

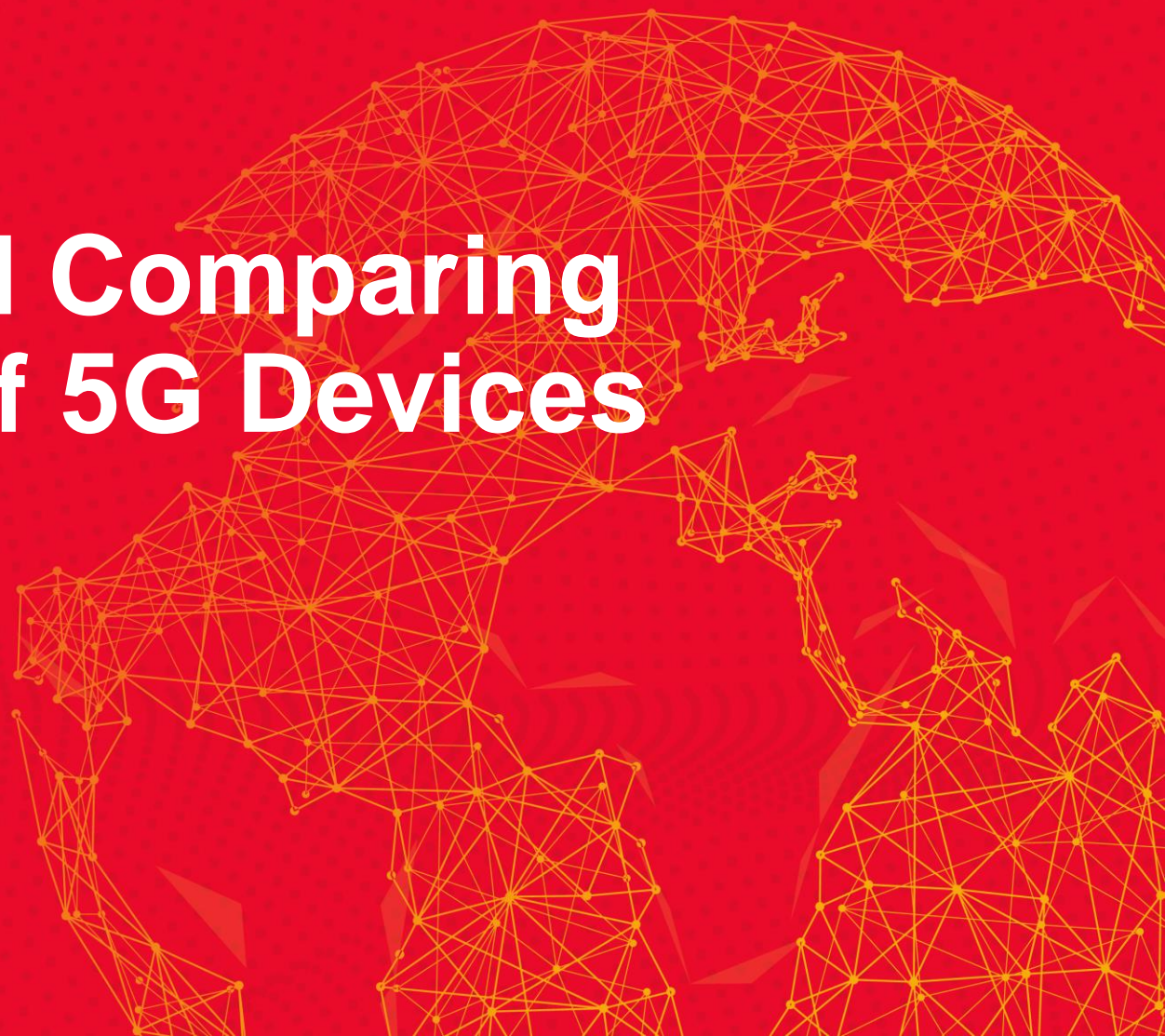


**KEYSIGHT  
WORLD 2020**

# **Benchmarking and Comparing the Performance of 5G Devices**

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## THE CHALLENGE

- Address sharp increase in demand for high speed data consumption on wireless networks
- Address growing amount of connected devices for the Internet of Things
- Extend wireless technology to new applications requiring ultra reliable low latency connections

## THE SOLUTION

The 5<sup>th</sup> Generation of wireless technology built from the ground up to address 3 main areas

## BY THE NUMBERS

Enhanced Mobile Broadband  
High data rates

**10 Gbps**

Massive Internet of Things  
Scalable and versatile for Internet of things

**1 million**  
devices per square km

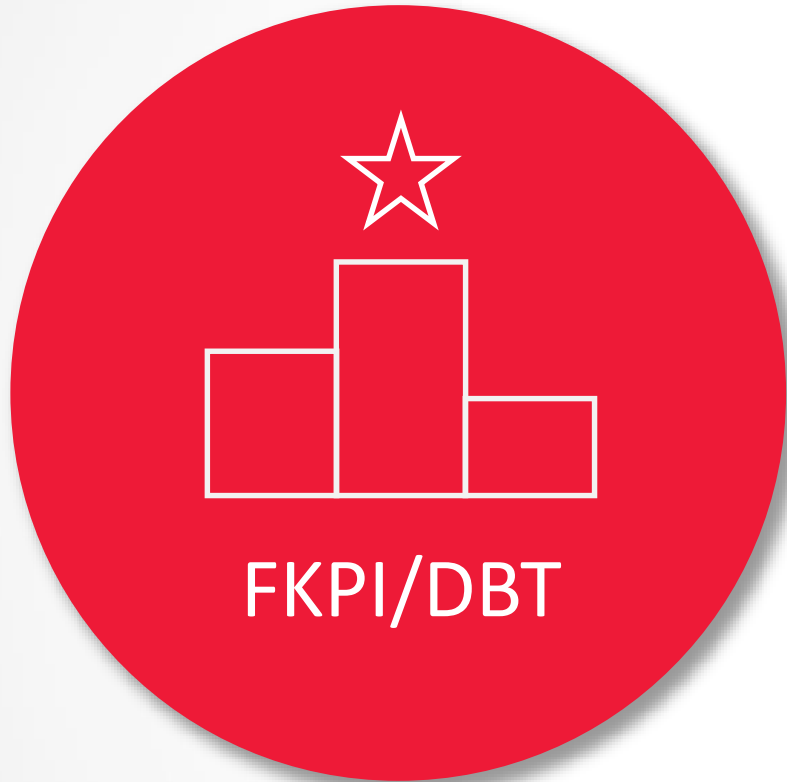
Ultra Reliable Low Latency Connections  
Fast, Secure and reliable connections

**1 ms**

The promise of  
**5G** at a glance



# Agenda



- 1 The Challenge**
- 2 5G Device Workflow Stages**
- 3 5G Performance KPIs**
- 4 Functional KPIs Solution**
- 5 Benchmarking Solution**



# The Challenge





# Challenges in 5G Device Benchmarking

Flood of new devices and frequent versions



Operator/Device Labs

How I could automate test process for daily builds to measure and follow software performance?

How can I catch concerning trends in device performance ahead of it becoming a serious problem?

