#THINKSIX 6G

3GPP TODAY AND INTO THE FUTURE

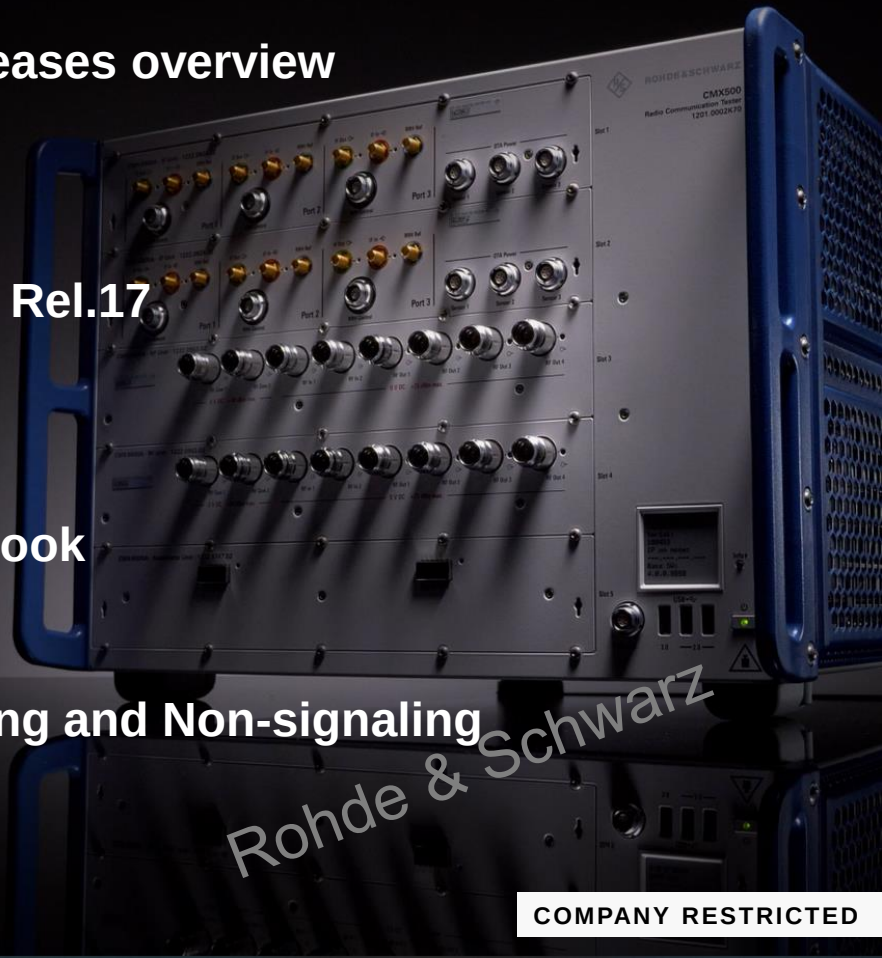
A TECHNICAL OVERVIEW OF R16, 17, 18 AND BEYOND

ROHDE&SCHWARZ

Make ideas real

AGENDA

1. 3GPP Releases overview
2. Rel.16 and Rel.17
3. Rel.18 outlook
4. 5G Signaling and Non-signaling solution



INTRODUCING 3GPP

- The original scope of 3GPP (1998) was to produce Technical Specifications and Technical Reports for a 3G Mobile System based on evolved GSM core networks and the radio access technologies that they support (i.e., Universal Terrestrial Radio Access (UTRA) both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes).
- The scope was subsequently amended to include the maintenance and development of the Technical Specifications and Technical Reports for evolved 3GPP technologies, beyond 3G.
- The 3GPP production of specifications and studies (TRs) are contribution-driven, by member companies, in Working Groups and at the Technical Specification Group (TSG) level.

3GPP Groups Home			
Core Network & Terminals (CT)	Radio Access Networks (RAN)	Service & System Aspects (SA)	Project Coordination Group (PCG)
CT WG1	RAN WG1	SA WG1	Closed Groups
CT WG3	RAN WG2	SA WG2	
CT WG4	RAN WG3	SA WG3	
CT WG6	RAN WG4	SA WG4	
	RAN WG5	SA WG5	
	RAN AH1	SA WG6	

INTRODUCING 3GPP

- The 3GPP Organizational Partners – from Asia, Europe and North America – determine the general policy and strategy of 3GPP

- The 3GPP Organizational Partners may invite a Market Representation Partner to take part in 3GPP

5G NR TECHNOLOGY EVOLUTION

LTE LTE Advanced LTE Advanced Pro

5G ADVANCED

5G NR Phase 1

| April 2019

1st 5G NR networks (FR1, FR2) launched; focus: eMBB

5GACIA

| June 2020

3GPP Release 16 (5G Phase 2); focus: two market verticals

5GAA Automotive Association

| June 2022

3GPP Release 17 (5G Phase 2+); focus: NTN, NR RedCap, FR2-2

| March 2024

3GPP Release 18 5G Advanced; focus: XR, AI, Energy Saving, …

5G is a marathon, not a 100 m sprint…

2018 2020 2022 2024 2026

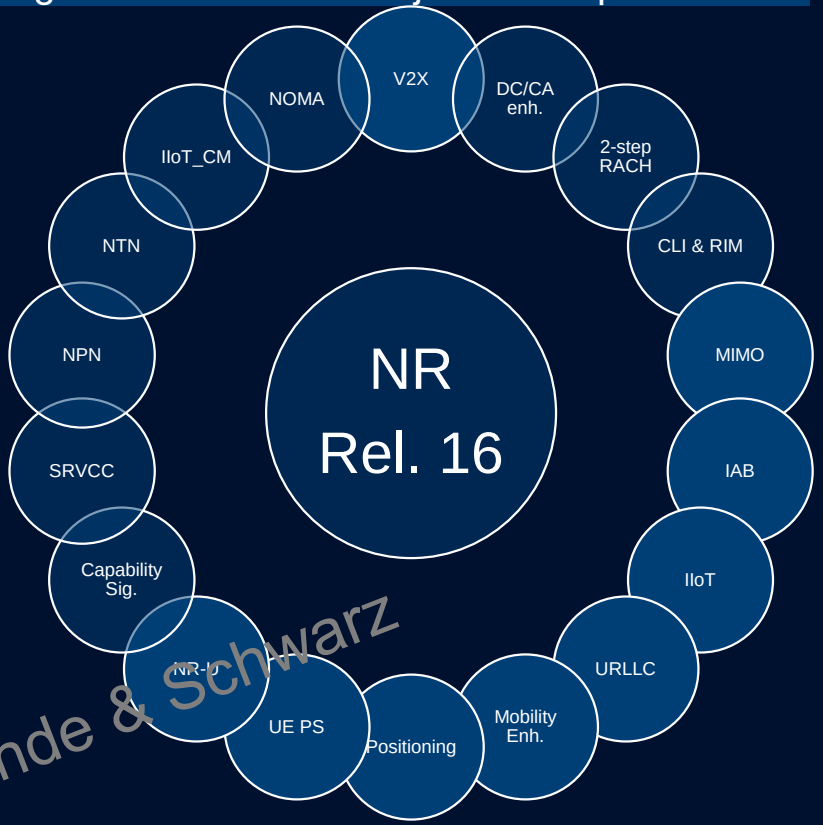
eMBB: enhanced Mobile Broadband
URLLC: Ultra-Reliable Low Latency Communication
mMTC: massive Machine Type Communication

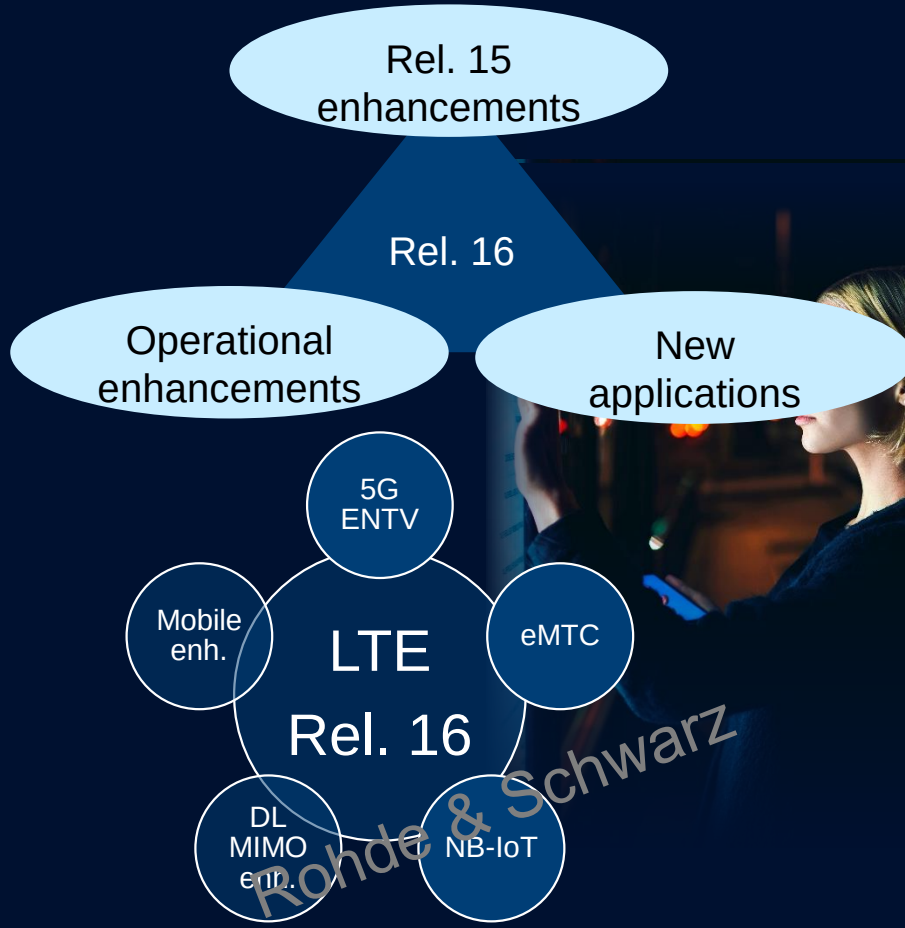
5G NEW RADIO (NR) AIR INTERFACE PARAMETERS

Parameter	FR1 (410 MHz – 7.125 GHz)	FR2-1 (24.25 – 52.6 GHz)	FR2-2 (24.25 – 71GHz)
Carrier aggregation	Up to 16 carriers		
Bandwidth per carrier	5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100 MHz	50, 100, 200, 400 MHz	100, 400, 1600, 2000 MHz
Subcarrier spacing	15, 30, 60 kHz	60, 120, 240 (not for data) kHz	120, 480, 960 kHz
Max. number of subcarriers	3300 (FFT4096 mandatory)		
Modulation scheme	QPSK, 16QAM, 64QAM, 256QAM; Uplink also supports π/2-BPSK (only DFT-s-OFDM)		
Radio frame length	10 ms		
Subframe duration	1 ms (alignment at symbol boundaries every 1 ms)		
MIMO scheme	Max. 2 codewords mapped to max 8 layers in downlink and to max 4 layers in uplink		
Duplex mode	FDD, FDD	TDD	
Access scheme	Downlink: CP-OFDM; Uplink: CP-OFDM, DFT-s-OFDM (network controlled)		

3GPP Rel. 16 topic summary

Highlighted work items: major new aspects





STRENGTHEN THE FOUNDATION AND IMPROVING VERTICALS

3GPP RELEASE 16

- Enhancement of Ultra-Reliable and Low Latency Communications (URLLC)
- Support of LAN-type services
- Cellular Internet of Things (IoT)
- Advanced V2X support
- Northbound APIs related items (Broadcast)
- Coexistence with Non-3GPP systems
- Railways and Maritime
- Mission Critical, Public Warning
- Conversational services, Streaming and TV
- 5G Location and Positioning Services
- Slicing
- Other system-wide Features
- Radio Features

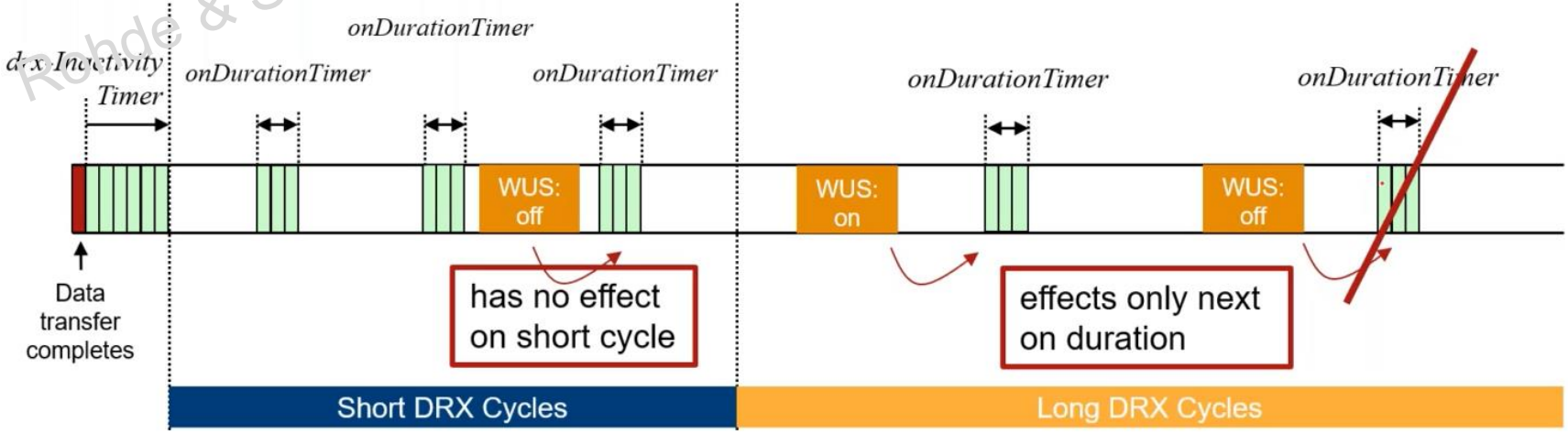
5G NR power saving aspects – overview

- **Power Saving Techniques in CONNECTED state**
  - WUS(DRX adaptation)
  - Maximum MIMO Layer Adaptation
  - Cross slot scheduling
  - Bandwidth part (BWP= switching)
  - Fast transition out of CONNECTED state
- **UE assistance information**
- **Power Saving Techniques in idle/inactive state**
  - Reduced RRM measurements in idle/inactive state

RRC-connected

RRC-idle/inactive

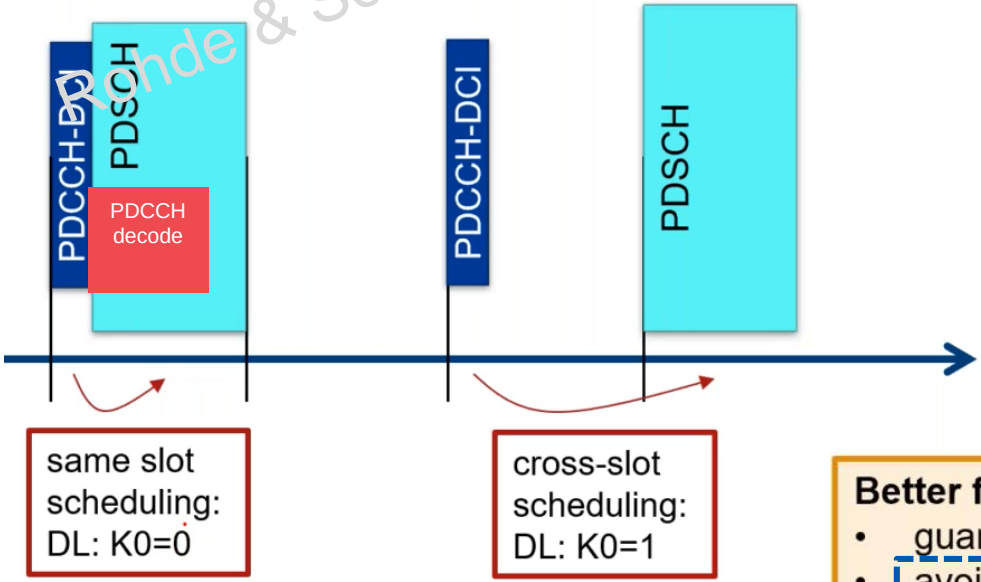
cDRX(LONG) + WUS



WUS = DCI 2-6 with Wake-up indication

- 0 = do not wake up (do not start next onDuration timer)
- 1 = wake up (start next onDuration timer)

