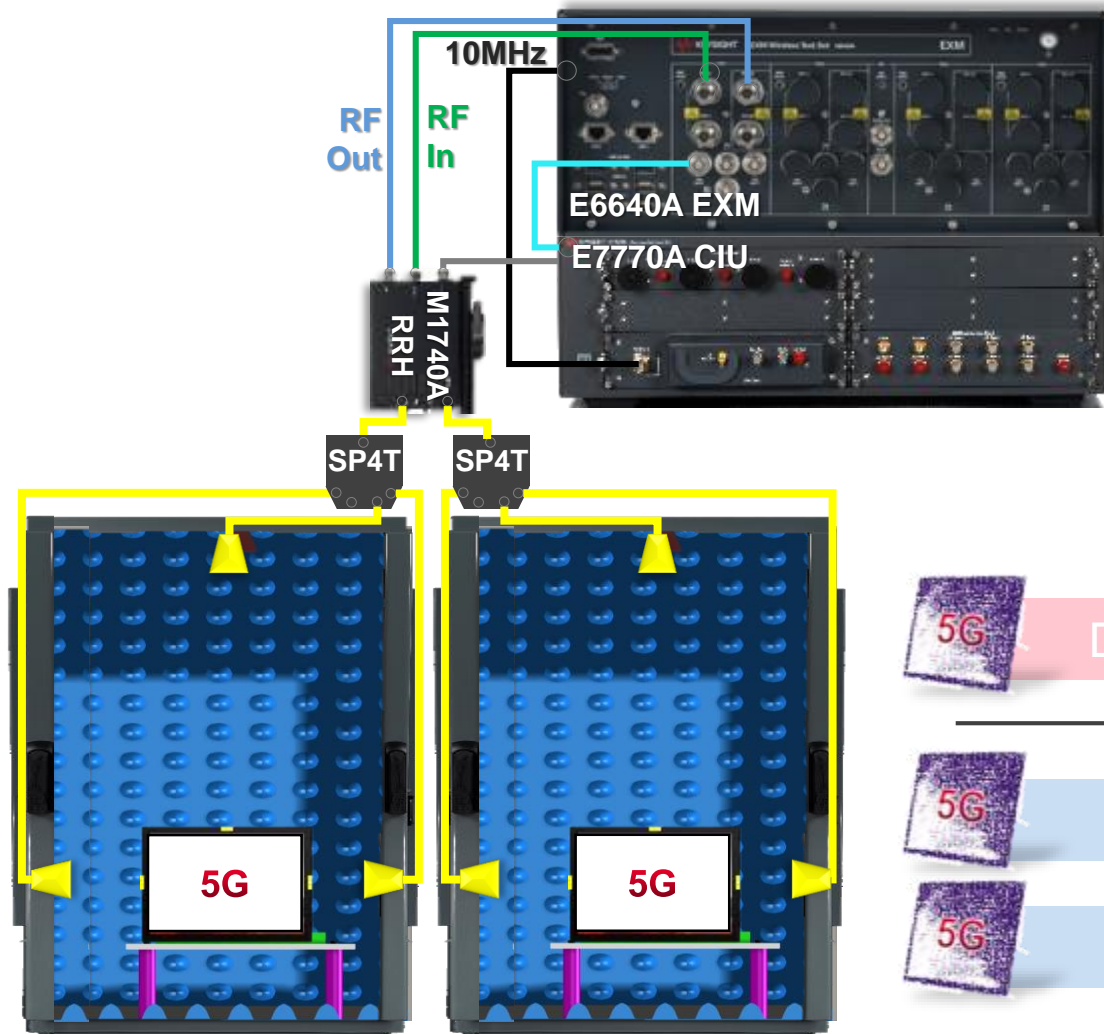


Controller TRX 1 TRX 2 Reference TRX 3 TRX 4



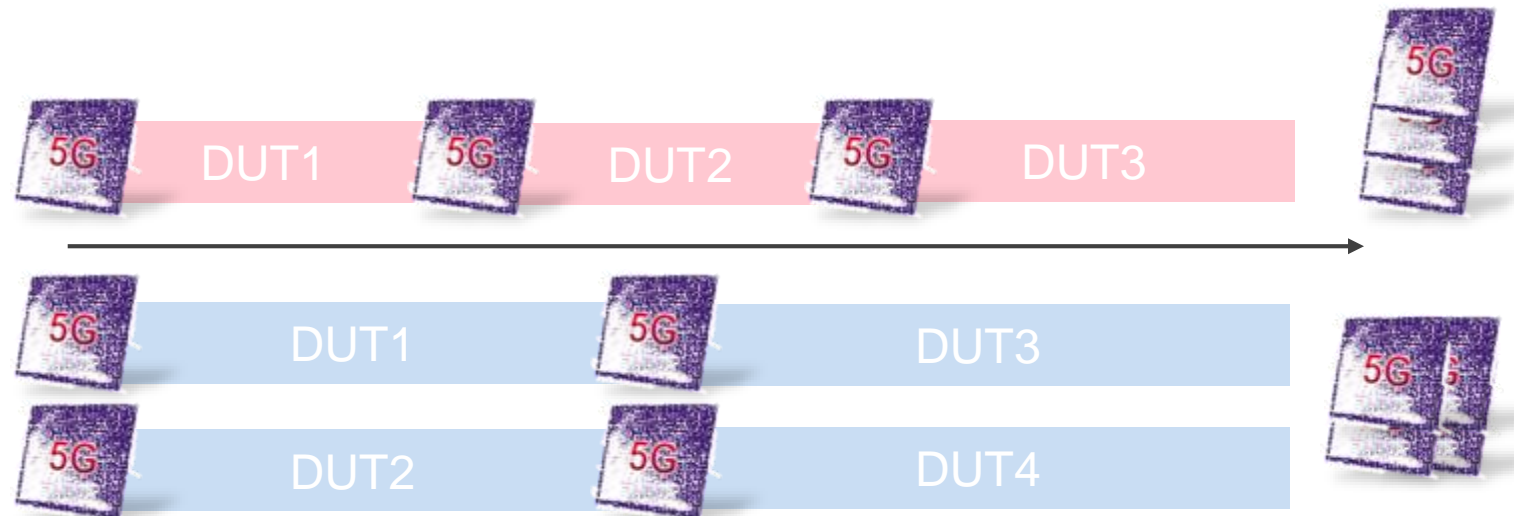
Verify more devices effectively

MULTIPLE DEVICES TESTING – SINGLE VSA/VSG



Key Advantages

- ✓ N-Type Cables between RRH and EXM for flexible layout
- ✓ Shortest mmW Cable Fixed between Chamber wall to Horn
- ✓ mmW Chamber with mmW Switch supporting UE supporting multiple AiP Modules even Dual Polarization
- ✓ T'put Multiplied by adding 2nd Chamber with fast switching test between 2 DUTs



Verify legacy & future standards effectively