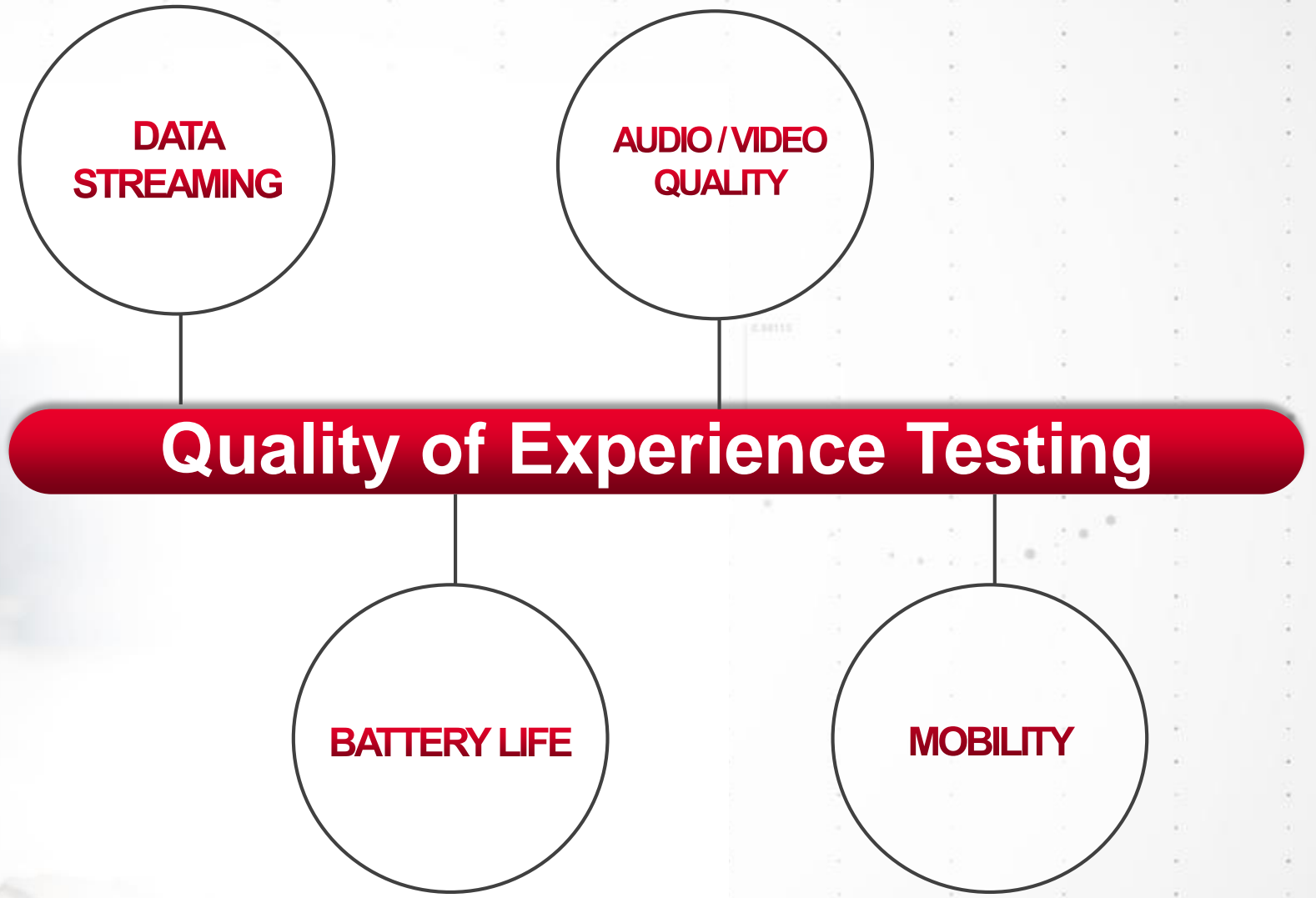
Is this new version of the device up to standard to be released to the field for testing?

How can I measure my device performance against the competitors?

How to run quick and robust set of tests and receive report and state of the device performance?



# What does this mean for users?

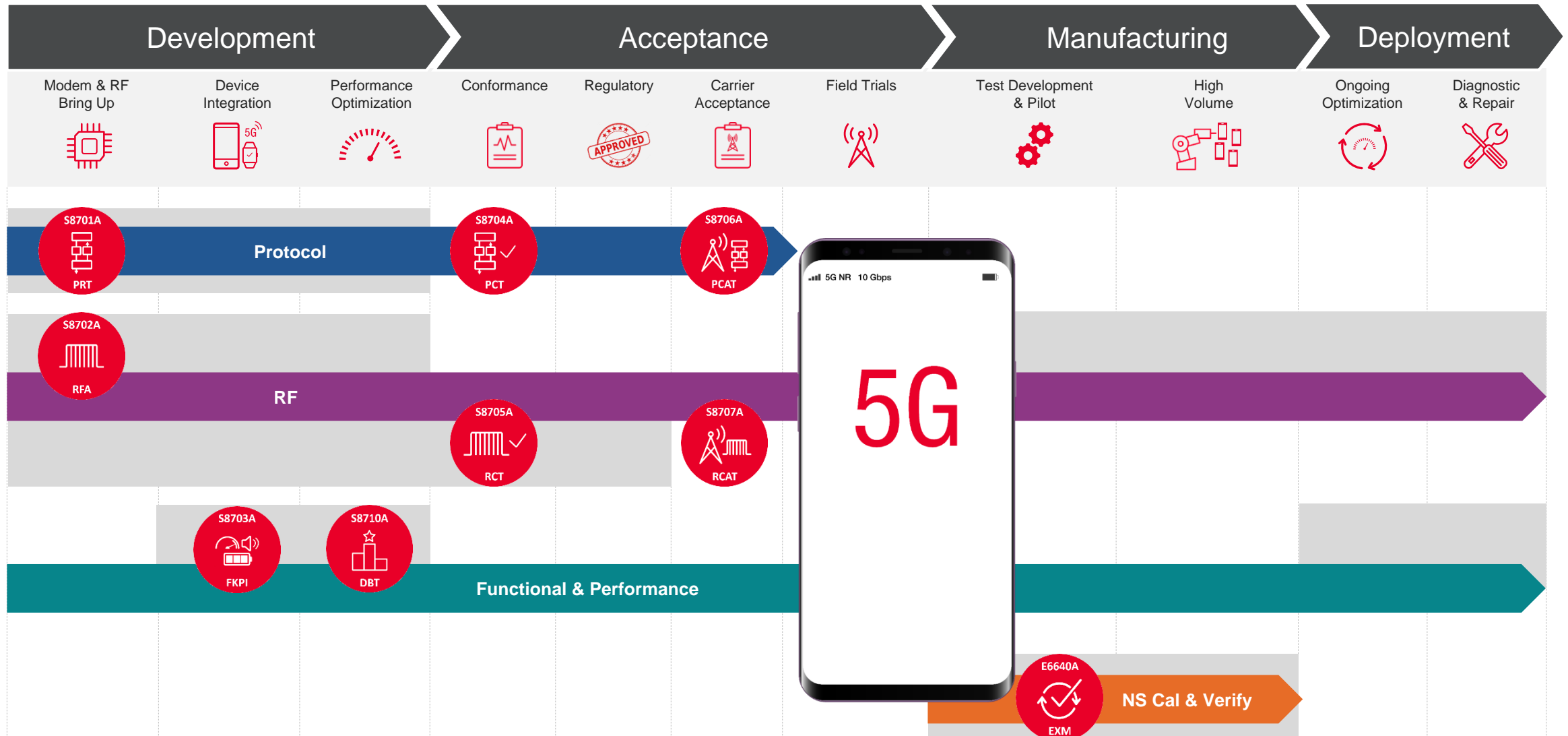


# 5G Device Workflow Stages





# 5G Device Workflow Stages





# 5G Performance KPIs



# 5G Performance KPIs

## KEY APPLICATIONS



### DATA THROUGHPUT

- Maximum data rates for 5G NR & LTE
- Verify multiple transfer protocols
- E2E receiver verification with different parameter sets in real user environment



