Validate 5G End-to-End Performance by Virtual Drive Testing Toolset

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Agenda

- Release 15 Basics
- Common Functional Test
 - Max Throughput Testing
 - UL Duty Cycle- Dynamic TDD
 - BWP switch
 - IP data Throughput. Split bearer
 - VoLTE/VoNR
 - Mobility
- Real environment testing- Virtual Drive Testing Toolset



Release 15 Basics



5G Scenarios and Use Cases

Broad range of new services and connectivity paradigms

Courtesy of METIS: 2014





3GPP NR Rel-15 Scope

3GPP NR ROADMAP & INTRODUCTION

- Acceleration of <u>eMBB Non-Standalone mode</u> by December'17
 - Standalone standardization dates as expected (June'18)
- Use cases:
 - Enhanced Mobile Broadband (eMBB)
 - Ultra Reliable Low Latency Communications (URLLC)
- Carrier aggregation operation
- Inter-RAT mobility between NR and E-UTRA

IN SCOPE

- Frequencies beyond 52.6 GHz
 - Other types of waveforms
- mMTC Machine type communications
- Internetworking with non-3GPP systems (e.g. WiFi)
- Vehicular communications
- Multicast services and multimedia broadcast
- Unlicensed spectrum access

OUT OF SCOPE



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Max Throughput Testing



Numerology Definition

WAVEFORM, NUMEROLOGY AND FRAME STRUCTURE

Scalable subcarrier spacing

$$\Delta f = 2^{\mu} \cdot 15 \ kHz$$

- Parameters defining a numerology:
 - Subcarrier spacing (i.e. µ parameter)
 - Cyclic prefix (i.e. Normal/Extended)

	μ	Δf = 2 ^μ ·15 kHz	Cyclic Prefix	
Sync	0	15 kHz	Normal	
< 6 GHz	1	30 kHz	Normal	∽ Data < 6 GHz
	2	60 kHz	Normal, Extended	
Sync	3	120 kHz	Normal	\sim Data > 6 GHz
> 6 GHz	4	240 kHz	Normal	

RFE: 3gpp 38.300-200 Table 5.1-1Ref : 3GPP TS 38.211 4.2 URLLC



Physical Resources

WAVEFORM, NUMEROLOGY AND FRAME STRUCTURE

- Resource elements are grouped into Physical Resource Blocks (**PRB**)
- Each PRB consists of **12 subcarriers**

μ	Δf	$N_{RB}^{min,\mu}$	$N_{RB}^{max,\mu}$
0	15 kHz	20 (240 subcarriers)	275 (3300 subcarriers, 49.5 MHz)
1	30 kHz	20	275 (3300 subcarriers, 99 MHz)
2	60 kHz	20	275 (3300 subcarriers, 198 MHz)
3	120 kHz	20	275 (3300 subcarriers, 396 MHz)
4	240 kHz	20	138



Numerology Example (Normal CP)



- Each symbol length (including CP) of 15 kHz equals the sum of the corresponding 2^{μ} symbols at F_s
- Other than the first OFMD symbol in every 0.5 ms, all symbols within 0.5 ms have the same length



Throughput Comparison

LTE VS NR FR1

- LTE 20MHz 4x4 256QAM: 395Mbps
- NR 20MHz FDD Band 4x4 256QAM: 423Mbps
- NR 100MHz FDD Band 4x4 256QAM: ~2100Mbps....No such BW available
- NR 100MHz TDD Band 4x4 256QAM: ~2100Mbps but need to split onto DL and UL
- n78C 200MHz? More inter-band CA to get more BW



Throughput Comparison

NR FR1 VS NR FR2

• NR FR1 100MHz vs NR FR2 100MHz



Max Throughput Testing

- Throughput per BW improvement from LTE to NR is not a lot
- NR higher Throughput can be achieved from high aggregated BW- n41,n78,n79,n257,n261...
- Throughput/BW for FR1 and FR2 is about the same
- For TDD, we are interested in Max DL and UL Throughput test
- NSA have the Throughput from LTE+NR