CROSS SLOT SCHEDULING



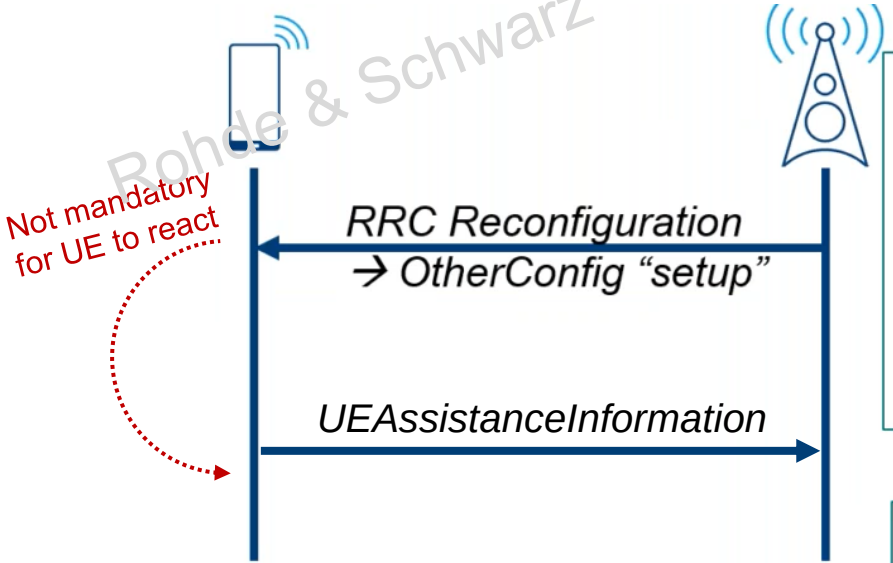
K0/K2 provided in each DCI, but only known to UE **after PDCCH is decoded**
→ UE has to **prophylactically** read RE into buffer

- scheduling delay for UL: K2
- K0/K2 can range from 0…32 slots

Better for power consumption:
- guarantee a minimum scheduling delay K0/K2
- avoid using K0/K2 = 0

trade-off: latency

UE ASSISTANCE INFORMATION



- drx-PreferenceConfig-r16
- maxBW-PreferenceConfig-r16
- maxCC-PreferenceConfig-r16
- maxMIMO-LayerPreferenceConfig-r16
- minSchedulingOffsetPreferenceConfig-r16
- releasePreferenceConfig-r16

→ including individual prohibit timers

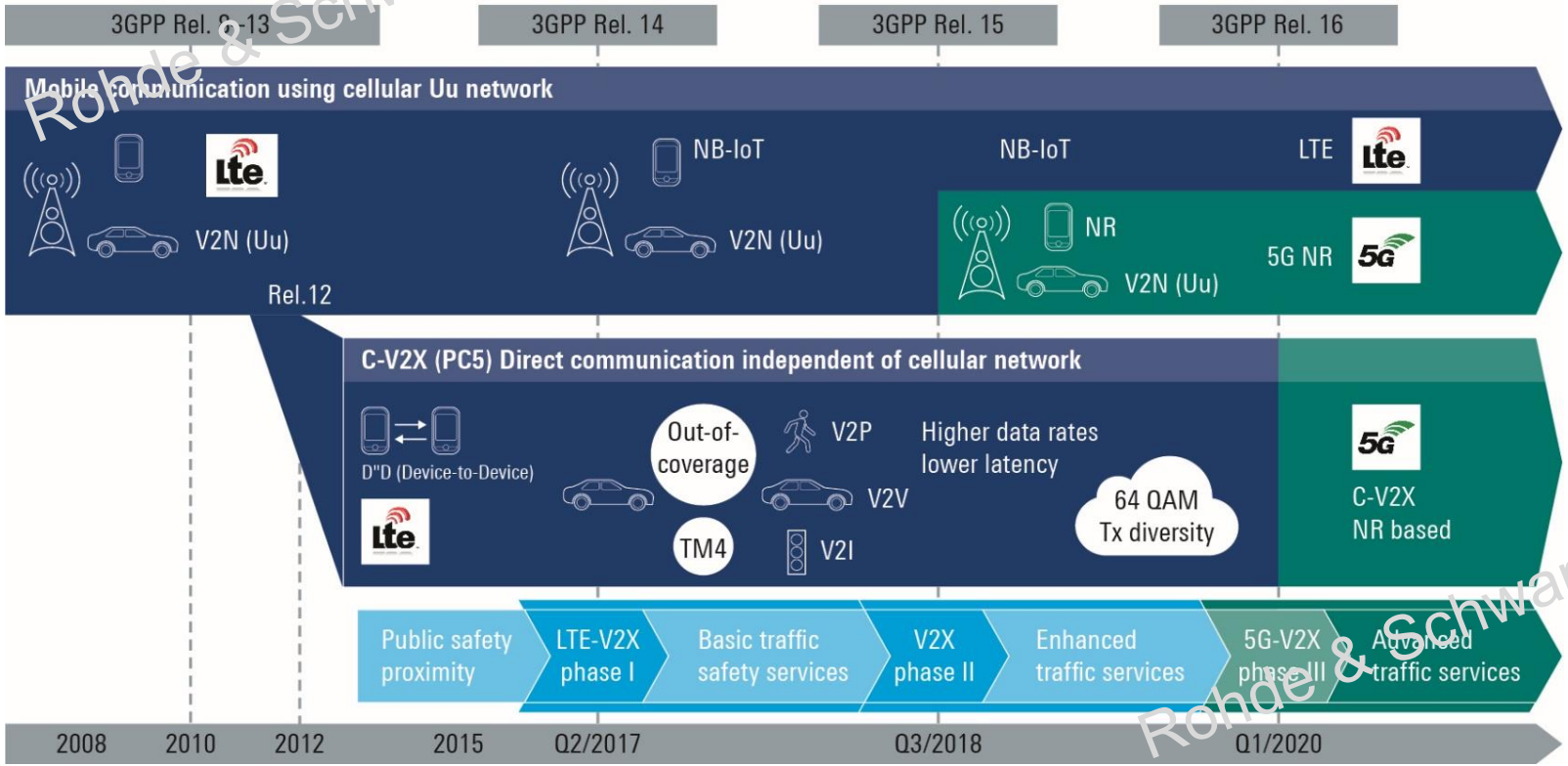
UE **may** initiate the procedure and add values for allowed parameters

- including upon having a preference
- upon change of its preference

- drx-Preference-r16
- maxBW-Preference-r16
- maxCC-Preference-r16
- maxMIMO-LayerPreference-r16
- minSchedulingOffsetPreference-r16
- releasePreference-r16

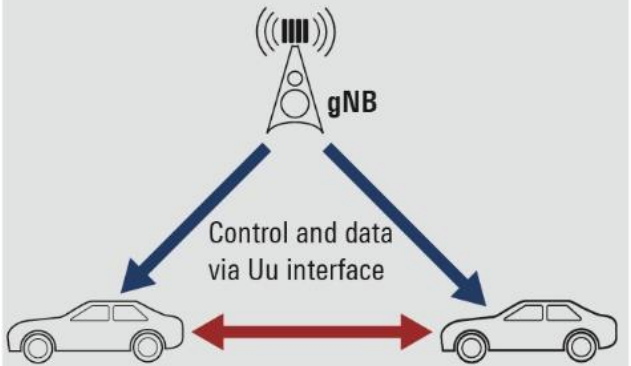
NR-V2X: Sidelink enhancements + relay

EVOLUTION OF 3GPP MOBILE COMMUNICATIONS STANDARD RELEASES 12 TO 16 FF RELEVANT FOR AUTOMOTIVE



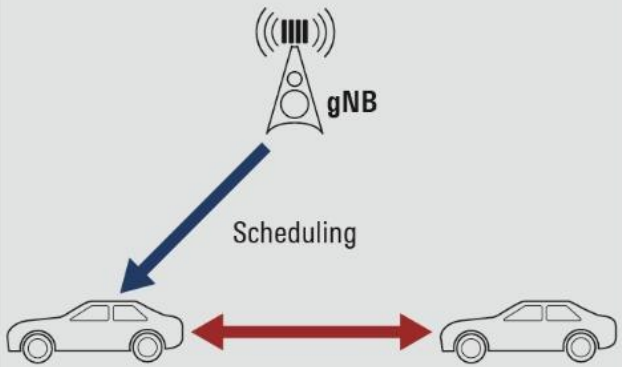
5G NR C-V2X COMMUNICATION MODES AT PHY LAYER

Uu based communication:
gNB optionally schedules sidelink,
data and control is sent over Uu-interface



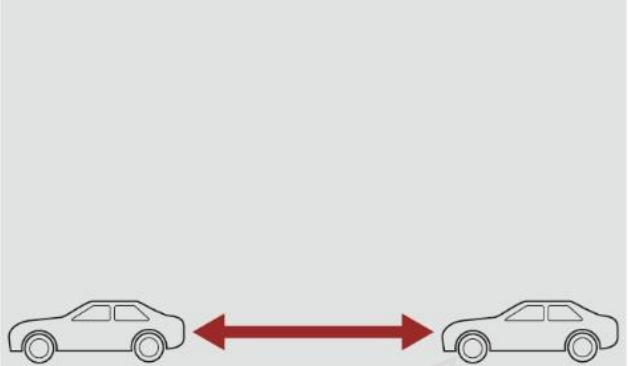
Optional: 5G NR sidelink

5G NR sidelink mode 1:
gNB schedules sidelink resources,
data and control is sent over 5G NR sidelink



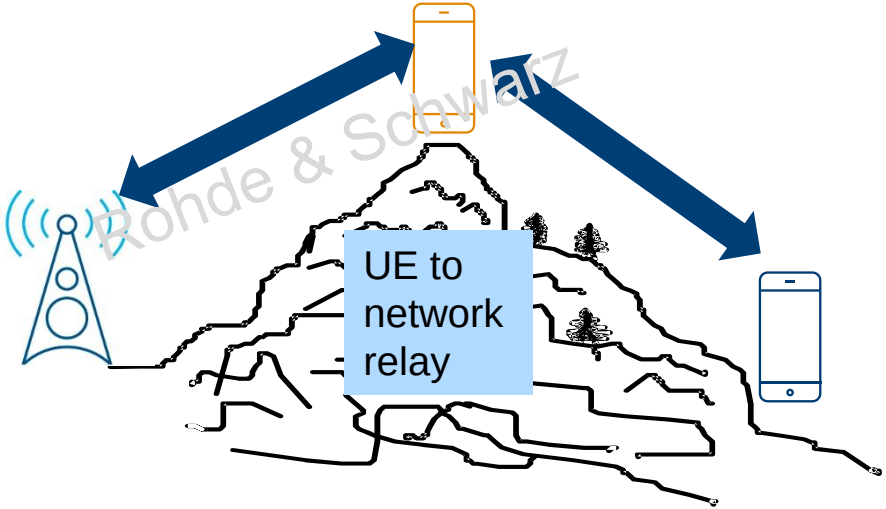
5G NR sidelink: control and data

5G NR sidelink mode 2:
UEs autonomously select 5G NR sidelink resources
- Contention-based
- Channel structure required
- Synchronization aspects

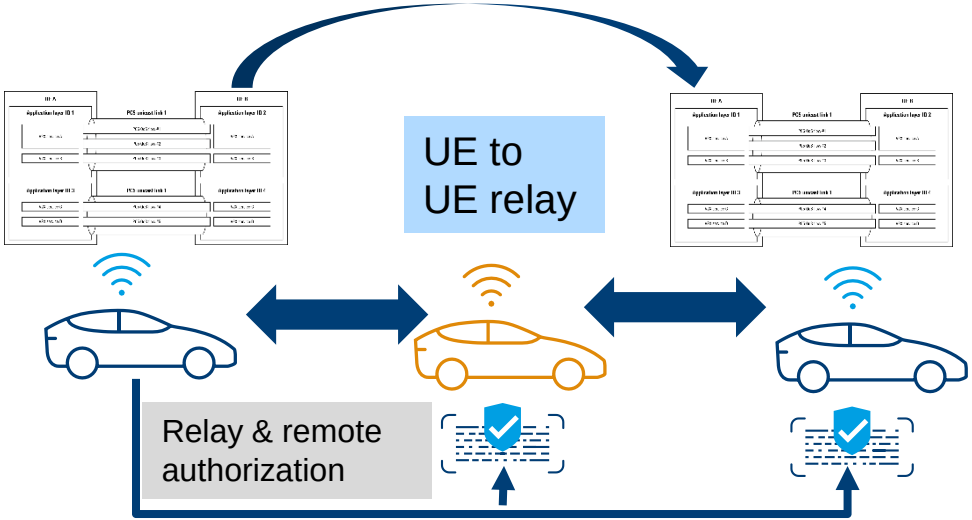


5G NR sidelink: control and data

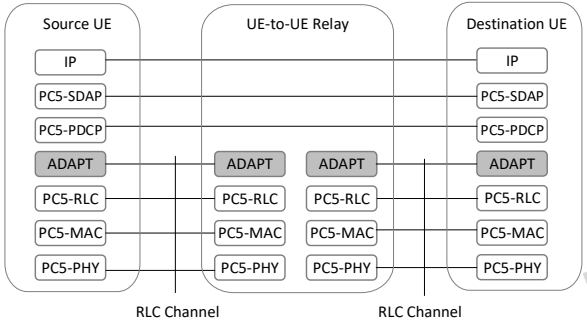
REL.17 NR RELAY

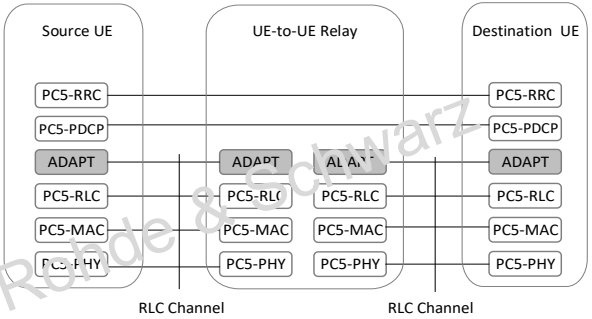


QoS mapping, e.g. new sidelink adaptation layer protocol



Procedures needed for: Discovery, QoS maintenance, C- and U-plane, authorization and service continuity