### BATTERY LIFE

- Current drain analysis with for UE in voice and data usage.
- Battery life estimations with different usage profiles
- Simulation of scenarios in real user environment with mobility and channel emulation



### AUDIO / VIDEO

- VoNR / VoLTE
- Audio / Video quality measurements
- IMS/SIP IR-92 Compliance
- Performance testing under different network and radio conditions



### MOBILITY

- Soft / Blind Handovers – NR ↔ NR, NR ↔ LTE with call continuity
- Dual SIM test deployments
- Channel Emulation support



# Demo video – LTE full throughput test

## FUNCTIONAL KPIS MEASUREMENTS



**Video:**  
Configuration of  
Throughput session  
and modification of  
parameters during the  
test session

### Tput Key Factor

- BW
- MIMO
- MCS

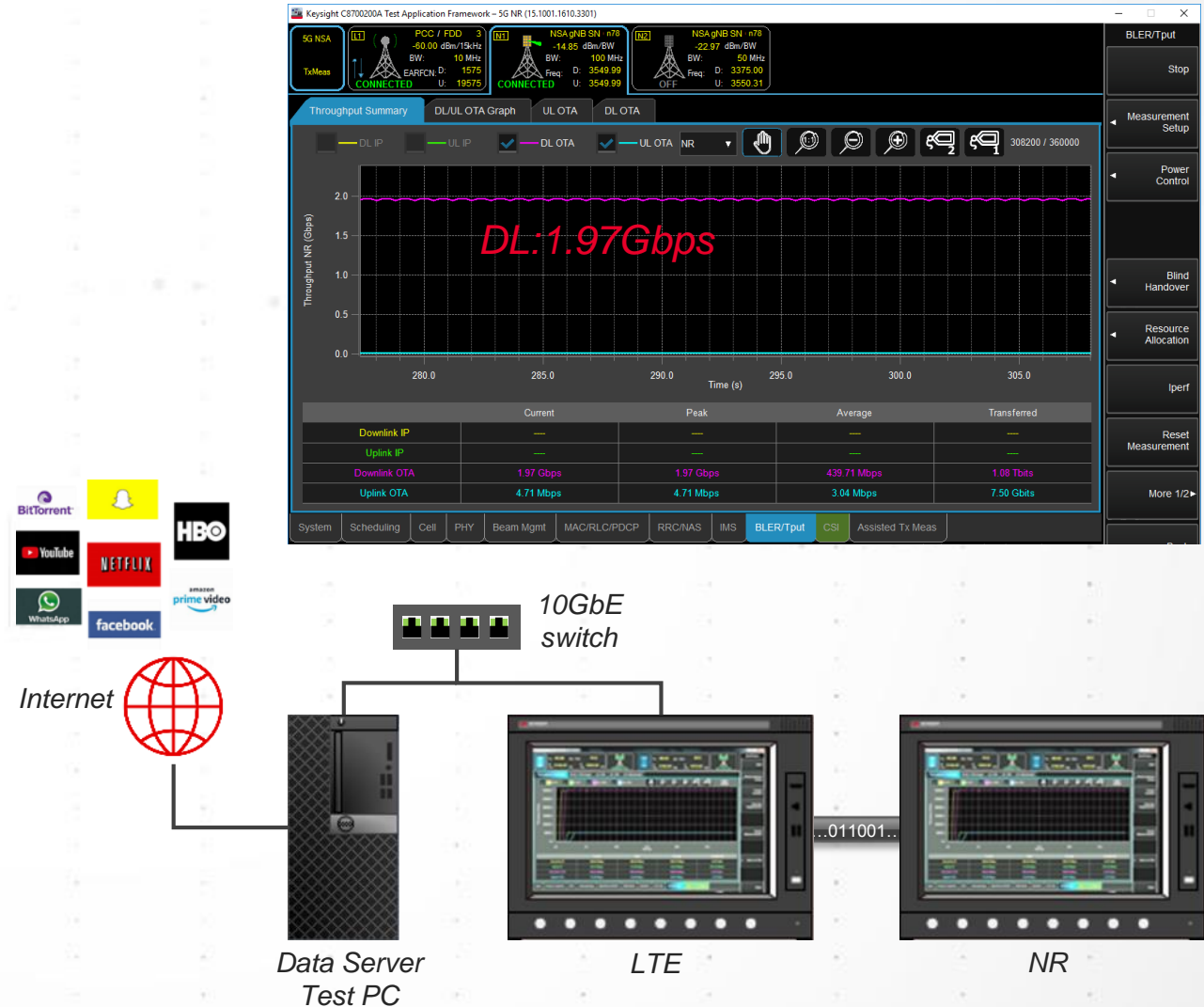


# Full Throughput Testing

## 5G PERFORMANCE KPIS MEASUREMENTS

- Benchmark 5G IP data throughput performance in a fully automated environment
- Make sure expected data rates are met in complex scenarios in both LTE and NR cells
- Verify end-to-end receiver performance for different MCS and RB
- Achieve sustained maximum data rate for most common transport protocols (FTP, TCP, UDP, ping)
- Connect to the Internet to test OTT applications (\*)

(\*) It might require 3<sup>rd</sup> party subscription (Netflix, Apple TV, HBO,...)