MULTIPLE RADIO STANDARD TESTING

Legacy Radio Standard Support Required

- E6640A EXM Wireless Test Set support cellular format from 2G, 3G,4G to 5G and wireless connectivity format from Bluetooth, 802.11b/g/ac to 11ax



- LTE/LTE-A FDD/TDD,
- HSPA+, W-CDMA
- 1xEV-DO, cdma2000
- GSM/EDGE/EDGE
- TD-SCDMA/TD-HSPA

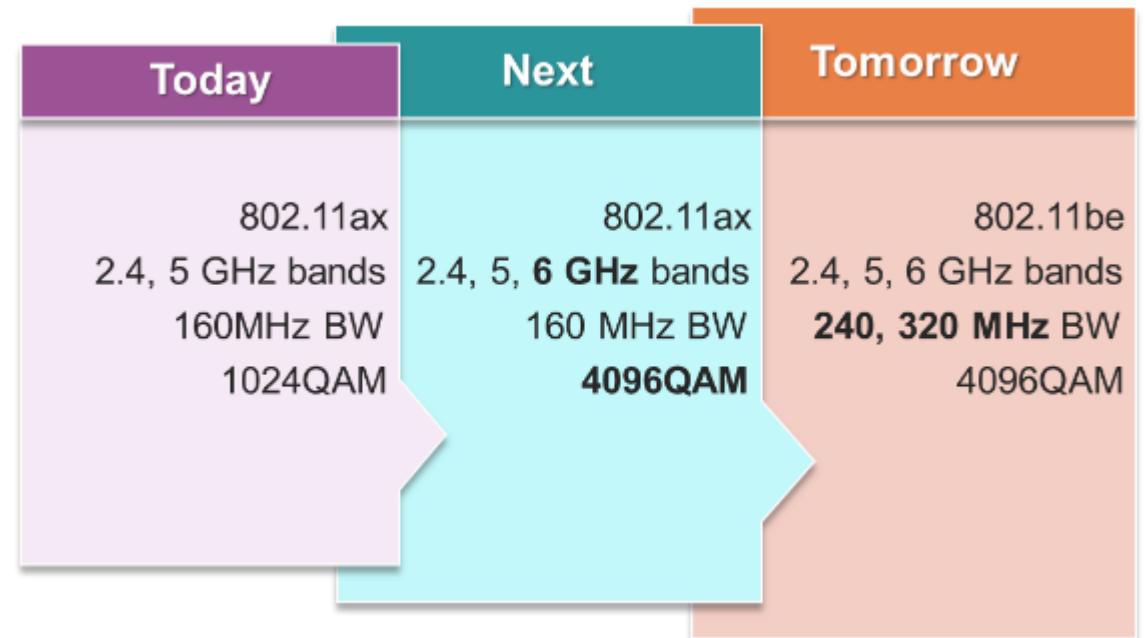
- WLAN 802.11a/b/g/n/j/p/ac/ah/ax
- Bluetooth 1.0 to 5.0
- ZigBee, Z-wave, Thread PHY
- 802.15.4, WiSUN (MR-FSK)
- Digital video, FM, Mobile WiMAX
- Multi-Satellite GNSS: GPS, Galileo, GLONASS, BeiDou, SBAS, QZSS