Non-Terrestrial Networks

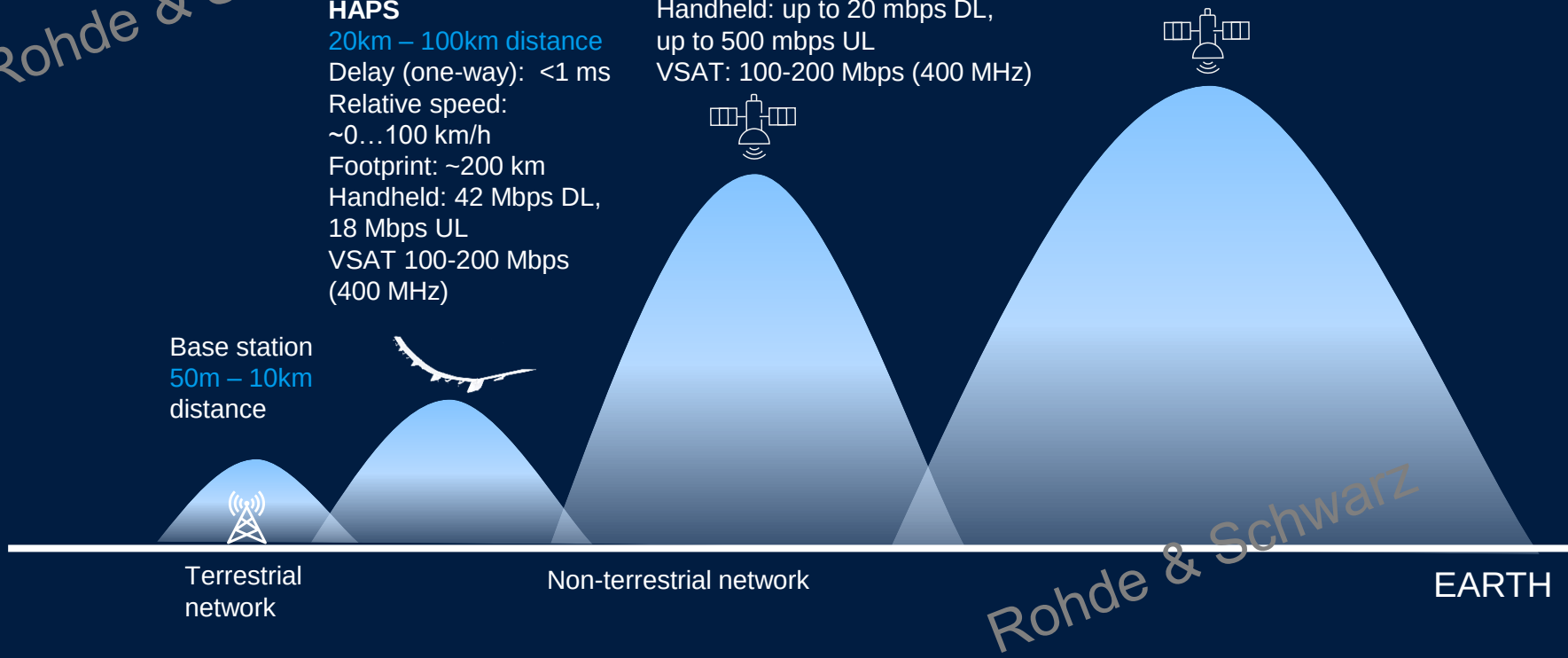
5G NTN

TR 38.811 (Release 17)

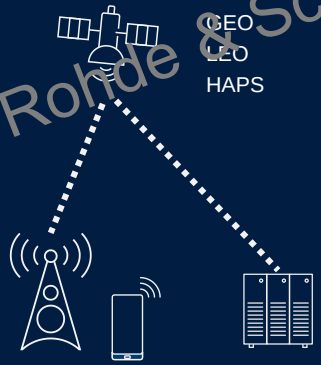
HAPS
20km – 100km distance
Delay (one-way): <1 ms
Relative speed:
~0…100 km/h
Footprint: ~200 km
Handheld: 42 Mbps DL,
18 Mbps UL
VSAT 100-200 Mbps
(400 MHz)

LEO
600km – 1900km distance
Delay (one-way): <6.4 ms
Relative speed: ~7.5 km/s
Footprint: <3000 km
S, L band in R17, Ka in R18
Up to 20 MHz bandwidth
Handheld: up to 20 mbps DL,
up to 500 mbps UL
VSAT: 100-200 Mbps (400 MHz)

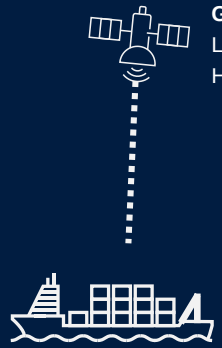
GEO
35000km – 40000km distance
Delay (one-way): 135.3 ms
Relative speed: ~0 m/s
Footprint: <10000
S, L band in R17, Ka in R18
Handheld LOW tpt IoT devices + VSAT



5G-NTN FOUR FACETS (PERSPECTIVE USE CASE)

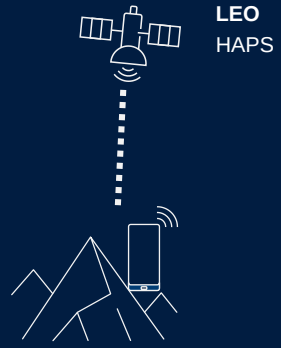


5G NTN backhaul >15 Ghz



IoT-NTN S/L Bands

IoT devices 23 dBm transmit power, omni directional antenna (0dBi), use smaller bandwidth than handheld



NR-NTN (direct handheld, <6 GHz)

Mobile service is provided to handheld devices (e.g. omni directional antenna and 23 dBm transmit power)

NR-NTN (VSAT, >10 GHz) Fixed

wireless service with high gain ground antenna, terminals use VSAT/phased array

Mobile backhaul for terrestrial NWs

Global IoT network

Mobile coverage and resiliency use cases

Rural consumer and enterprise broadband services

Emergency connectivity (temporary networks)

NTN – SPECTRUM IN FR1

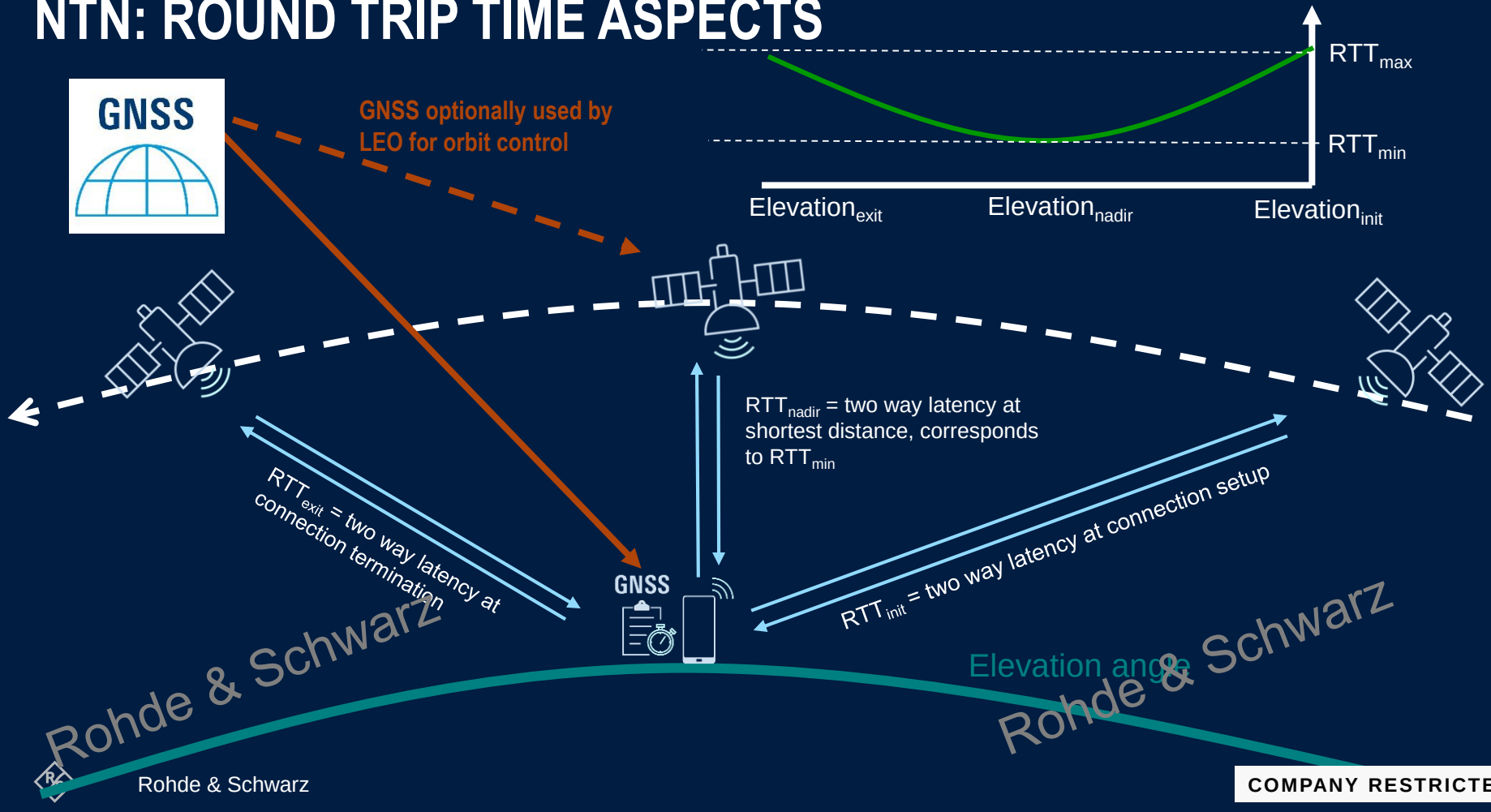
3GPP, first NTN bands for S and L-band

NTN band #	Uplink	Downlink	Duplex
n256	1980 – 2010 MHz	2170 – 2200 MHz	FDD
n255	1626.5 – 1660.5 MHz	1525 – 1559 MHz	FDD

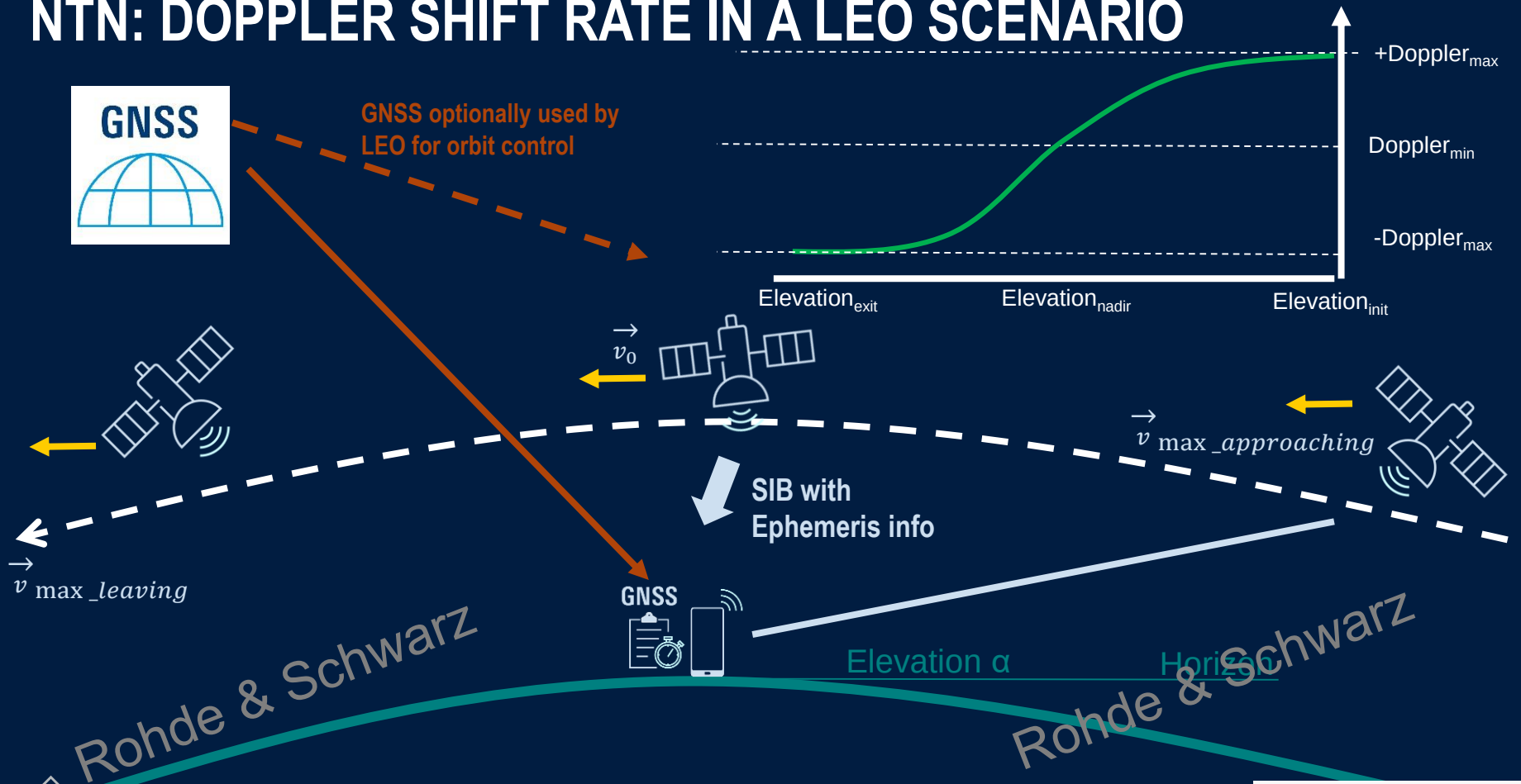
3GPP, bandwidth and subcarrier spacing for NTN bands + #RB

NTN band #	SCS (kHz)	5 MHz	10 MHz	15 MHz	20 MHz
256	15	Yes	Yes	Yes	Yes
	30		Yes	Yes	Yes
	60		Yes	Yes	Yes
255	15	Yes	Yes	Yes	Yes
	30		Yes	Yes	Yes
	60	N/A	Yes	Yes	Yes
		#RB	#RB	#RB	#RB
Max. transmission bandwidth configuration	15	25	52	79	106
	30	11	24	38	51
	60	N/A	11	18	24

NTN: ROUND TRIP TIME ASPECTS

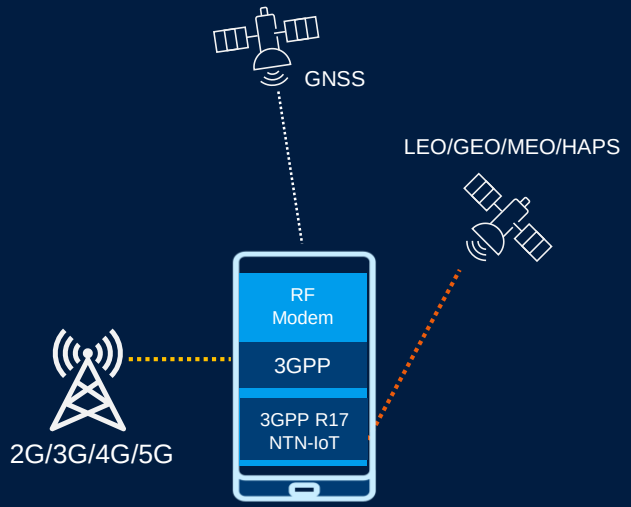


NTN: DOPPLER SHIFT RATE IN A LEO SCENARIO



NTN IoT UE PROCEDURES

1. The UE determines its terrestrial position, e.g. via GNSS.
2. The satellite informs about its orbit information, velocity and common parameters in SIB broadcast.
3. Based on the estimated UE and satellite position, a calculation of the propagation delay is executed by the UE.
4. Finally, the UE derives the initial timing advance and frequency shift for first radio access. Depending on SIB setting, the UE reports the timing advance during the RACH procedure.