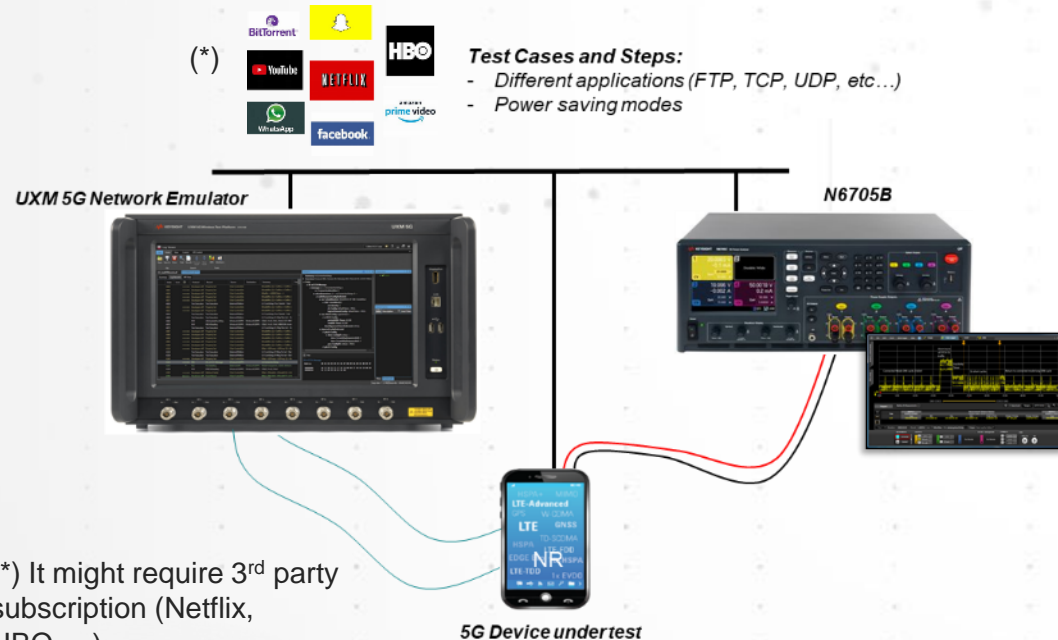
# Battery Life Evaluation

## 5G PERFORMANCE KPIS MEASUREMENTS

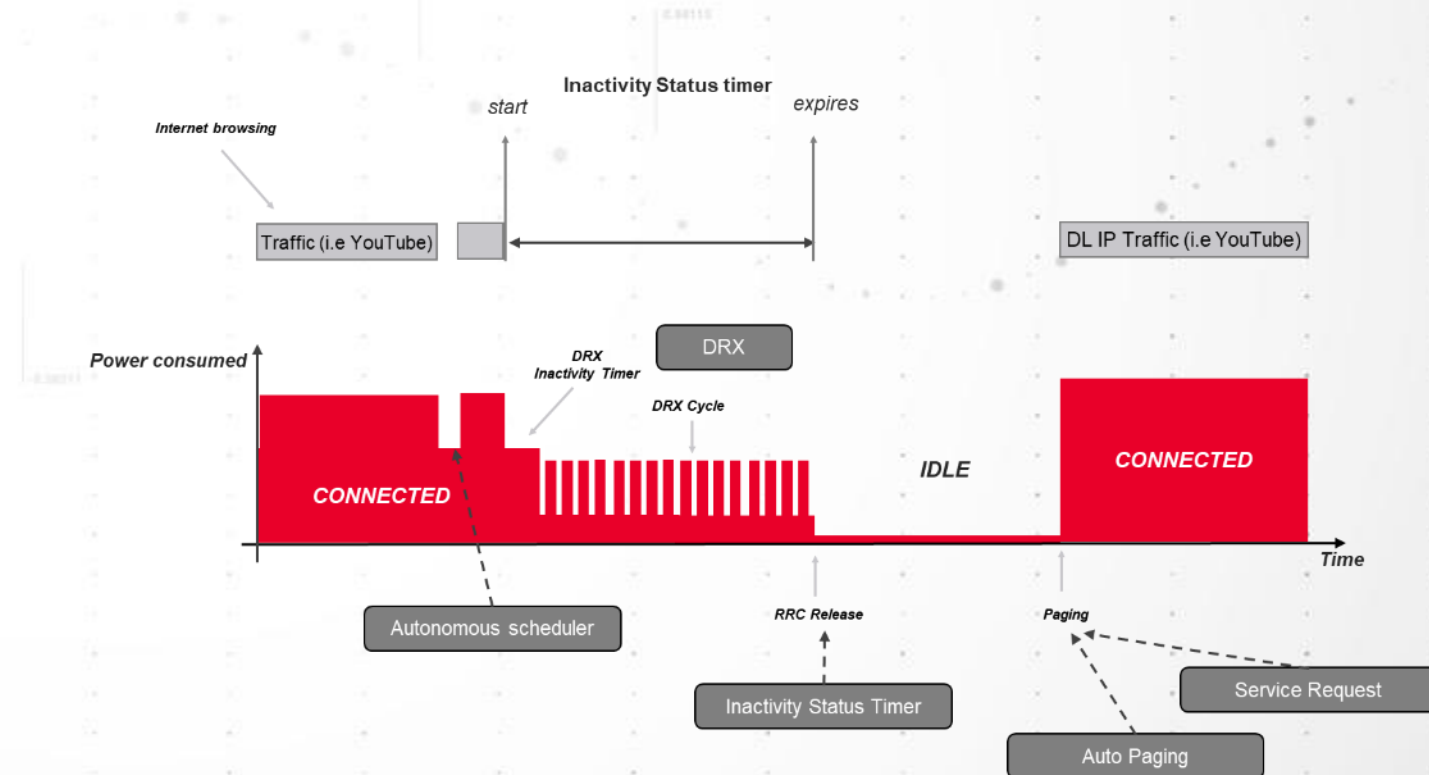


Keep the power controlled under:

- High data rate drains
- Mobility and beam-management scenarios
- Sleep and power saving modes
- File transfer
- Video streaming, www browsing



(\*) It might require 3<sup>rd</sup> party subscription (Netflix, HBO,...)

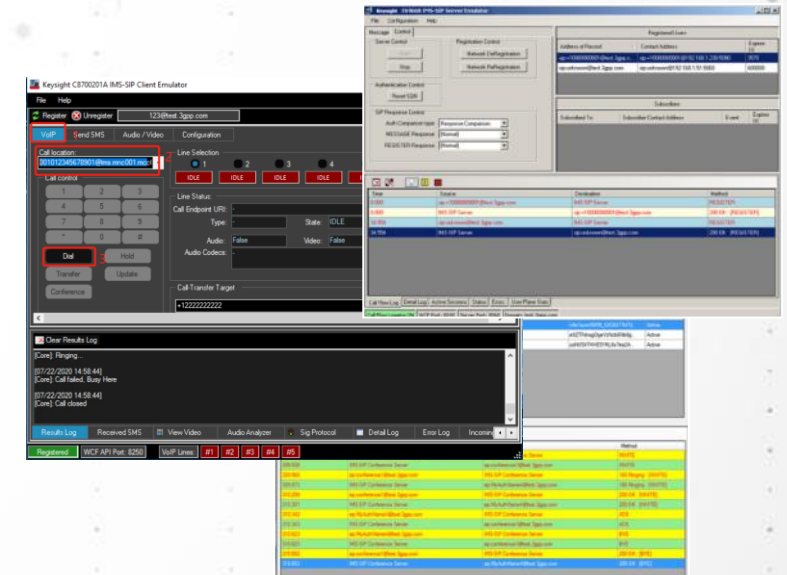


# Integrated IMS-SIP Emulation

## 5G PERFORMANCE KPIS MEASUREMENTS

IMS server integrated in the Test Application as a sub-tab, supporting detailed message summary with protocol interaction.

- Verify UE support for VoLTE complexities
  - Ipv4,Ipv4v6, Ipv6
  - Multiple Data Radio Bearers (DRB)/PDNs
  - Dedicated bearers
  - Traffic Flow Template (TFT)
- Confirm VoLTE functional performance
  - IMS registration (multiple clients) / emergency call E911
  - End-to-end voice calls (VoIP), voice echo
  - Video calls
  - SMS, AKAv2 authentication
  - Call waiting, SMS forwarding, PRACK support
  - Message Logging, error insertion
  - Supplementary services (including conference call, call waiting...)