- NB-IoT / CAT-M

- 5G NR FR1/FR2

Future Proof for Wider Bandwidth & Frequency

- RRH to extend FR2 Band over 43.5GHz possible
- How to support 6GHz (5.925 ~ 7.125GHz) band?
- How to support 320MHz Bandwidth, e.g. 802.11be?



Introducing S8780A Wireless Device Solution

FOR WI-FI 5/6E, 802.11AX/BE, BT5.0, 2/3/4/5G



800 MHz bandwidth, 32 ports, 7.3 GHz



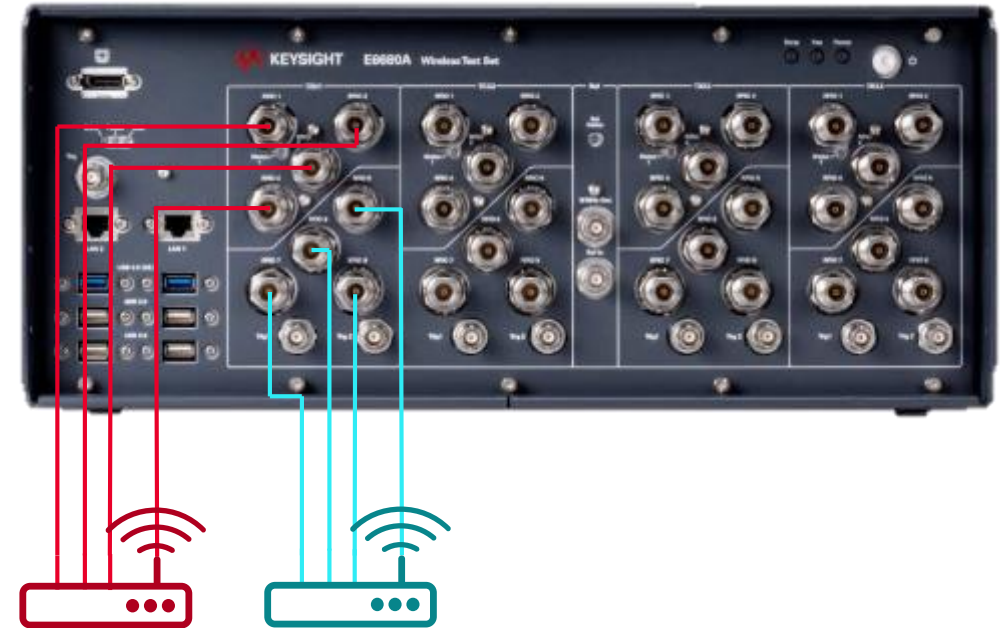
Keysight's S8780A uses new hardware, the E6680A Wireless Test Set, optimized for calibration and verification test while looking to the future with a wideband test solution for 5G NR, Wi-Fi 6E & 802.11be devices. The hardware and software support:

- ✓ 200, 400, or 800 MHz bandwidth
- ✓ 380 MHz to 7.3 GHz frequency range
- ✓ Up to 4096QAM
- ✓ MU-MIMO and OFDMA with statistics and RF performance for each user
- ✓ Up to 4x4 MIMO and 8x8 switched MIMO
- ✓ Dual-band and triple-band simultaneous testing
- ✓ Power, transmit spectral mask, spectral flatness, EVM measurements and analysis

Introducing S8780A Wireless Device Solution

MORE ADVANCED SCENARIOS FOR MULTI DEVICES

- Calibrate and verify each individual Tx and Rx path, up to eight connections
 - Maximize output power by configuring ports for half duplex
 - Maximize flexibility by configuring ports for full duplex
- Calibrate and verify up to two devices per transceiver by broadcasting on four ports and using internal switching
- Test twice as many devices per TRX



Tx test: Using internal switching through 8 ports, measure Transmit power, Transmit spectrum mask, EVM,...