3GPP Rel. 17 NTN-IoT

NB-NTN REL. 17 TEST SOLUTION- MWC 2023

Reduced capability (RedCap) + power saving

5G DEVICE EXPANSION WITH REDCAP

high

Device complexity

low

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eMTC/NB-IoT
Lowest complexity
and delay tolerance

Low end
wearables

Sensors:
agriculture,
smart city

Utility
meter

RedCap
Lower complexity
and power

Surveillance
cameras

High end
logistic

High end
wearables

High end
industrial
sensors

eMBB/URLLC
Highest performance

*size of bubble indicates device cost

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Device performance

high

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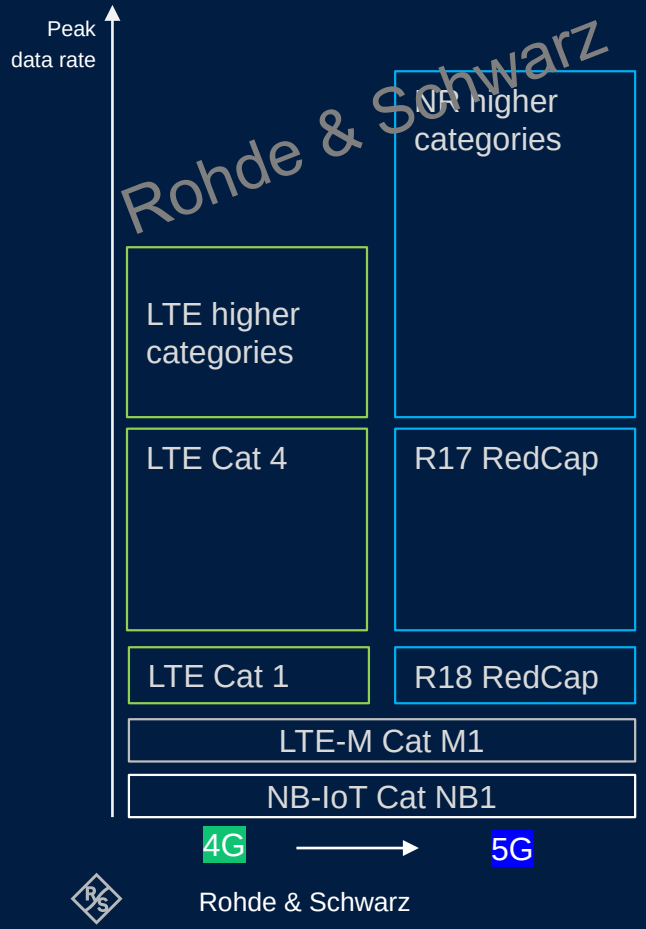
Cellular IoT Evolution

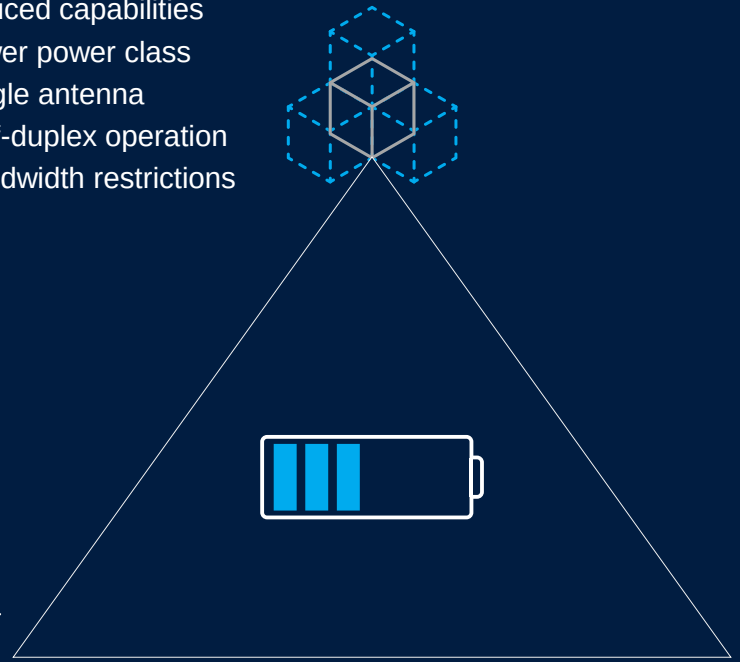


Features		5G NR	5G RedCap (1T2R)	5G RedCap (1T1R)	Cat 4	Cat 1/Cat 1bis
Throughput		UL: 175 Mbps	UL: 50 Mbps	UL: 50 Mbps	UL: 50 Mbps	UL: 5 Mbps @16QAM
	FDD	DL: 350 Mbps @256QAM/2T4R/100M	DL: 150 Mbps @64QAM/1T2R	DL: 85 Mbps @64QAM/1T1R	DL: 150 Mbps @64QAM/1T2R	DL: 10 Mbps @64QAM/1T1R
		UL: 250 Mbps	UL: 22 Mbps	UL: 22 Mbps	UL: 15 Mbps	UL: 1 Mbps @16QAM
	TDD	DL: 1.7 Gbps @256QAM/2T4R/100M	DL: 124 Mbps @64QAM/1T2R	DL: 62 Mbps @64QAM/1T1R	DL: 110 Mbps @64QAM/1T2R	DL: 7.4 Mbps @64QAM/1T1R
URLLC		1 ms support URLLC	5~10 ms@99.99% support URLLC	5~10 ms@99.99% support URLLC	>100 ms	>100 ms
Power consumption		100 mA~3 A	Working: 120~160 mA Idle:12~22 mA	Working: 120~160 mA Idle:12~22 mA	Working: 120~160 mA Idle:12~22 mA	<100 mA
Network slicing		✓	✓	✓	✕	✕
5G LAN		✓	✓	✓	✕	✕
Voice		VoNR	VoNR	VoNR	VoLTE	VoLTE
Mobility		✓	✓	✓	✓	✓
NTN		✓	Discussed	Discussed	✕	✕
Chipset/modem cost		$80-$150	$20-$40	$5-$20		

RedCap Device Power Saving Cluster

Hardware restrictions
and reduced capabilities

- Lower power class
- Single antenna
- Half-duplex operation
- Bandwidth restrictions
- Etc.



Enhanced mechanisms and innovations

- Wake-up signals
- Relaxed measurements
- Adaptive bandwidth
- Etc.

Operational enhancements

- Discontinuous reception (DRX)
- Sleep mode
- Power save mode (PSM)
- Signaling reduction, i.e. TAU
- Cross-slot scheduling
- Etc.

DEVICE OPTIMIZATION

FR1 max. BW 20 MHz
DL: 256QAM optional

SISO | 2 DL MIMO layers

FR2 max. BW 100 MHz

SISO **or** 2 DL MIMO layers

FR1 and FR2

SISO

- Half duplex FDD type A (full duplex optional)
- No support for: CA, MR-DC, DAPS, CPAC and IAB → **only NR-SA**

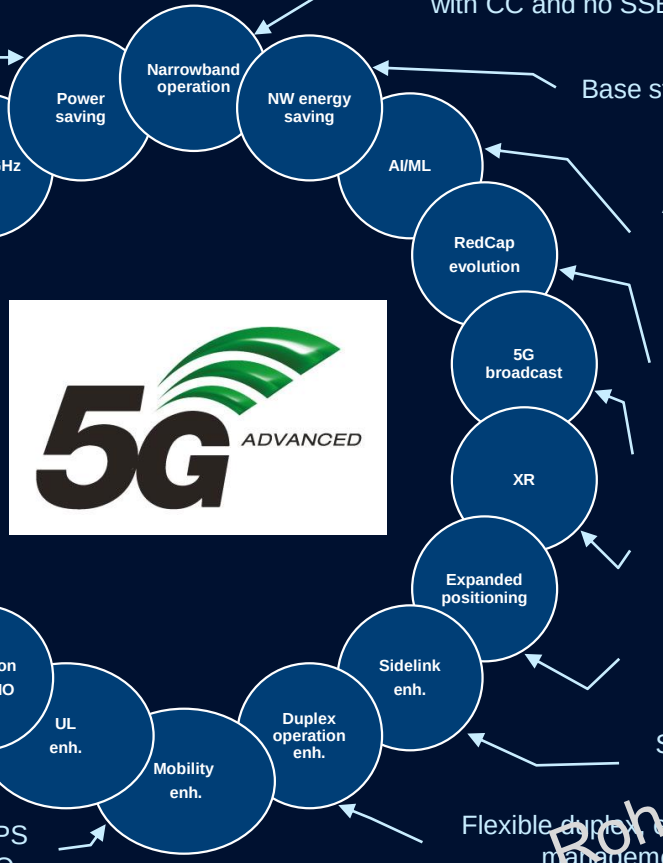
DEVICE OPTIMIZATION

Other R15-17 features may be used by a RedCap device, but they may not be optimized for them

“useful ?”
Power saving
Coverage enhancement
Positioning (will be optimized for RedCap in R18)
SDT
2-step RACH
Side link
NTN
……..

“maybe not useful?”
IIoT
URLLC
MBS
MUSIM
……..

R18 KICKOFF DISCUSSIONS



Continued NB-IoT support, usage of spectrum chunks, e.g. CA with CC and no SSB sync there, narrowband cell operation

Base station downtime, breathing cell + SON

AI framework for UE, use cases, evaluation, link and positioning prediction, Ref. Signal reduction, beam management

5 MHz UE bandwidth, power saving enhancements, wake-up signals

LTE & 5G broadcast, NR MBS and multicast

New KPI / QoS, application awareness, power consumption coverage, capacity and mobility

SL positioning, high accuracy, RedCap positioning, positioning integrity

SL enh. (unlicensed, power saving, efficiency), SL relay, coexistence LTE-NR V2X

Flexible duplex, eg. DL only deployments, interference management, cross division duplex XDD

L1/L2 inter cell HO, DAPS improvements, FR2 HO

> 4 TX, freq. selective precoding, coverage enh.

CSI reporting + multi-TRP / multi-beam

Indoor 5G + WLAN operation, dual connectivity with > 2 DC

Mobile IAB, smart repeater

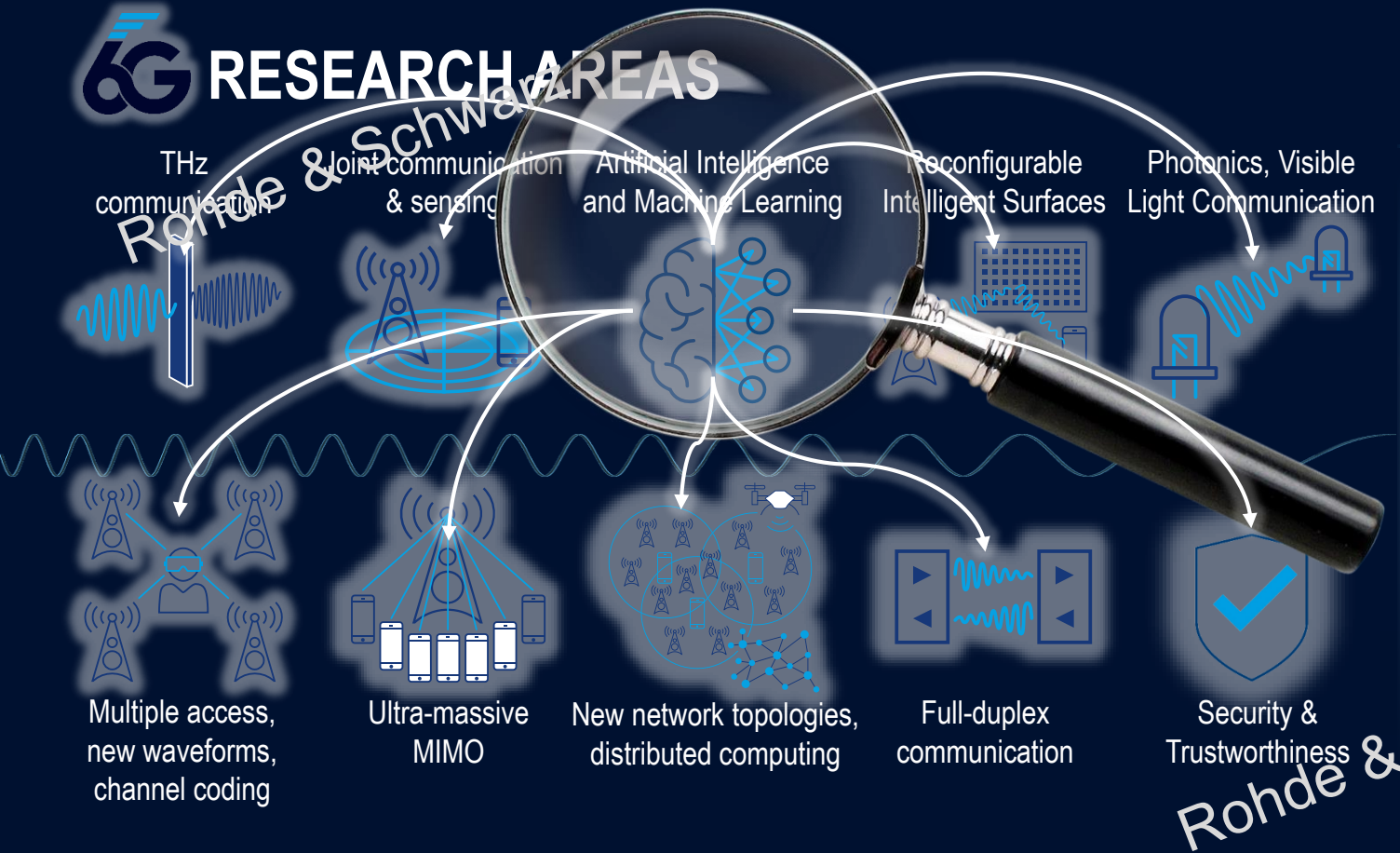
Short interruption time, including sidelink into NPN

HAPS + UAV, network slicing NTN, IoT optimizing (no GNSS

V2X in FR2, unlicensed bands, extension up to 114.25 GHz

Reduce measurements, almost zero power RX, energy harvesting

6G RESEARCH AREAS



A high-level overview on all these research areas is provided in one of our #THINKSIX video. Don't miss it!