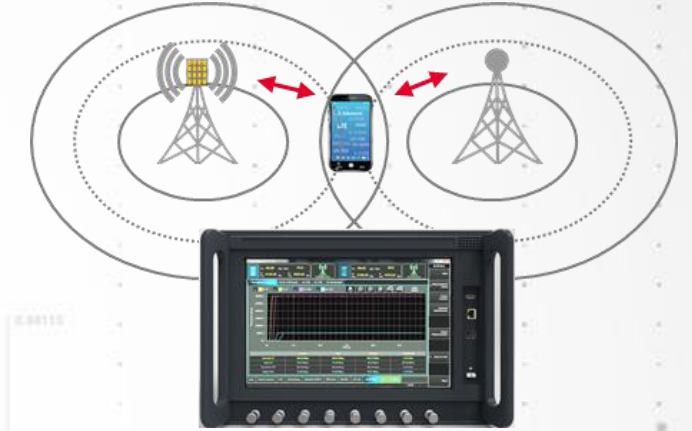
Multiple soft Clients



# Blind Handover LTE, NSA and SA

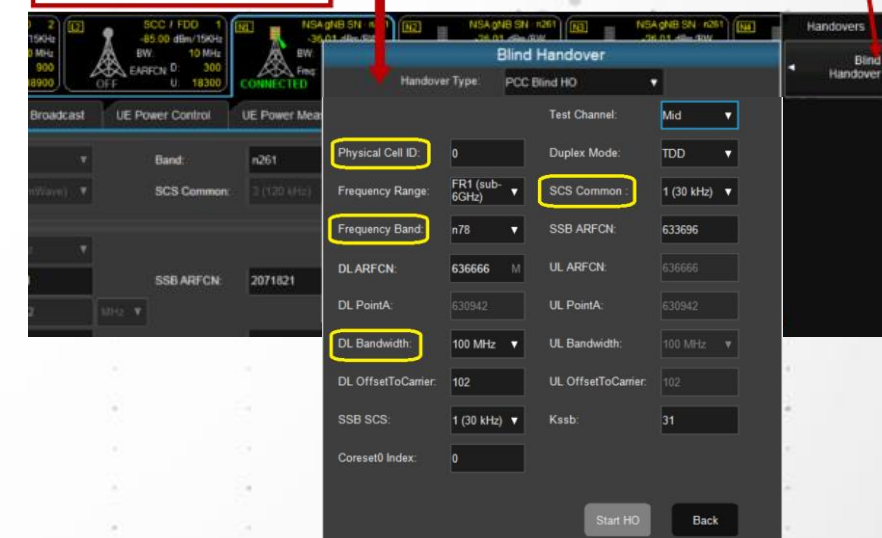
## 5G PERFORMANCE KPIS MEASUREMENTS

- Quickly sweep across all channels supported by the UE without dropping connection.
- Blind Handover is a mechanism to change basic parameters of the cell while in CONNECTED state.
- Performing a PCC Blind Handover sends an RRC Connection Reconfiguration message to tell the UE to move its PCC to a new cell.
- It is possible to do blind handover with the following parameters:
  - **LTE:** Band, EARFCN, Cell ID
  - **NR NSA:** Band, ARFCN, Cell ID
  - **NR SA:** Band, ARFCN, Cell ID



It allows to modify Band, ARFCN and PCID

Blind HO is used to quickly sweep channels in CONNECTED state.

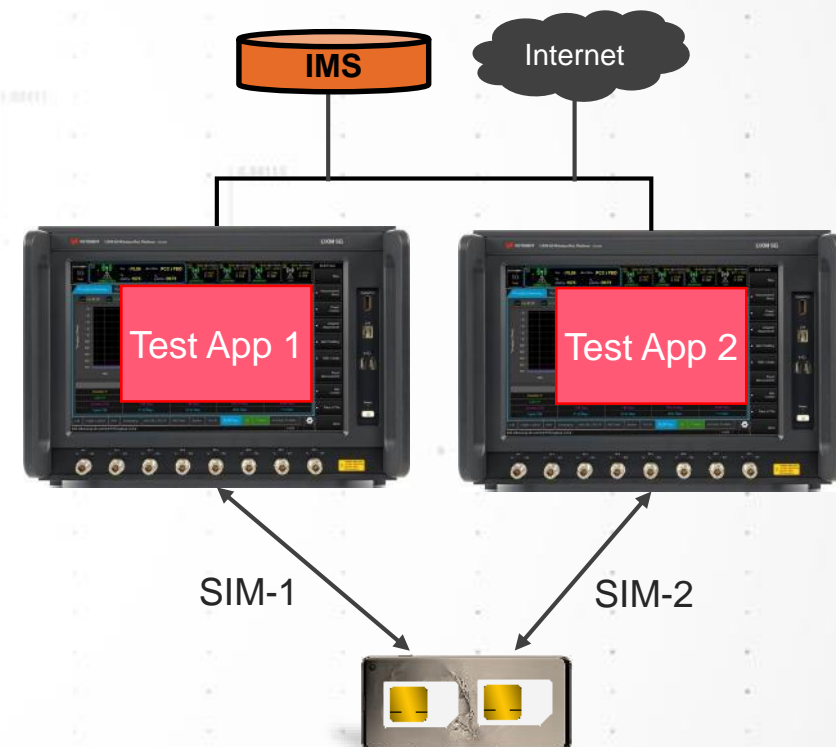


# Dual SIM Test System Deployment

## 5G PERFORMANCE KPIS MEASUREMENTS

- Two test sets with Test App running in each of them
- Each SIM connects to a different instance of the Test Application
- Each Test App can be configured as LTE, NSA or SA
- Possible to run scenarios like:

SIM1 state	SIM2 state
ATTACH	ATTACH
Data call	IDLE
Voice (VoLTE)	Data call → No service
IDLE	IDLE





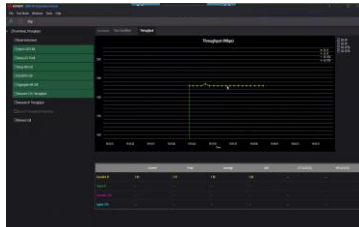
# Functional KPIs Solution



# S8703A - 5G Functional KPI Toolset

## Solution Components

UXM 5G Automation Toolset  
C8702000A



Test Application Framework  
C8700200A



Functional Test Case  
Packages  
C8703xxxA

Software

+



Test System PC  
C8801A-TPC



10Gbps Switch  
C8802B

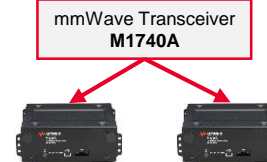


UXM 5G Network Emulator  
E7515B or E7515E

For FR1 (sub 6GHz) testing

+

2D MPAC Chamber  
Z2160A-112



mmWave Transceiver  
M1740A

Common Interface Unit  
E7770A



For FR2 (mmWave) testing



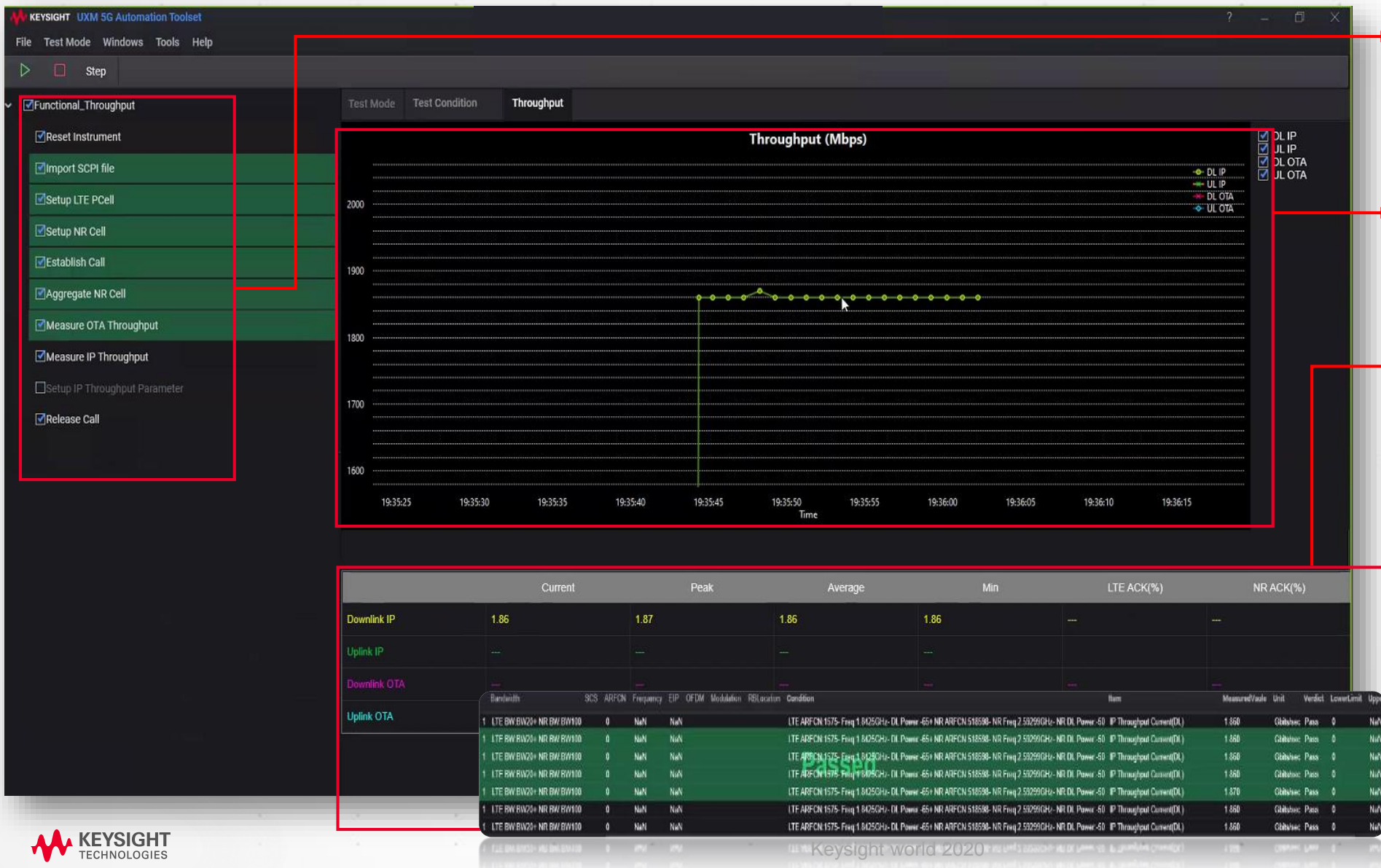
# S8703A - 5G NR Data Throughput Testing