1-2.50221

UL Duty Cycle- Dynamic TDD



Slot Format Indication

WAVEFORM, NUMEROLOGY AND FRAME STRUCTURE

- Slot Format Indication informs the UE whether an OFDM symbol is *Downlink*, *Uplink* or *Flexible*
- SFI can indicate link direction over one or many slots (configured through RRC)
- The SFI carries an index to a pre-configured UE-specific table (configured through RRC)
- SFI can be either:
 - Dynamic (i.e. through a DCI)
 - UE assumes there is no conflict between dynamic SFI and DCI DL/UL assignments
 - Static or semi-static (i.e. through RRC)

tdd_UL_DL_ConfigurationCommon enabled => Static/semi-static tdd_UL_DL_ConfigurationCommon disabled => dynamic

Quick Config	D UL-DL Config	Scheduling Map	Slot Config Mi								
Use same TDD pattern on all cells: FR2 Only											
Common Pattern Configuration											
✓	Enable Pattern 1		Reference SCS (µref								
Pattern 1			1								
Tx Periodicity (P):	5 ms 🔻										
DL Slots (d _{slots}):	7	UL Slots (u _{siots}):	2								
DL Symbols (d _{sym}):	6	UL Symbols (u _{sym}):	4								
d _{stots} = 7	d _{sym} = 6	u _{sym} = 4	u _{slots} = 2								
	•	• • •	•••								
	P =	5 ms									

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5G NR Slots Formats

TS 38.211 TABLE 4.3.2-3: SLOT FORMATS

D: Downlink symbol U: Uplink symbol X: Flexible symbol

Format						Symbo	ol num	ber in a	a slot						04		-	-	-	-	-	D	D	-	-	-	X		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	31	D	D	D	D	D	D	D	D	D	D	D	X	U	U
0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	32	D	D	D	D	D	D	D	D	D	D	X	X	U	U
1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	33	D	D	D	D	D	D	D	D	D	X	X	X	U	U
2	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	34	D	X	U	U	U	U	U	U	U	U	U	U	U	U
3	D	D	D	D	D	D	D	D	D	D	D	D	D	Х	35	D	D	X	U	U	U	U	U	U	U	U	U	U	U
4	D	D	D	D	D	D	D	D	D	D	D	D	Х	Х	36	D	D	D	X	U	U	U	U	U	U	U	U	U	U
5	D	D	D	D	D	D	D	D	D	D	D	Х	Х	Х	37	D	X	X	U	U	U	U	U	U	U	U	U	U	U
6	D	D	D	D	D	D	D	D	D	D	Х	Х	Х	Х	38		D	X	X	U	U	U	U	U	U	U	U	U	U
7	D	D	D	D	D	D	D	D	D	Х	Х	Х	Х	Х	39	D	D	D	X	X	0	U	U	U	0	U	U	U	U
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9	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	U	U	41	D	D	X	X	X	U	U	U	U	U	U	U	U	U
10	Х	U	U	U	U	U	U	U	U	U	U	U	U	U	42	D	D	D	X	X	X	U	U	U	U	U	U	U	U
11	Х	Х	U	U	U	U	U	U	U	U	U	U	U	U	43	D	D	D	D	D	D	D	D	D	X	X	X	X	U
12	Х	Х	Х	U	U	U	U	U	U	U	U	U	U	U	44			D		D	D	X	X				<u> </u>	U	
13	Х	Х	Х	Х	U	U	U	U	U	U	U	U	U	U	45		D	D	D	D	D	X	X	U	U	U	U	D	U
14	Х	Х	Х	Х	Х	U	U	U	U	U	U	U	U	U	46		D	D	D	D	D	X	D	D	D	D	D	D	X
15	Х	Х	Х	Х	Х	Х	U	U	U	U	U	U	U	U	47		D	D	D	D	X	X	D	D	D	D	D	X	X
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22	D	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	U	U	55			V							v				
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24	D	D	D	Х	Х	Х	Х	Х	Х	Х	Х	Х	U	U	57					V	V	0					V	V	
25	D	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	U	U	U	50			V	V	^		0			V	V	~		
26	D	D	Х	Х	Х	Х	Х	Х	Х	Х	Х	U	U	U	50		V	×		0	0	0		U Y	×				
27	D	D	D	Х	Х	Х	Х	Х	Х	Х	Х	U	U	U	59		×	×	v	v	v	0	D	×	×	V	V	V	
28	D	D	D	D	D	D	D	D	D	D	D	D	Х	U	61			×	×	×	X		D		×	×	×	X	11
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Ref: 3GPP TS 38.211 Table 4.3.2-3