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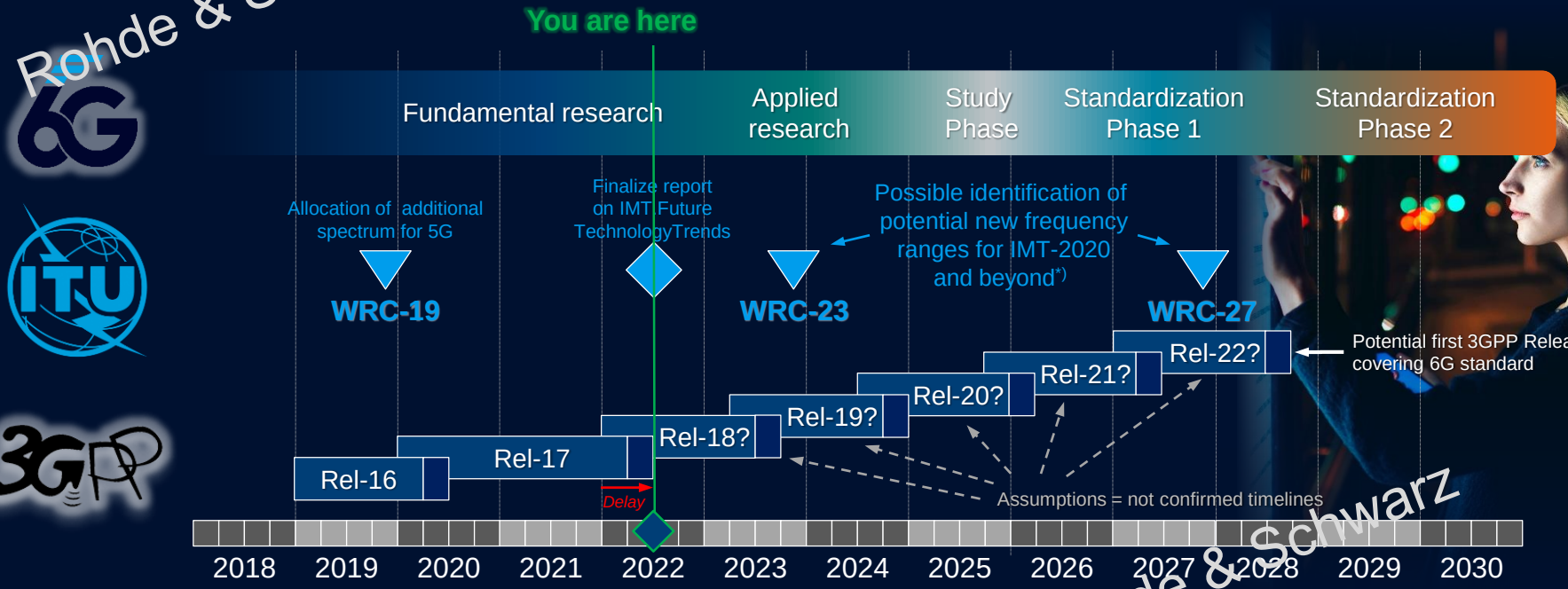
STANDARDISATION AND REGULATION ROADMAP



*) IMT-2020 systems are usually called 5G. The ITU has already started a new report to prepare the work on IMT-2020 and beyond that is likely to become 6G

OBT CONFIGURATIONS

OBT - THE BEST COMPROMISE

- Up to 32 NR Layers
- Up to 32 LTE Layers
- 48 layers on air simultaneously
- Extensive Fading support

- 10 GHz RF DL iBW
- Sub8: 400 MHz - 8 GHz
- mmW: 22 … 50 GHz

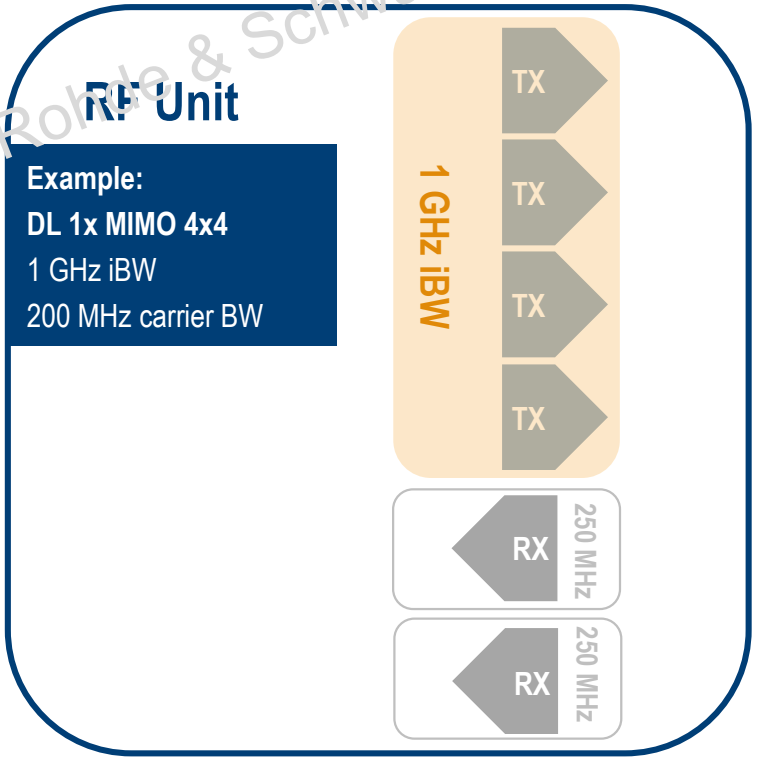
OBT PLUS CAPABILITIES

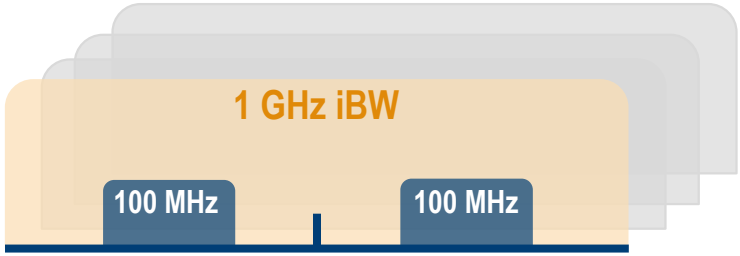
- Support for FR1/LTE
- Support for FR2 2x2 MIMO
- Up to 16CC LTE/NR
- **Up to 64** FR1/LTE Layers

- High Throughput Testing
- High order CA Testing (massive band combos)

- **14** GHz RF DL iBW
- Sub8: 400 MHz - 8 GHz

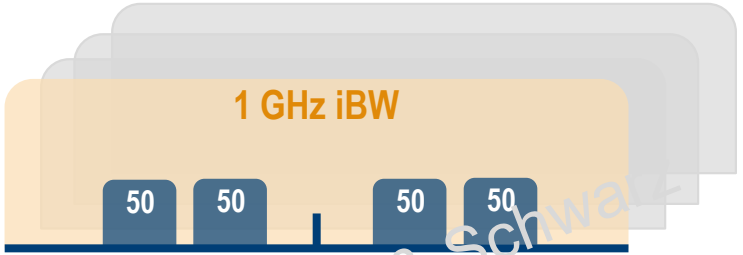
RF UNIT BASICS
DL





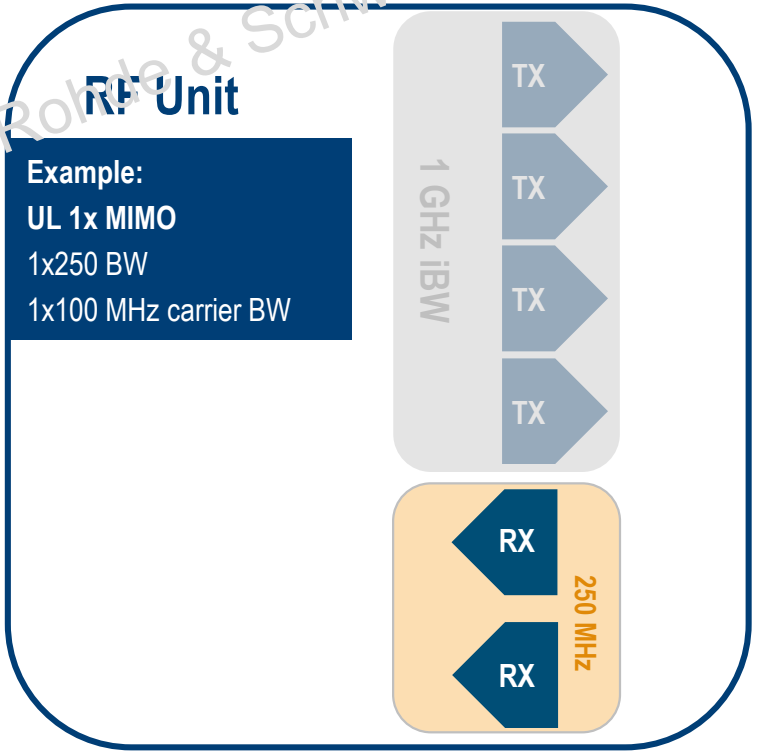
→ DL 2xCC 4x4 MIMO

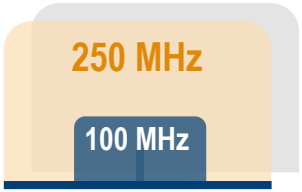
OR



→ DL 4xCC 4x4 MIMO

RF UNIT BASICS
UL





→ UL 1xCC MIMO

CMX500 UPDATE

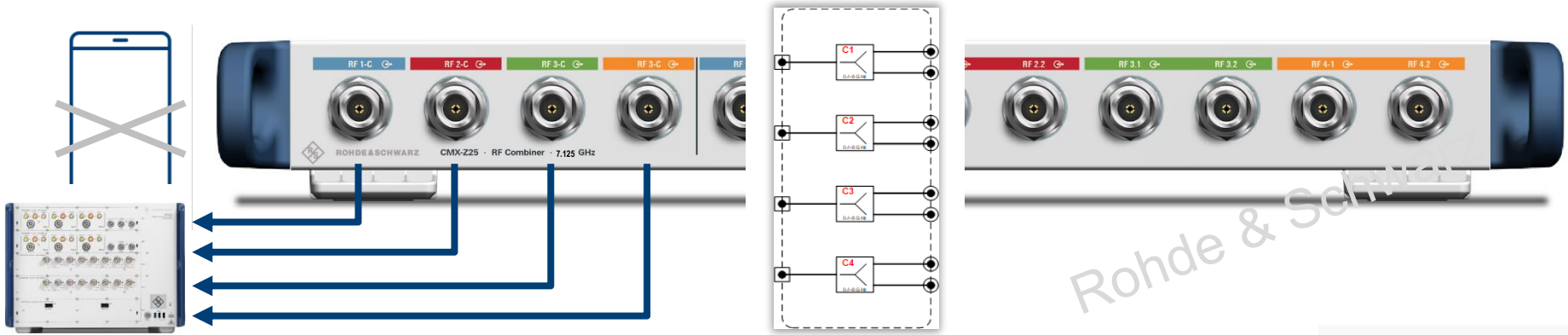
Rohde & Schwarz validates 10 Gbps end-to-end (E2E) peak downlink IP data throughput

Rohde & Schwarz announced today the next breakthrough in 5G data performance: With support of Qualcomm Technologies, Inc., Rohde & Schwarz has validated 10 Gbps end-to-end (E2E) IP data performance using its R&S CMX500 5G radio communication tester platform. The setup was powered by Snapdragon® X65 5G Modem-RF System, the world's first 3GPP Release 16 modem-RF system with Qualcomm® QTM545 mmWave Antenna Module.

Rohde & Schwarz achieved the milestone results based on a 3GPP Release 16 5G New Radio Dual Connectivity (NR-DC) network simulation, provided by its R&S CMX500 5G radio communication tester. In the simulation, two cell groups were simultaneously connected, one using spectrum in frequency range 1 (FR1) and the other in frequency range 2 (FR2; mmWave). The FR1 carrier spans over full 100 MHz bandwidth using an antenna configuration of MIMO 4x4 and 256QAM modulation. Eight additional component carriers are combined in FR2, using MIMO 2x2 and 256QAM modulation.

The demonstration covered several test cases that verified high data throughput in downlink over IP layer, using different configuration modes of the 5G protocol stack's lower layers such as Radio Link Control (RLC) in Unacknowledged Mode (UM) and Acknowledged Mode (AM). These configuration modes made it possible to push real IP data over the wireless communication link, making this the first time ever that real IP end-2-end data was used in a performance of this kind. Previously, throughput had simply been verified on the modem's lower layer 5G protocol stack. This opens up a new era of 5G data performance, which eventually will enable eMBB use cases like 4K and 8K video streaming or augmented reality applications.

CMX-Z25: 7.125 GHZ // FOUR COMBINER – EACH 2:1



FLEXIBLE FR2 TESTING ON CMX500 PLATFORM

OBT Lite

Supports FR2 SISO and FR1/LTE 4x4 MIMO

- 5 GHz RF DL iBW
- Sub8: 400 MHz - 8 GHz
- mmW: 22 … 50 GHz

OBT

Support for FR2 2x2 MIMO and up to 8 CC
Up to 16 CC LTE /FR1

- CB RF test up 50 GHz and
  8CC FR2 2x2 + 4CC FR1 4x4
  8CC FR2 2x2 + 8CC LTE 4x4
  8CC FR1 4x4 + 8CC LTE 4x4
- >10 Gbps Data Throughput
- 3GPP pre-conformance tests

OBT Plus

Support for FR2 2x2 MIMO and up to 8 CC
Up to 16 CC LTE /FR1

- High Throughput Testing
- High order CA Testing (massive band combos)

OBT FR2 Specialist

Support for FR2 2 AoA
Up to 14 CC
Data Throughput > 10 Gbps

- For Sub8: FR1 & LTE
  - DL: 4x 1000 MHz TX RF BW
  - UL: 2x 250 MHz RX RF BW

NEW IN FR2 SIGNALING

3 New CMX-RF42

- More dynamic range
- Advanced CA

2 New CMXHEAD50

Up to 50 GHz (n262)