## KEY FEATURES

- Support for 5G NR FR1 / FR2 Scenarios as well as LTE
  - Single 5G NR carrier (FR1/FR2)
  - 1CC NR + Up to 4CC LTE
- Modify test parameter sets such as bands, bandwidth, MCS values etc
- Verified maximum IP throughput rates
- Support for FTP, TCP, UDP, transfer protocols
- Pre-defined testcase for easy data throughput verification based on Iperf
- Import recorded SCPI configuration from manual testing for quick test setup
- Create bespoke scripts for user defined test scenarios

# S8703A - 5G NR Data Throughput Testing



## Test Campaign

- Add test cases into one Test Mode Condition
- Configure test conditions
- Import previously recorded SCPI files

## Test Result Graph

- Real-time throughput graphs
- Monitor UL / DL simultaneously
- IP layer and MAC layer monitoring

## Test Result List

- Scalar test results for throughput
- Pass / Fail indication
- Export results to CSV and Excel formats



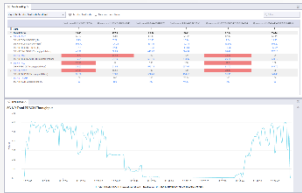
# Benchmarking Solution



# S8710A 5G Device Benchmarking Toolset (DBT)

## Software

Nemo 5G Device Analytics  
**NTL50000A**



Nemo Outdoor  
**NTA50000B**



Test Application Framework  
**C8700200A**



5G  
Nemo Active Testing  
Application (NATA)  
**NTA60209B**



## HW for FR1 (sub 6GHz) testing

UXM 5G Network  
Emulator  
**E7515B**



Test System PC  
**C8801A-TPC**



1Gbps Switch  
**C8803A**



10Gbps Switch  
**C8802B**



Data Server PC  
**C8801A-DPC**



## Upgrade to FR2 (mmWave) testing

2D MPAC Chamber  
**Z2160A-1A5 (1 AoA)**



mmWave Transceiver  
**M1740A**



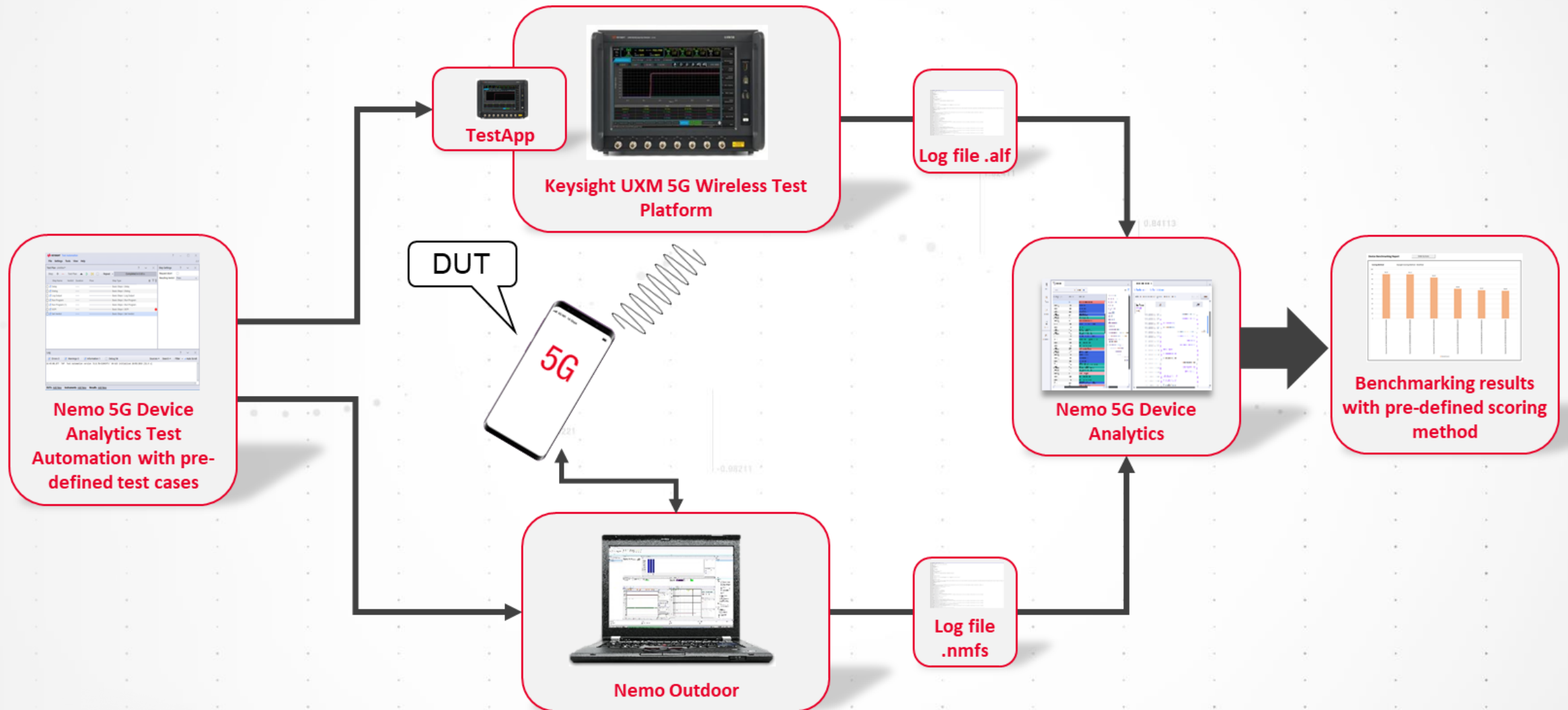
x2 for 1 AoA

Common Interface Unit  
**E7770A**

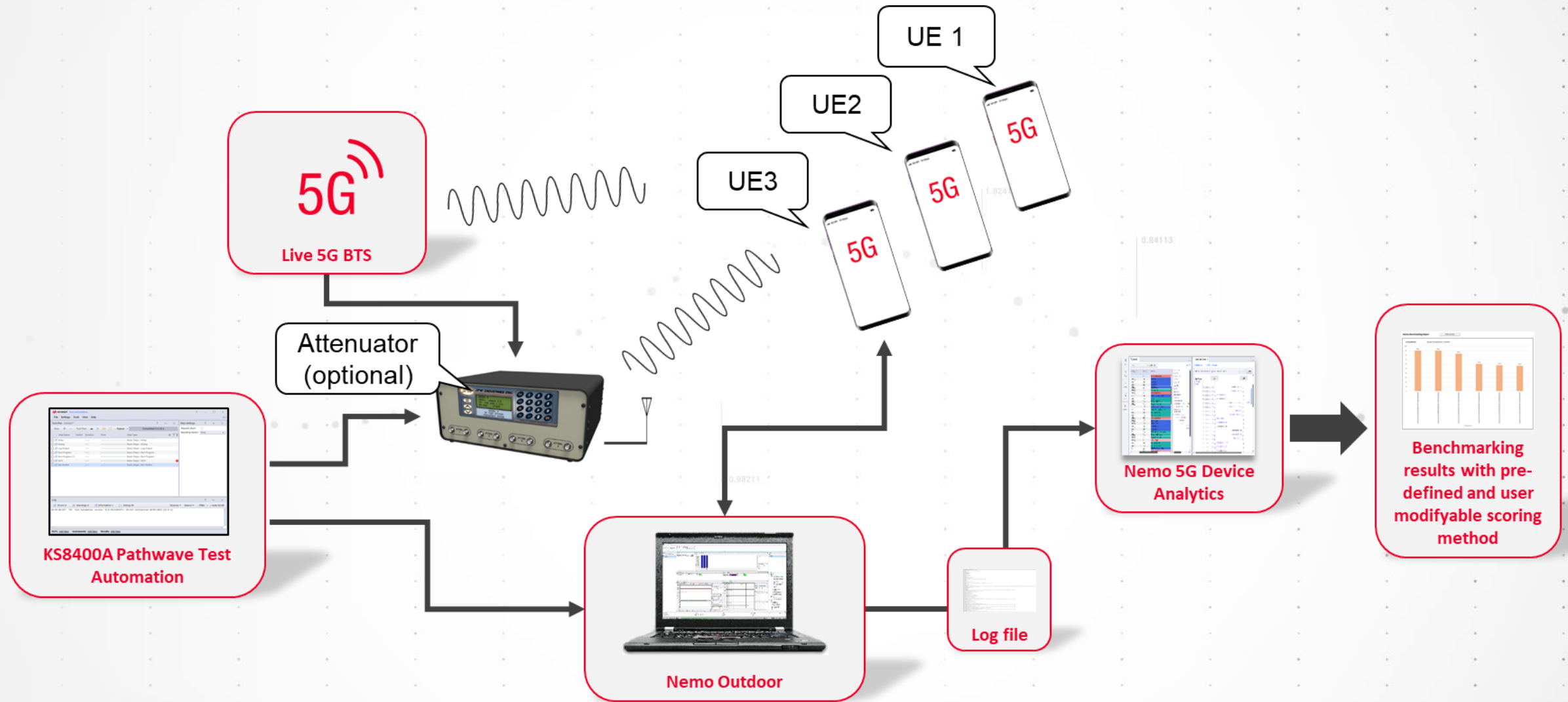