Rx test: Broadcast signal on 4 ports to calibrate received power, use internal switching on the other 4 ports to measure sensitivity

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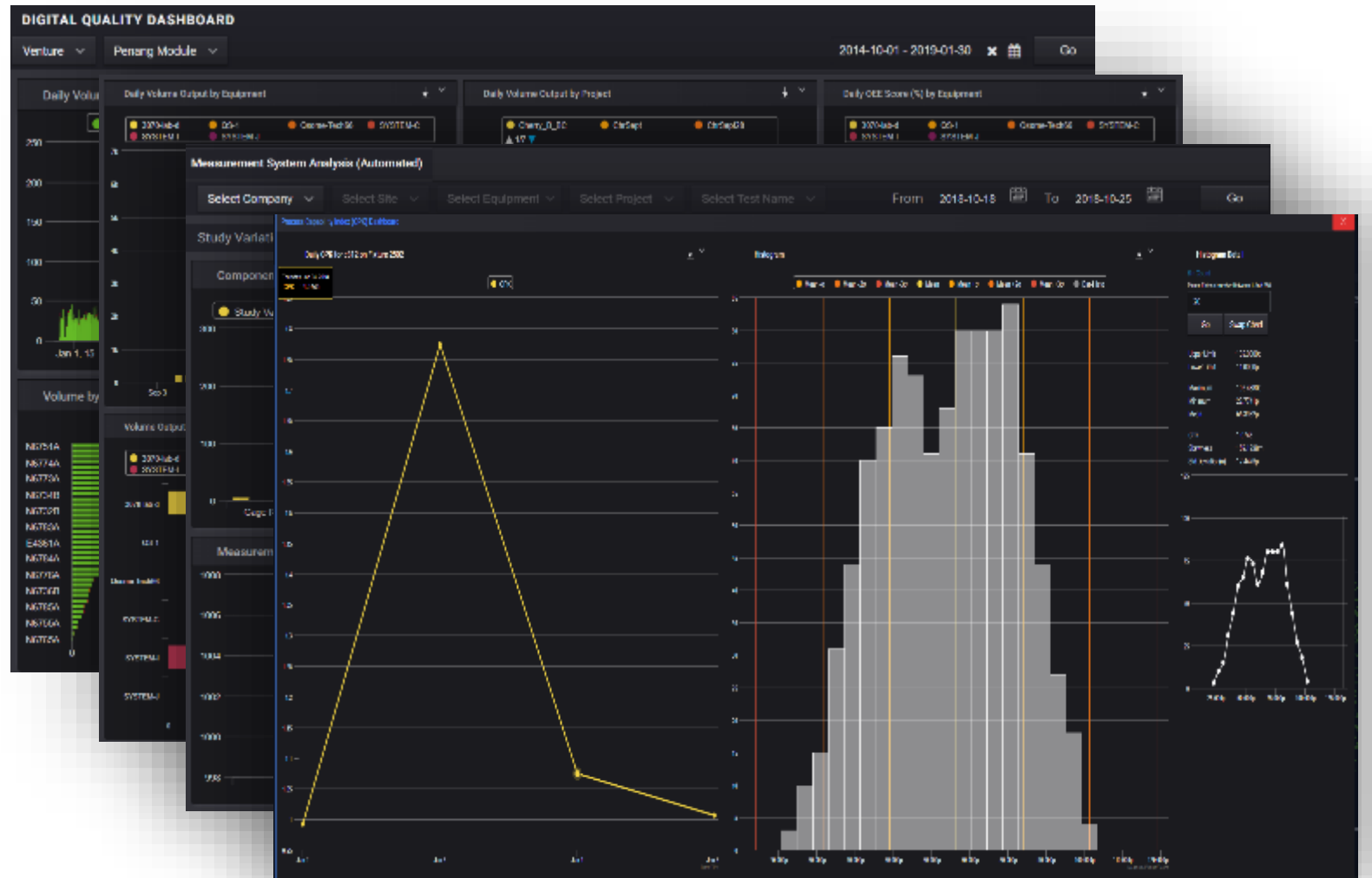
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 - More future standard, frequency bands
- **Smart Factory and Industry 4.0**

5G Device Manufacturing Test Challenges

MOVING TOWARD INDUSTRY 4.0

PATHWAVE
Manufacturing Analytics

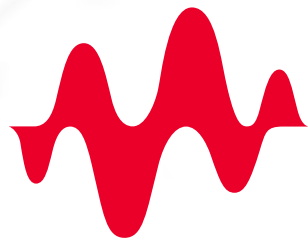
- Analytics as a Service software with Real-Time, Actionable Insights and accelerate time-to-market
- Industry 4.0 ready solution for manufacturing vision to Smart Factory
- Real time anomaly detection and predictive alert allow customer to make decision accurate and faster



Questions for 5G Device Manufacturing Test?

THANK YOU FOR PARTICIPATION

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