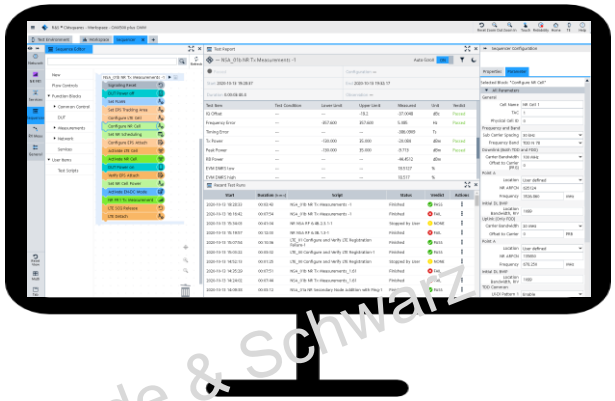
1 New FR2 Specialist

For advanced FR2

New ATS800R

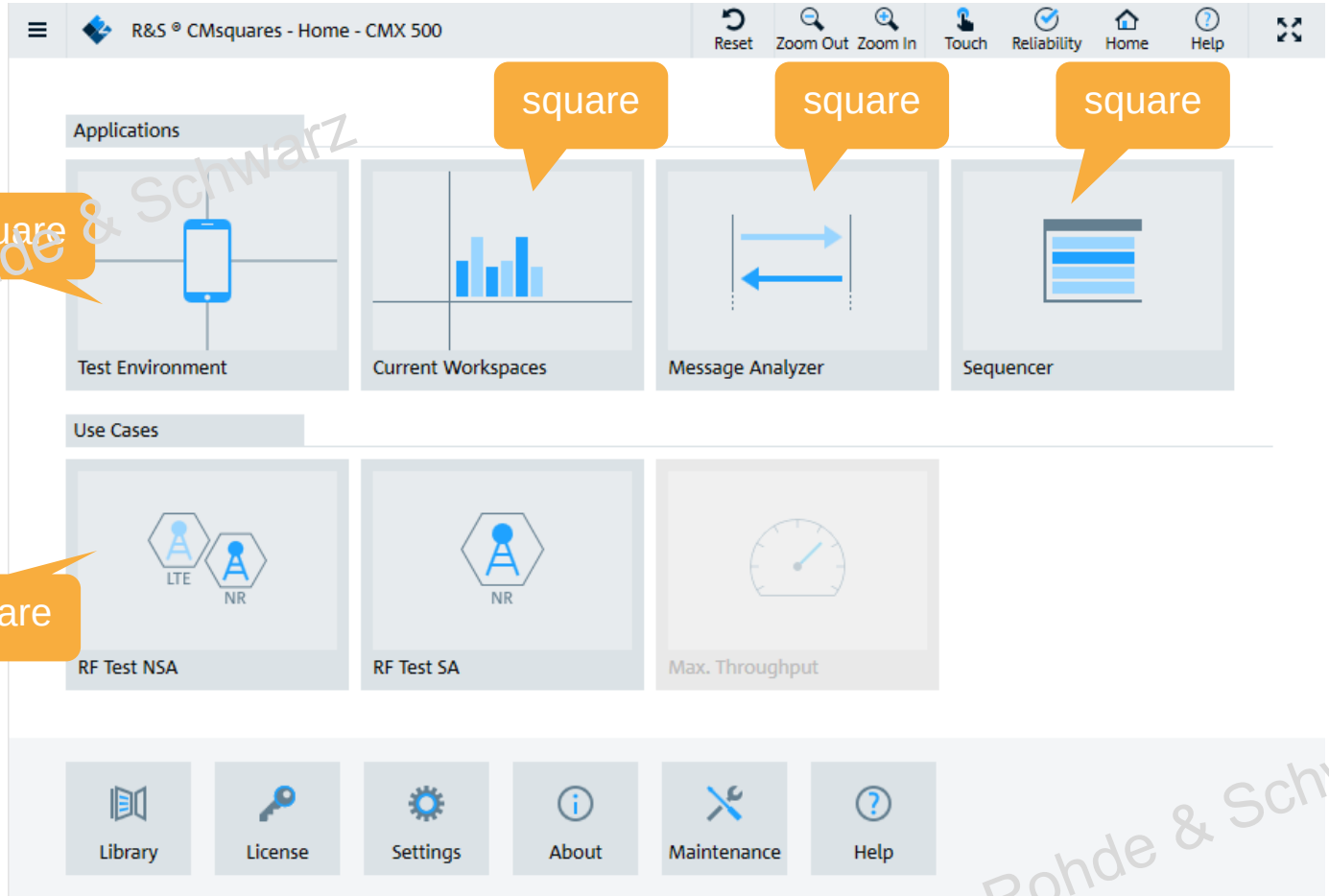
4 5 6

- 200 MHz bandwidth
- New FR2 measurements
- Contest FR2 for free*

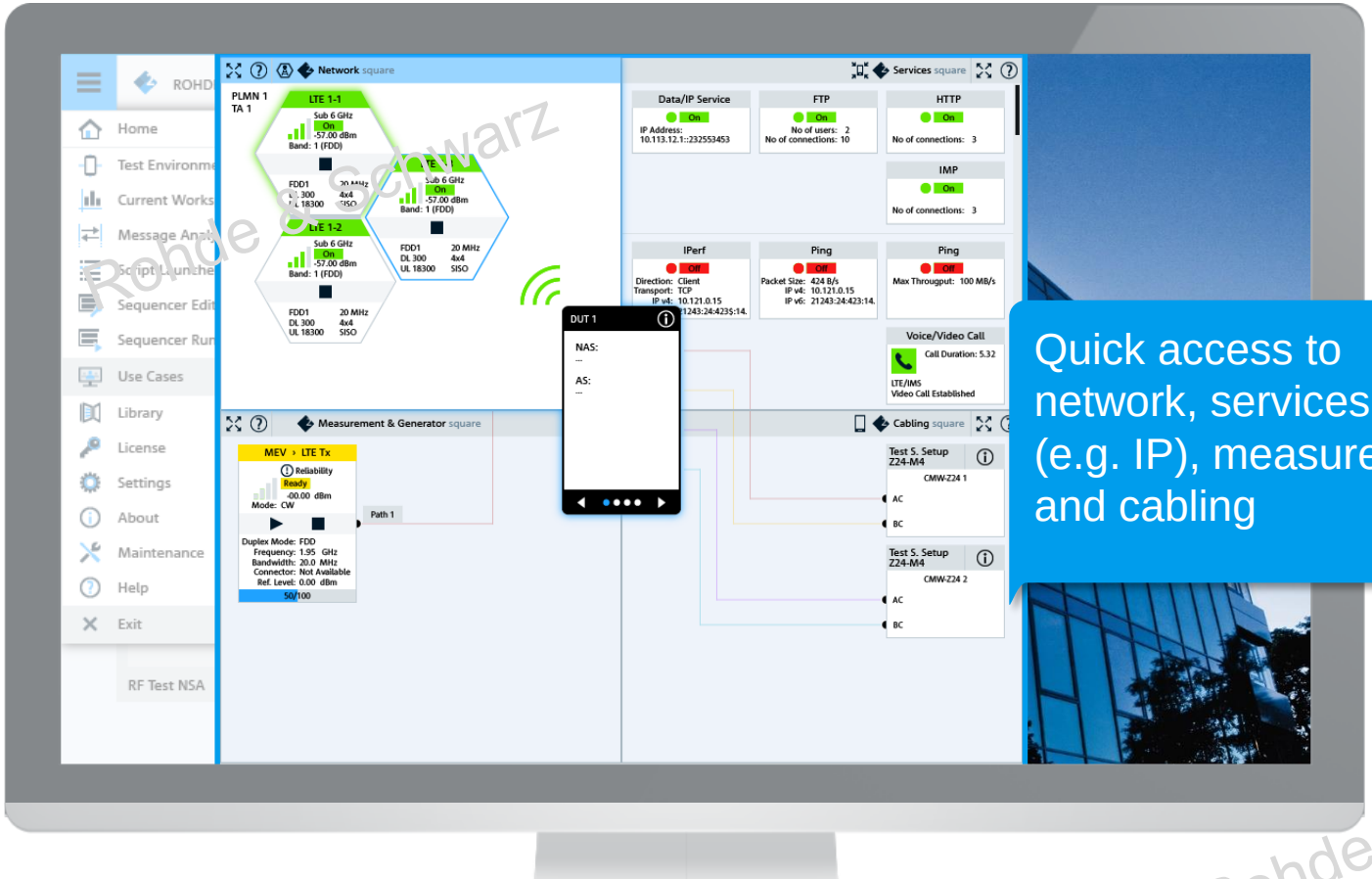


* Free use of selected Contest RF conformance test cases until summer 2023

CMX500 SOFTWARE TOOL
CMSEQUENCER


R&S ® CMsquares - Home - CMX 500
Reset
Zoom Out
Zoom In
Touch
Reliability
Home
Help
square
square
square
square
Applications
Test Environment
Current Workspaces
Message Analyzer
Sequencer
Use Cases
LTE
NR
NR
RF Test NSA
RF Test SA
Max. Throughput
Library
License
Settings
About
Maintenance
Help
Rohde & Schwarz
Rohde & Schwarz

UNIFIED USER INTERFACE FOR PROTOCOL, RF AND APPLICATION TESTING



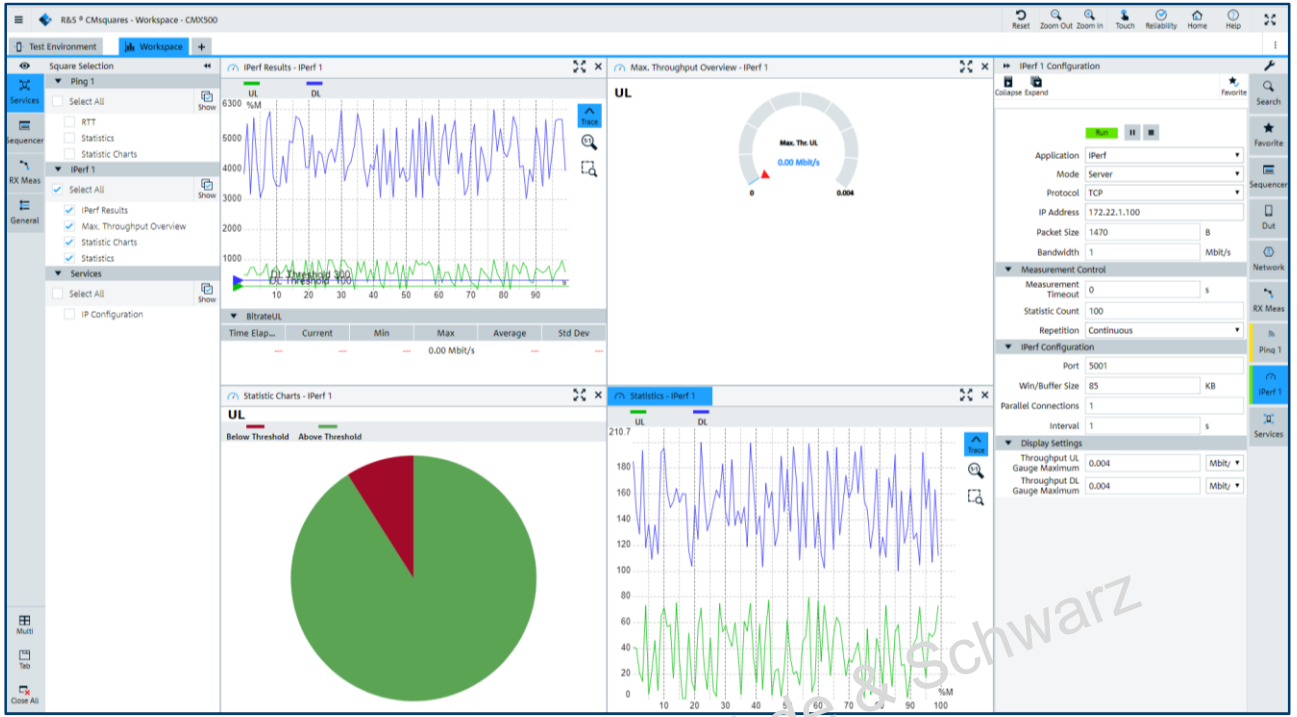
Quick access to network, services (e.g. IP), measurements and cabling

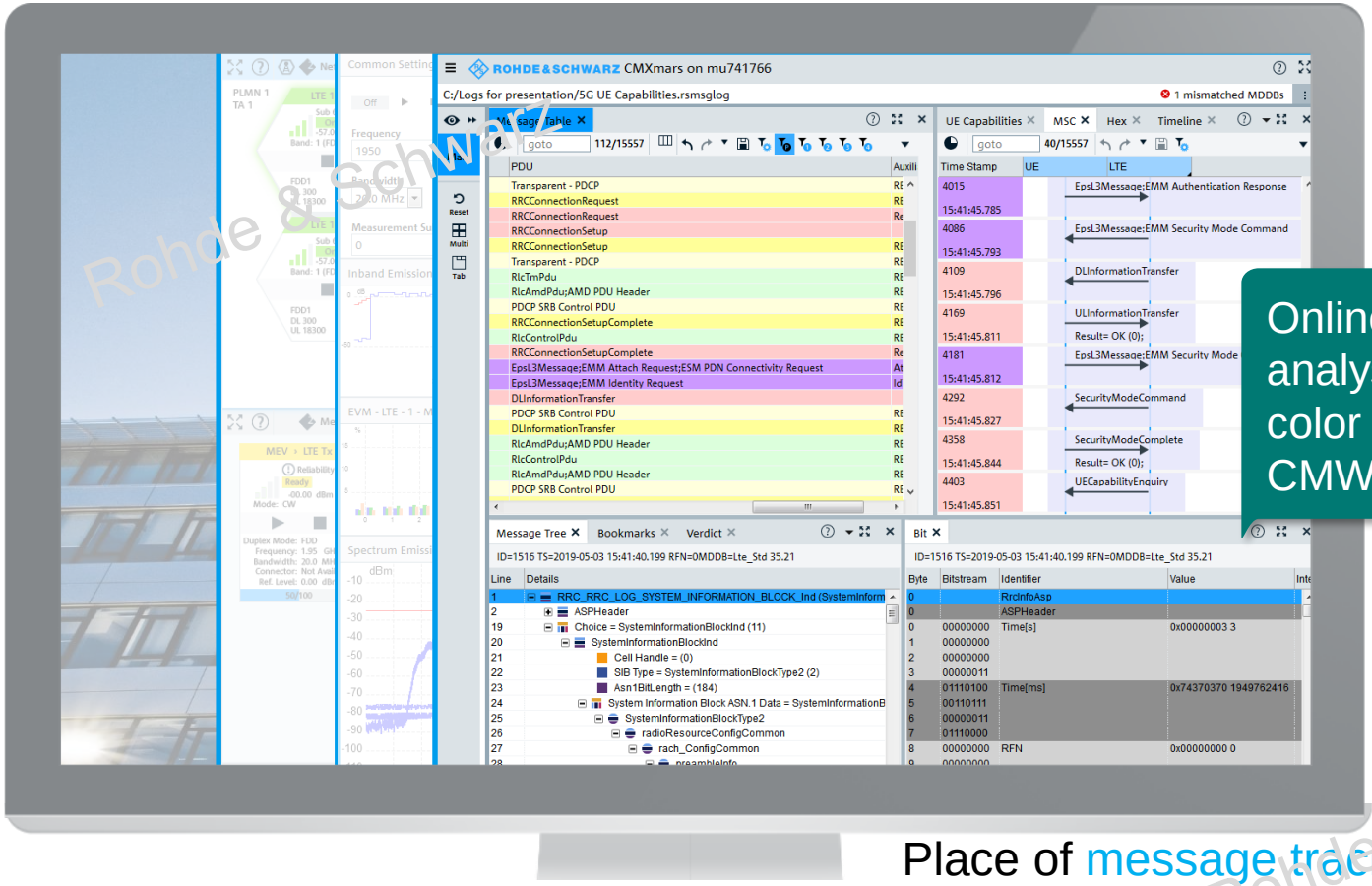
UNIFIED USER INTERFACE FOR PROTOCOL, RF AND APPLICATION TESTING

Easy mixing of all types of measurements ⇨ unified user experience

E2E THROUGHPUT MEAS

- IPERF Result Graph
- Max Throuput Overview
- Statistic in %
- Statistic Chart (Threshold)