# 5G DBT with UXM 5G – High Level Setup Diagram

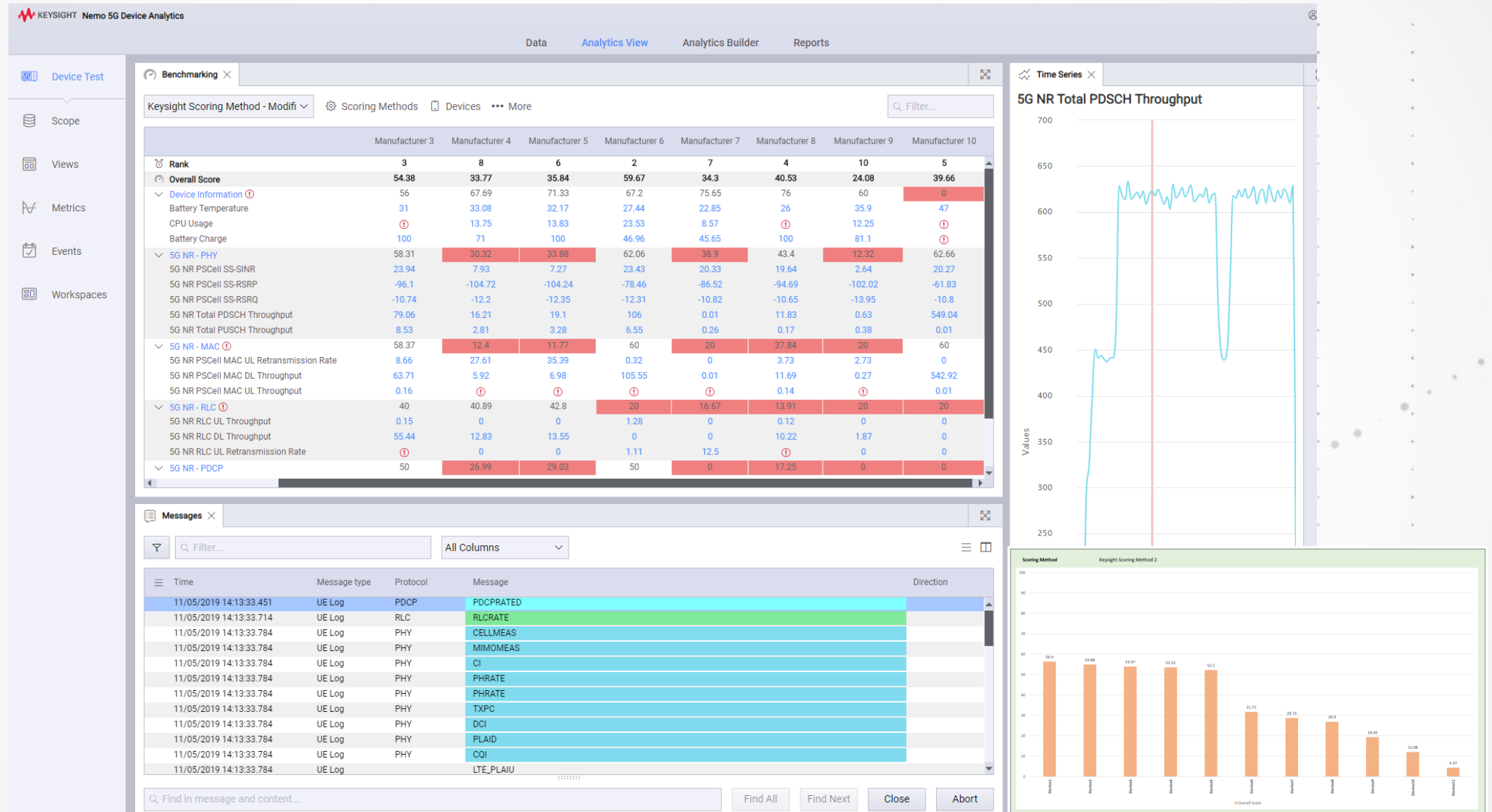


# 5G DBT with live BTS – High Level Setup Diagram





# 5G DBT User interface



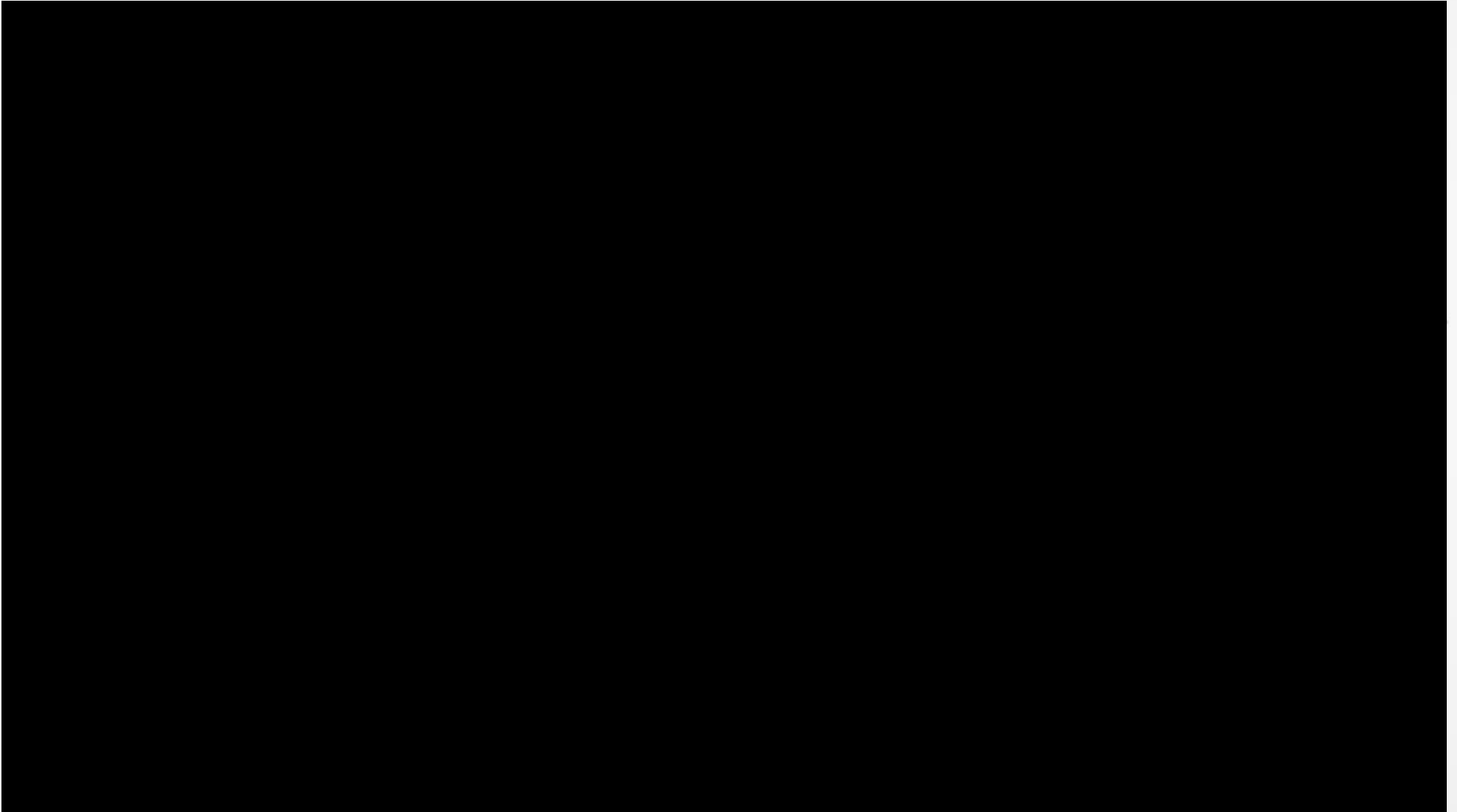
# 5G DBT Report

Device Information	Qualcomm-UE-86442104	Qualcomm-UE-86484404	Qualcomm-UE-86442104	Qualcomm-UE-35553510	Qualcomm-UE-35733510	Qualcomm-UE-35553510				
Chipset	Qualcomm	Qualcomm	Qualcomm	Qualcomm	Qualcomm	Qualcomm				
Device Label	OnePlus 5G	ZTE 5G		ATT2		ATT1				
IMEI	864421040032578	864844040000305	864421041255533	355535100250840	357335100148195	355535100256706				
IMSI	244052163699900	244052162368368	244052163510018	310410208311527	311480498149251	310410191558794				
Rank	1	2	3	4	5	6				
Overall Score	90,33	90,12	83,34	60,66	57,57	56,54				
5G NR - PHY	61,33	60,49	65,92	55,08	52,32	55,37				
5G NR PSCell SS-SINR	67,52	64,05	59,75	44,66	24,51	47,51				
5G NR PSCell SS-RSRP	39,11	38,38	65,2	30,74	37,07	29,36				
5G NR PSCell SS-RSRQ	0	0	4,67	0	0	0				
5G NR Total PDSCH Throughput	100	100	100	100	100	100				
5G NR - MAC	100	100	100	20,52	22,22	14,77				
5G NR PSCell MAC DL Throughput	100	100	100	20.52	22.22	14.77				
5G NR - RLC	Device Information		Agg.	Unit	Qualcomm-UE-86442104	Qualcomm-UE-86484404	Qualcomm-UE-86442104	Qualcomm-UE-35553510	Qualcomm-UE-35733510	Qualcomm-UE-35553510
5G NR RLC DL Throughput	Chipset				Qualcomm	Qualcomm	Qualcomm	Qualcomm	Qualcomm	Qualcomm
5G NR - PDCP	Device Label				OnePlus 5G	ZTE 5G		ATT2		ATT1
5G NR PDCP DL Throughput	IMEI				864421040032578	864844040000305	864421041255533	355535100250840	357335100148195	355535100256706
5G NR - Events	IMSI				244052163699900	244052162368368	244052163510018	310410208311527	311480498149251	310410191558794