BWP switch

A. SU22



Bandwidth Adaptation / Bandwidth Part





Example of Bandwidth Part Operation

BANDWIDTH PARTS config for PCell BWP # 1 BWP # 2 PCell BWP switch by BWP switch by DCI DCI **BWP # 1** BWP # 1 BWP RRC-layer config Initia BWP SSB BWP # 2 BWP config for SCell BWP#1 BWP # 2 SCell BWP # N. **BWP # 1** BWP # 1 BWP switch by BWP switch by Scell Activation DCI DCI CONNECTED Initial Access Single Multiple Activated Cells Activated 5G Test Seminar Cell © Copyright 2020: Keysight Technologies, Inc.



IP data Throughput. Split bearer





NSA split bearer

- PDCP split bearer
- Split ratio. BSI method.
- Challenge in NR split bearer



VoLTE/VoNR

A. SU22





• in NR split bearer



Mobility

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Show different example for mobility case

• in NR split bearer



Real environment testing- Virtual Drive Testing Toolset



5G Device Performance Challenges











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5G Device Performance Challenges



Benchmark Device Performance in Field Conditions

- Benchmark devices (UE's) performance in repeatable and realistic field conditions
- Validate device (UE) in MNO specific signaling and radio channel environment
- Verify Device (UE) operation in advanced mobility scenarios such as High-Speed Train



Ready and Validated Tests

- Stress test of Device (UE) against measured field conditions in repeatable and controlled test environment
- Run verified test cases and access the quick KPI metrics with confidence for decision making
- Verify Device (UE) maximum data throughput performance and mobility under real world fading and signaling conditions
- Debug Device performance in multiple test runs under rapidly changing RF channel and signaling conditions recorded in different locations around the world









Detailed Data from Live network

- Channel Modelling
 - RSRP
 - 5G NR Channel Impulse Response
 - GPS data
- Signaling
 - Layer 3/RRC signaling
 - NR + LTE handovers



	Participant Company and Company an	Layer 3/ F	IRC Messages - 1	I. Histicon Bal	ong 2000 🗠 🛛		
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Supported Tests

- The flexible and user-friendly UI enables effective testing for users with different levels of experience
 - Push button solution to replicate field scenario
 - Customization options for advanced users
- Virtual Drive Test builds on top of Keysight's NEMO field testing tools and global presence.
- Test case customizing is possible with state of the art signaling and channel modelling tools available for UXM and PROPSIM
 - Protocol R&D Toolset for network signalling script create/edit.
 - PROPSIM Geometric Channel Modeling tool for spatial (CDL, Umi/Uma) 3D models
- Capabilities for effective benchmarking to speed up the time-to-revenue of new 5G NR devices.

-84.7 dBm 50.0 km/h 5G Test Seminar RSRP Mobile Speed © Copyright 2020: Keysight Technol



Network Operator Test Plans

FIRST CLASS PERFORMANCE

- High performance in an advanced propagation environment set the first class of network operators
 - Verify new devices prior to market launch
 - Assure device and software interoperability
- Keysight can help network operators to benchmark success in real-world implementations
 - show case network segments, such as high-speed train.
 - Launch test plans based on field tests in the selected network segments.





VDT 5G NR TC-01: Urban City test cases (NSA FR1)

Test Case Package

- Network operators have unique configurations.
 - Validate device combability and performance in different network signaling configurations
 - Network site planning and geography results result in varying Radio Channel Conditions
- Test scenarios resembling the conditions of typical urban areas in different parts of the world. test case package including the following groups of tests:
 - Urban city in Europe
 - City centers in US
 - Highways in US
 - Downtown with skyscrapers in Asia





KEYSIGHT TECHNOLOGIES

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