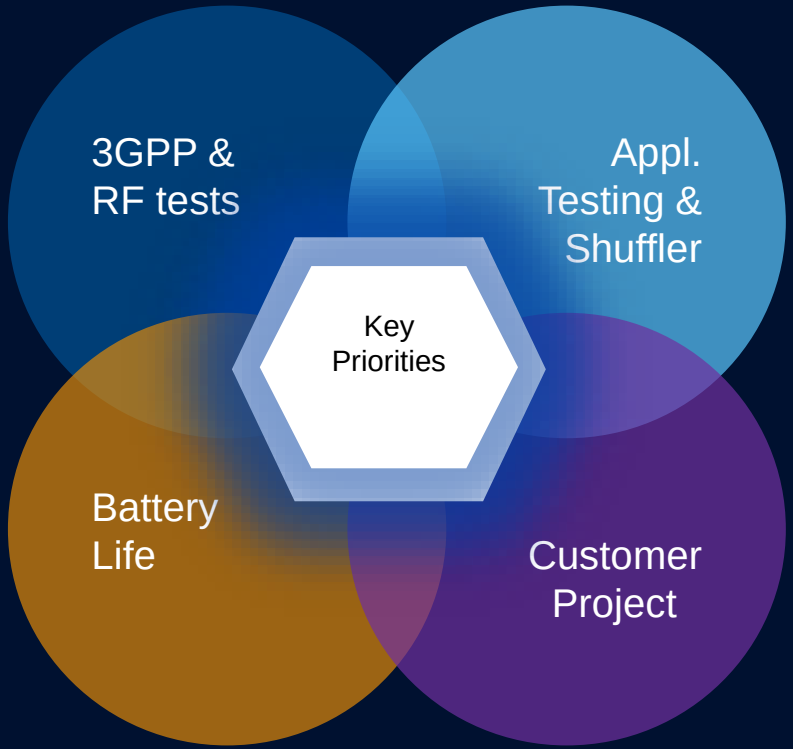
UNIFIED USER INTERFACE FOR PROTOCOL, RF AND APPLICATION TESTING

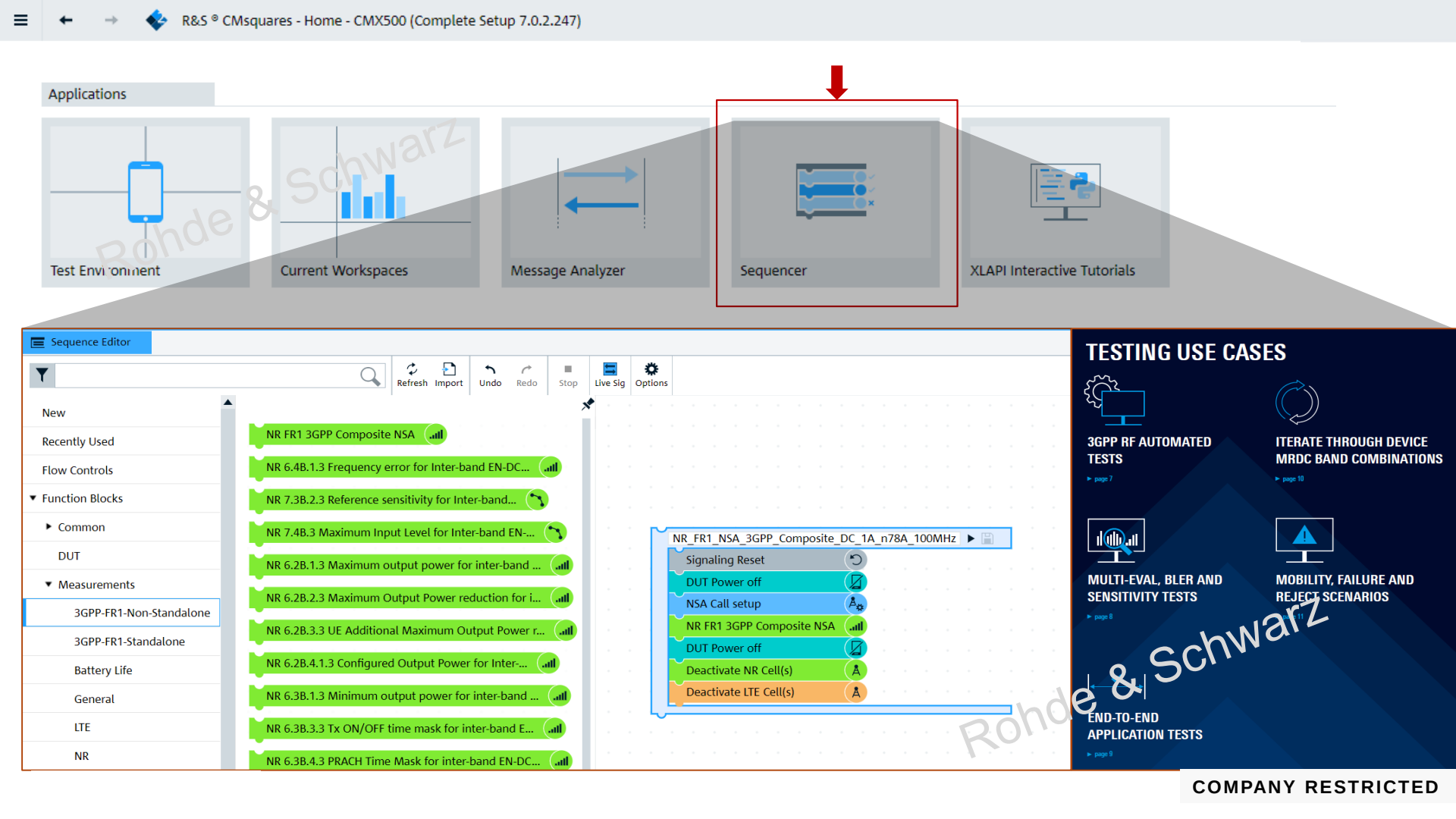
Online mode and offline analysis. Well-known color scheme of CMWmars

Place of message tracing

Evolution of well established CMWmars

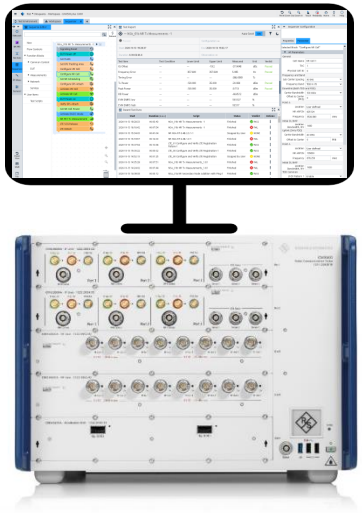
CMsequence RPRIORITIES

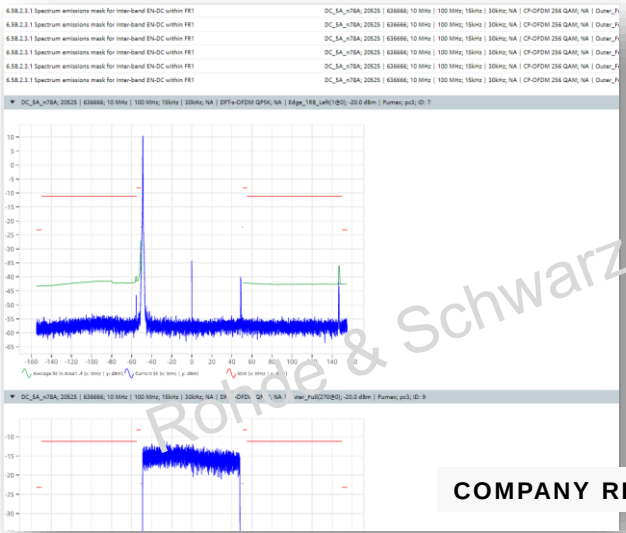



R&S ® CMsquares - Home - CMX500 (Complete Setup 7.0.2.247)
Applications
Test Environment
Current Workspaces
Message Analyzer
Sequencer
XLAPI Interactive Tutorials
Sequence Editor
Refresh
Import
Undo
Redo
Stop
Live Sig
Options
New
Recently Used
Flow Controls
Function Blocks
Common
DUT
Measurements
3GPP-FR1-Non-Standalone
3GPP-FR1-Standalone
Battery Life
General
LTE
NR
NR FR1 3GPP Composite NSA
NR 6.4B.1.3 Frequency error for Inter-band EN-DC...
NR 7.3B.2.3 Reference sensitivity for Inter-band...
NR 7.4B.3 Maximum Input Level for Inter-band EN-...
NR 6.2B.1.3 Maximum output power for inter-band ...
NR 6.2B.2.3 Maximum Output Power reduction for i...
NR 6.2B.3.3 UE Additional Maximum Output Power r...
NR 6.2B.4.1.3 Configured Output Power for Inter-...
NR 6.3B.1.3 Minimum output power for inter-band ...
NR 6.3B.3.3 Tx ON/OFF time mask for inter-band E...
NR 6.3B.4.3 PRACH Time Mask for inter-band EN-DC...
NR_FR1_NSA_3GPP_Composite_DC_1A_n78A_100MHz
Signaling Reset
DUT Power off
NSA Call setup
NR FR1 3GPP Composite NSA
DUT Power off
Deactivate NR Cell(s)
Deactivate LTE Cell(s)
TESTING USE CASES
3GPP RF AUTOMATED TESTS
ITERATE THROUGH DEVICE MRDC BAND COMBINATIONS
MULTI-EVAL, BLER AND SENSITIVITY TESTS
MOBILITY, FAILURE AND REJECT SCENARIOS
END-TO-END APPLICATION TESTS
Rohde & Schwarz
COMPANY RESTRICTED

3GPP PRE-CONF TX/RX TESTS

- 3GPP 38.521 Tx and Rx tests for 5G FR1 NSA and SA
- Flex configuration for more user flexibility (add user defined Freq, BW, SCS, …)
- Single place for TC selection and its settings
- Comprehensive test reports with meas verdicts, tables and graphs
- Automated RF attenuation tuning for clean RF path





SHUFFLER UPDATES

- More CA and MR-DC band combinations supported
- More Shuffler tests in CMX-KF612M (6 new tests)
- Band combination CSV enhanced with RB allocation inputs
- Trigger UE Capabilities to request all supported band combos

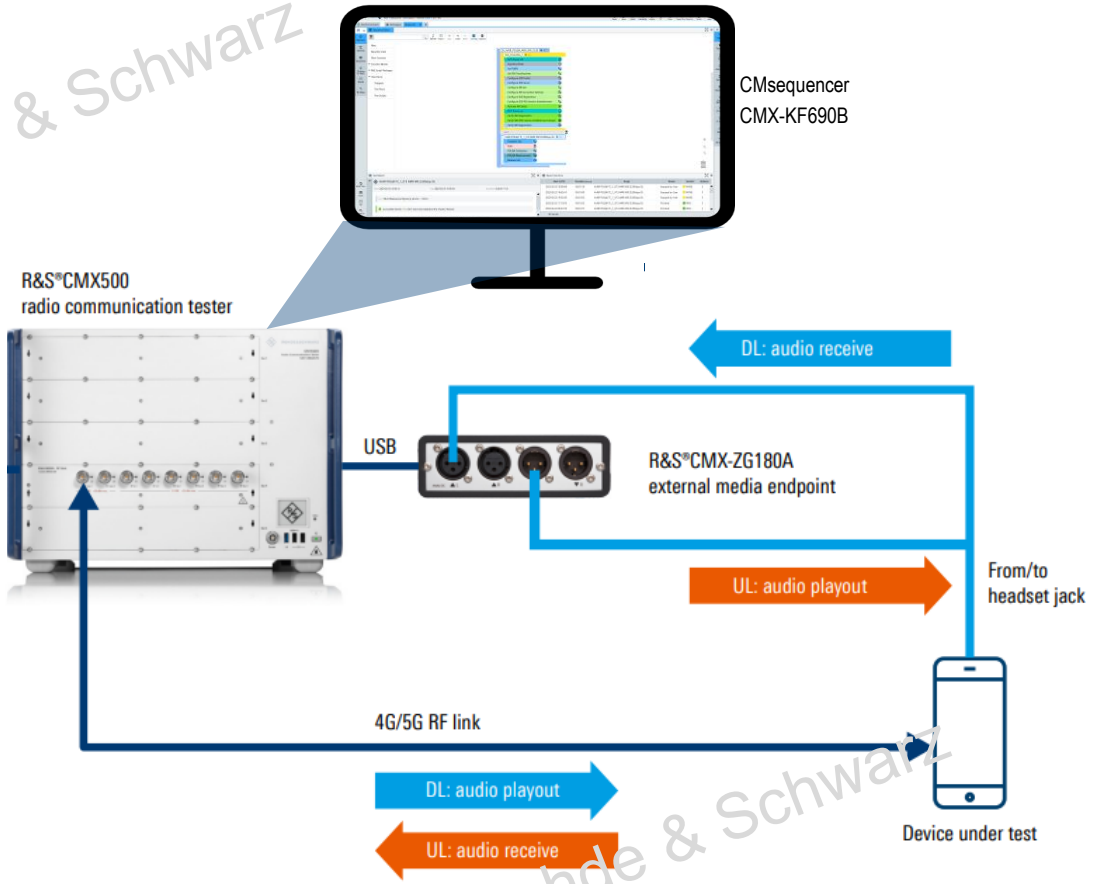
Band Combo	LTE	NR
LTE	• 4 LTE CA • 5 LTE CA	• 4LTE + 2NR • 5 LTE + 2NR
NR	• LTE + FR1 • LTE + FR2	• 2 NR CA • 4 NR CA • NRDC in pipeline

CMX-KF612M		
Shuffler_01	MR-DC+LTE 3CC UE Capabilities and NR TX Measurements	verified
Shuffler_02	MR-DC UE Capabilities and NR TX Measurements	verified
Shuffler_02a	MR-DC UE Capabilities and NR TX Measurements - Without Signaling Reset	verified
Shuffler_03	LTE UE Capabilities and LTE TX Measurements	verified
Shuffler_03a	LTE UE Capabilities and LTE TX Measurements - Without Signaling Reset	verified
Shuffler_3b	No Sig Reset - LTE UE capabilities Band_Selection and LTE TX Measurements	verified
Shuffler_04	NR UE Capabilities and NR TX Measurements	verified
Shuffler_04a	NR UE Capabilities and NR TX Measurements - Without Signaling Reset	verified
Shuffler_4b	No Sig Reset - NR UE Capabilities and band_selection NR TX Measurements	verified
Shuffler_05	ENDC with throughput with band combinations from CSV	verified
Shuffler_06	ENDC with 4x4 Max throughput with band combinations from CSV	verified
Shuffler_07	ENDC with NR 2CC with band combinations from CSV	verified

CA Combo	NR Cell 0 MIMO	NR Cell 0 NRARFCN	NR Cell 0 DL Scheduling (Start RB|Num RB|Modulation Type)
DC_1A_n78A	1	LOW	0|273|64 QAM|23
DC_7C_n78A	1	LOW	0|273|256 QAM|25
DC_1A_n_77A_n78A	1	LOW	0|273|64 QAM|15
DC_5A_n77C	1	LOW	

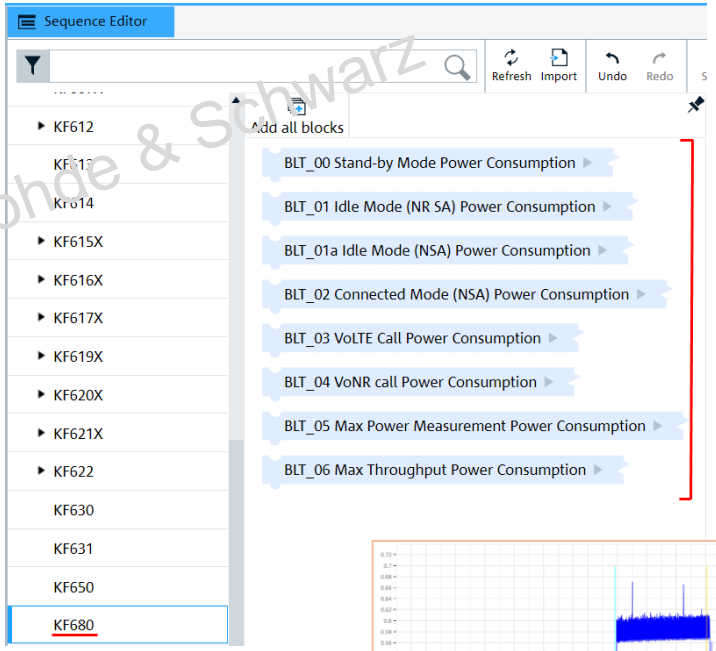
AUDIO QUALITY MEASUREMENTS

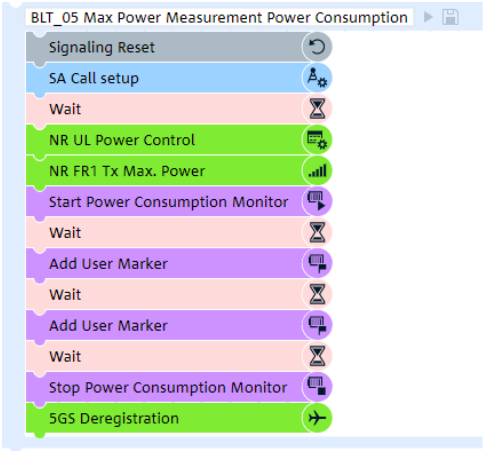
- CMsequencer
  for VoLTE & VoNR POLQA audio tests
- Everything on board – internal
  IMS Server & ITU-T P.501 Annex D
- Using CMX500 integrated POLQA measurements – no external Audio analyzer required – option CMX-KA181 in Cmsquares
- Easy to handle and clean setup