5G NR RACH Success Rate	Rank				1	2	3	4	5	6
	Overall Score				90,33	90,12	83,34	60,66	57,57	56,54
	5G NR - PHY									
	5G NR PSCell SS-SINR	AVG	dB	12,53	11,73	10,74	7,27	2,64	7,93	
	5G NR PSCell SS-RSRP	AVG	dBm	-101,31	-101,57	-92,18	-104,24	-102,02	-104,72	
	5G NR PSCell SS-RSRQ	AVG	dB	-12,23	-12,02	-11,58	-12,35	-13,95	-12,2	
	5G NR Total PDSCH Throughput	MAX	Mbps	612,67	707,16	596,99	68,99	68,44	46,88	
	5G NR - MAC									
	5G NR PSCell MAC DL Throughput	MAX	Mbps	581,46	670,12	513,47	24,49	26,11	19,04	
	5G NR - RLC									
	5G NR RLC DL Throughput	MAX	Mbps	573,15	645,75	657,67	61,05	31,79	36,07	
	5G NR - PDCP									
	5G NR PDCP DL Throughput	MAX	Mbps	568,63	648,43	494,58	57,83	31,96	35,88	
	5G NR - Events									
	5G NR RACH Success Rate	AVG	%	100	100	97,67	100	100	100	



# Demo video – S8710A 5G DBT

BENCHMARKING SOLUTION



# Summary

## ACCELERATING PERFORMANCE VALIDATION

- Automation testing and reporting across different device builds and models
- Consistent process, reducing engineering test time and manual processing/errors
- Benchmarking against golden devices or competitor devices



## END-TO-END ENVIRONMENT FOR BENCHMARKING DEVICES

- Performance under different, and repeatable, emulated real-world operating scenarios
- Real-time KPI reporting from network emulator and device under test



## INTUITIVE, FRIENDLY AND DATA RICH GUI

- Application layer KPIs and adjustable scoring methods
- Chipset agnostic pre-defined KPI tests and ranking report templates
- Enables issues debugging and enhance product quality



## CUSTOMER SUPPORT

- Faster reaction to customer reported issues
- Increased customer satisfaction and reduced churn







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