Wireless Communications

REDCAP MARKET OVERVIEW

Goce Talaganov
Market Segment Manager – Cellular Device

ROHDE&SCHWARZ
Make ideas real

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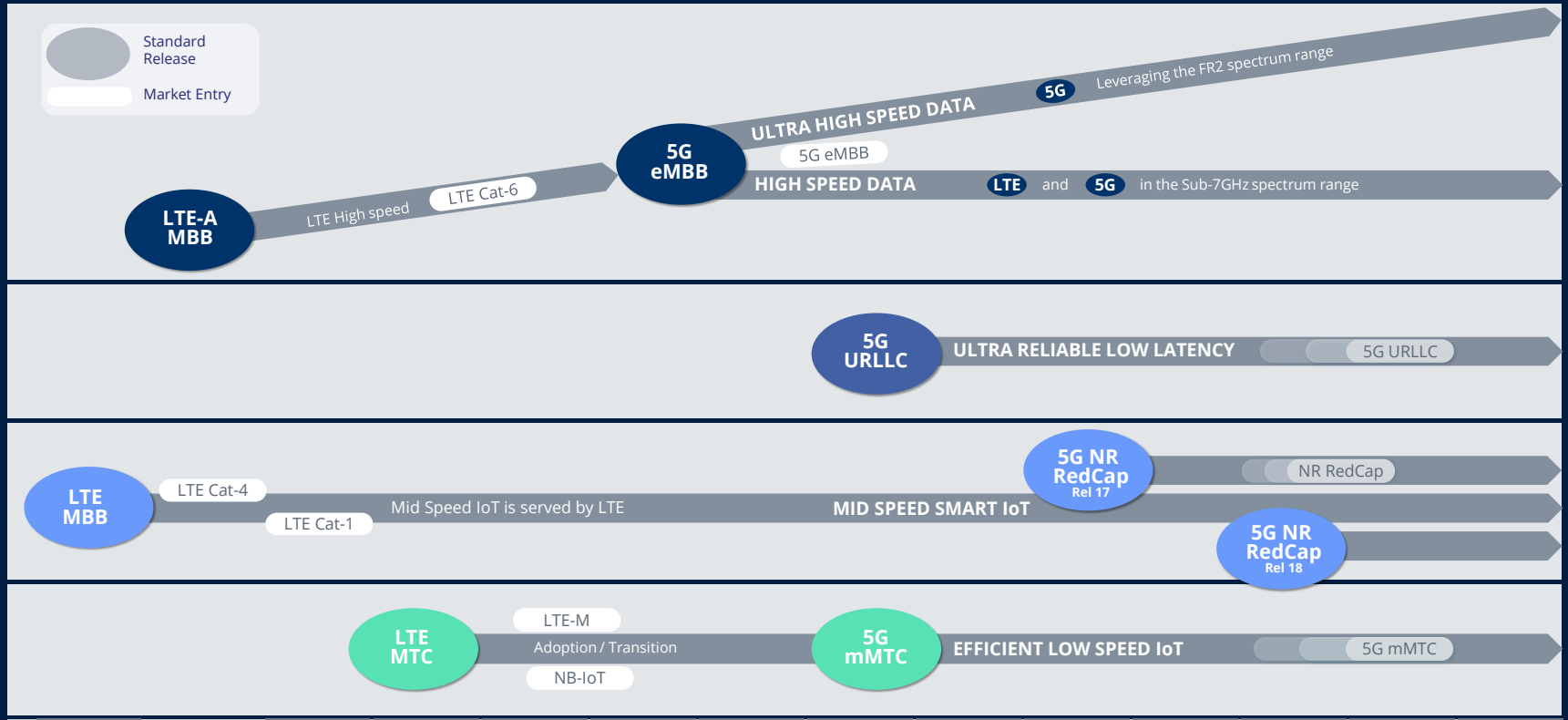
3GPP TECHNOLOGY EVOLUTION



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5G REDCAP MAIN USE CASES AND STAKEHOLDERS

5G RedCap

Consumer IoT
Wearables, XR

Industrial IoT
Surveillance, Robots

End User	MNOs	Infra/Chipset/Device OEM	Test Houses
• IoT – better price performance for different use cases, especially smart IoT, IIoT • XR, Drones, AI chat bots • More performant wearables • Future proof	• Future proof IoT 5G technology • Allow EoF life for other techno like LTE cat4 • New revenue streams/usecases XR, Drones • Expansion of 5G devices	• Driver for SA deployments and upgrades • New use case creation: XR, Drones • Mainly a SW upgrade in the core • Enable 5G adoption • Scale IoT and Wearable Chipset platforms • Enter new usecases	• New Device Types • More Testing • GCF/PTCRB • CE/FCC