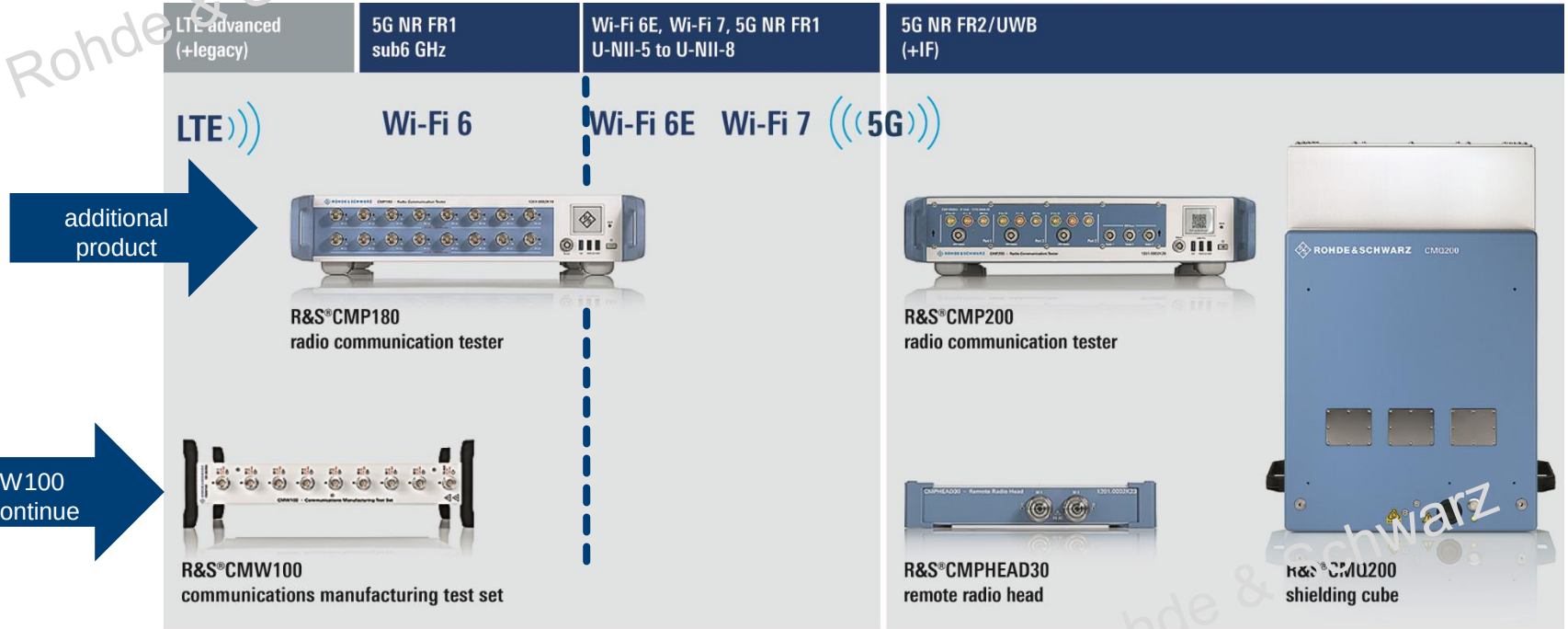
POWER CONSUMPTION TESTS

- Test script package for Battery life tests
- Rel.15 and Rel.16 features covered
- Test Reports summarizing power consumption at various events in test script

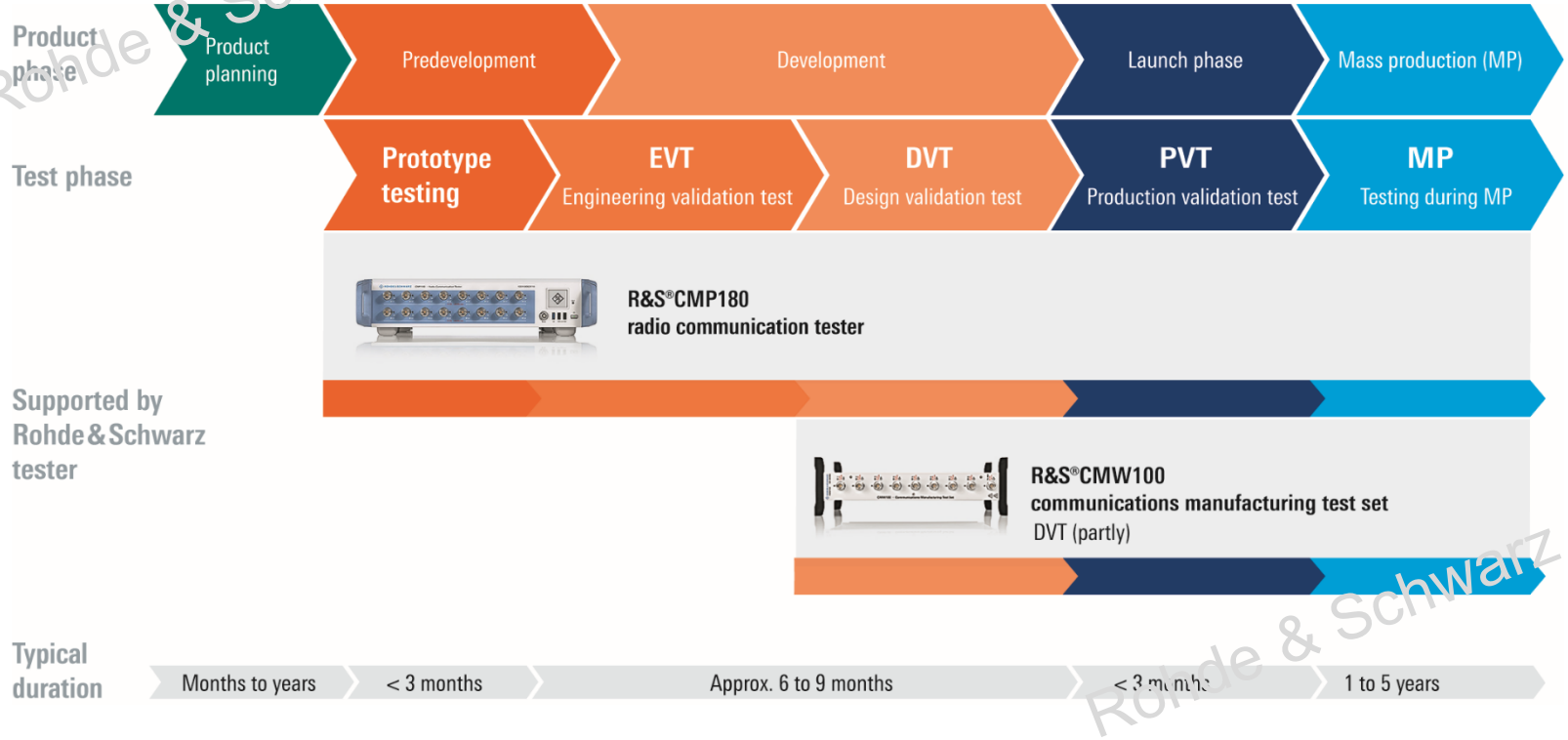




THE NEXT WORLD
R&S RADIO COMMUNICATION TESTER (NON-SIG)



PRODUCT DEVELOPMENT CYCLE



R&S® CMP180 NEW MEMBER IN THE CMP/CMX FAMILY

► General

- High performance radio communication tester for R&D and production purposes
- Support of all well known production features
  - Smart Channel
  - Broadcast

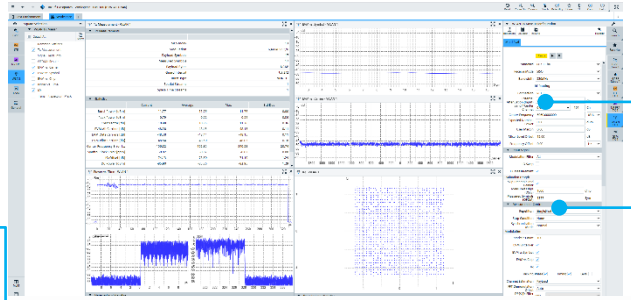
► R&S CMP180

- up to 2 VSAs / 2 VSGs / 2 x 8 bidirectional & full duplex RF ports
  - Enable 2nd Channel (VSA/VSG/ 8 RF ports)
- Frequency range
  - 400 MHz up to 6/8 GHz, up to 250/500 MHz bandwidth
- High accuracy
- Extraordinary EVM values

► Platform

- OS: Linux
- GUI: CMSquares
- Look & feel of CMP200 and CMX500

CMP180 OVERALL PRODUCT INFORMATION



Compact design
→ 2 HU x 19 inch
→ 1x HU per Channel

Higher Bandwidth: 250 / 500 MHz

Improved HF parameters
→ increased Freq. up to 8 GHz
→ increase output power +8 dBm
→ increased EVM performance

Enable 2nd Channel

Doubled number of analyzers and generators (2xVSA/2xVSG / 2x 8 RF ports)

Increased number of RF ports (2x8)

Integrated controller / processor

R&S NRPx PowerSensors connectable

Integrated power supply

Broadcast mode enables simultaneous transmission on all RF ports/outputs for receiver tests/ RX tests on the DUT

Integrated intuitive user interface CMsquares

Simple Option concept

Linux Operating System

Status Display

R&S®CMP180 supports RF testing of the primary wireless communication technologies

Technology	RF generator	RF analyzer
5G NR FR1	◆	◆
LTE-A	◆	◆
WCDMA/HSPA+	◆	◆
GSM/GPRS/EGPRS	◆	◆
eMTC	◆	◆
NB-IoT	◆	◆
C-V2X	◆	◆
CDMA2000, 1xRTT	◆	◆

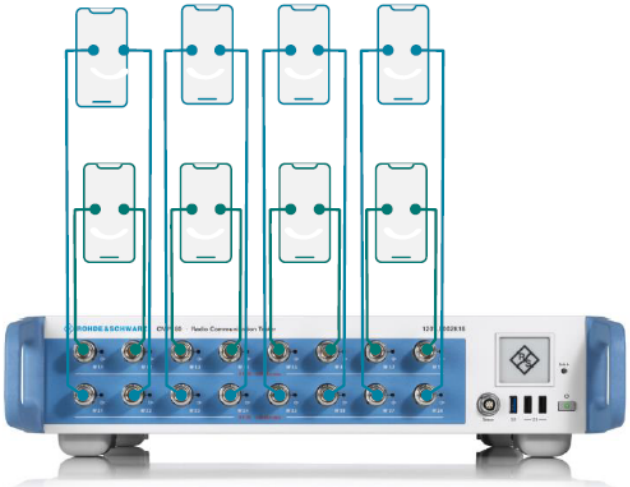
Technology	RF generator	RF analyzer
IEEE802.11a/b/g/n/ac/ax/be	◆	◆
Bluetooth® BR, EDR	◆	◆
Bluetooth® Low Energy	◆	◆
Low Power IoT		
802.15.4 (Zigbee, Thread)	◆	◆
LoRa®	◆	(-)
SigFox	◆	(-)
GNSS	◆	(-)

Multi DUT testing using CMP180 and Smart Channel / CMP-K108

Production

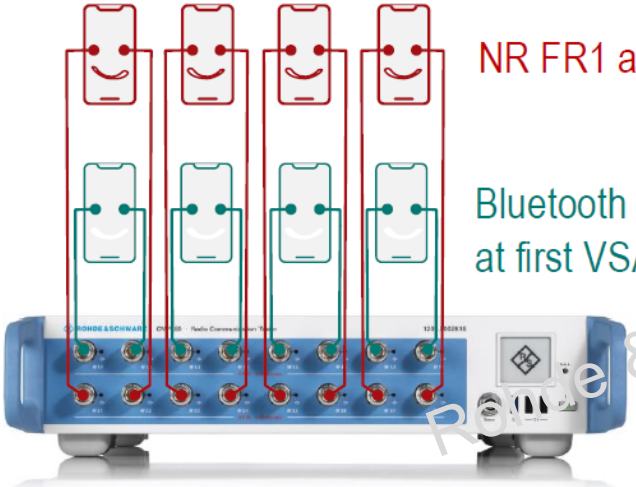
R&S®CMP180

Parallel testing on up to 16 RF ports
and R&S®SmartChannel support for
optimized test performance



R&S®CMP180

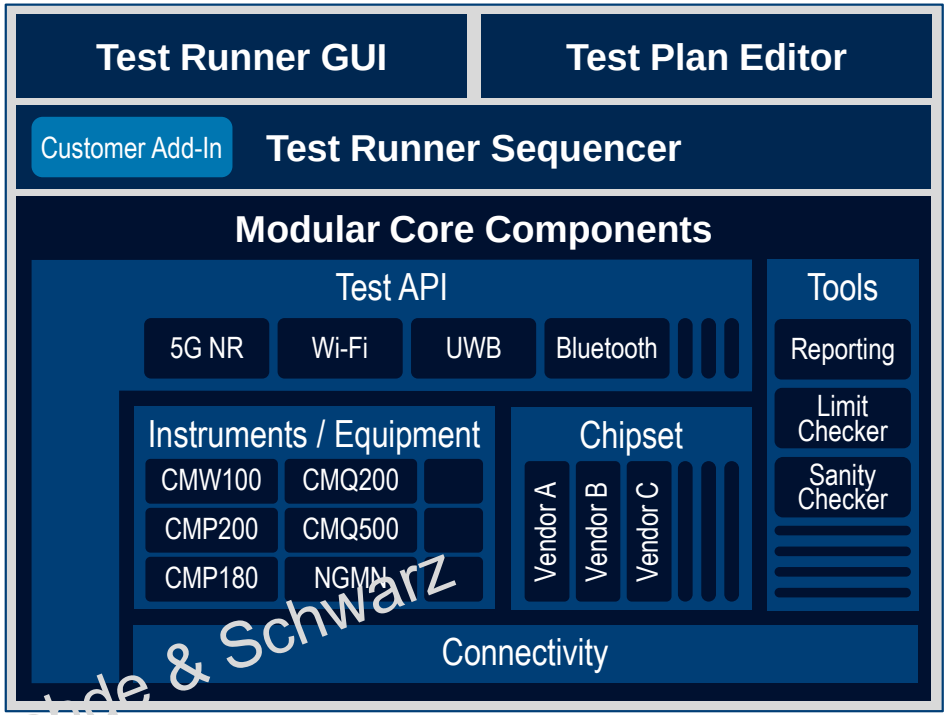
parallel test (simultaneous, independent)
of different technologies using different
VSA´s / VSG´s



NR FR1 at second VSA/VSG

Bluetooth / Wi-Fi
at first VSA/VSG

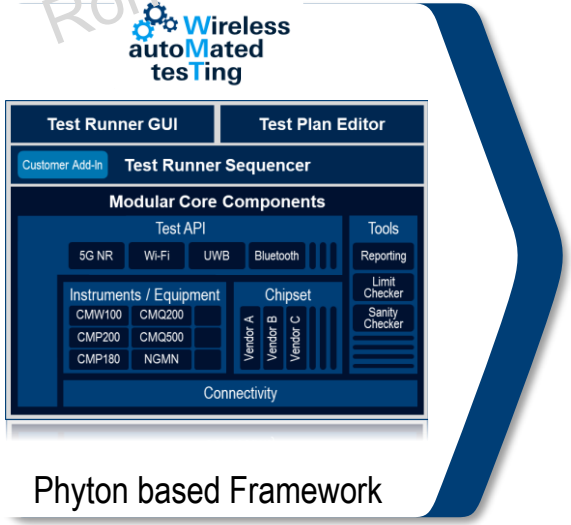
Ready to integrate wireless test automation framework which makes non-signaling testing fast, accurate & easy



Tailored for production testing and non-signaling R&D applications

- Flexible integration into any automated testing environment
- Fully customizable from a basic test tool to a full-blown turnkey solution incl. Phyton based customer add-ins.
- Field-proven speed of test execution
- High efficiency by broadcasting and interleaving (smart channel)
- Insightful and easy customizable GUI for sequencing and test plan creation

Our offering to provide a customized automated test solution based on WMT



Phyton based Framework

Customization & Integration

Automated Test Solution

Thank you for your attention!

"If you want to go fast, go alone.
If you want to go far, go together!"

African proverb

#THINKSIX 6G

https://www.rohde-schwarz.com/us/knowledge-center/videos/-thinksix-main-6g-research-areas-video-detailpage_251220-1043073.html