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5G DEVICE EXPANSION WITH REDCAP – SMART IoT

Full 5G is too complex and power-hungry to fit into a smartwatch or similar.

high

Device complexity

low

eMTC/NB-IoT – 3GPP R15/16/LTE
Lowest complexity
and delay tolerance

Low end
wearables

Sensors:
agriculture,
smart city

Utility
meter

RedCap - 3GPP R17
Lower complexity
and power

Surveillance
cameras

High end
logistic

High end
wearables

High end
industrial
sensors

SMART IoT

eMBB/URLLC - 3GPP R15/16/LTE
Highest performance

*size of bubble indicates device cost

Device performance

high

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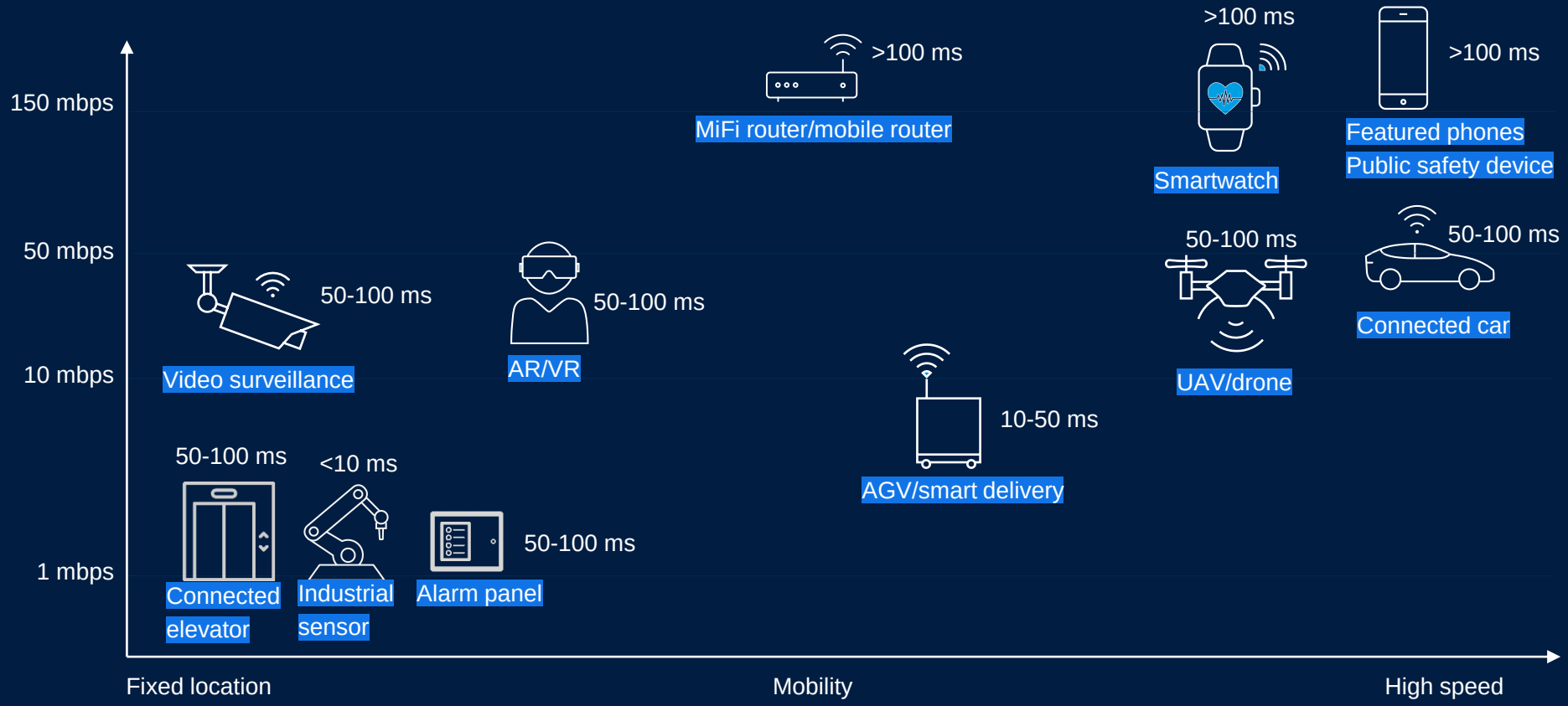
5G DEVICE EXPANSION WITH REDCAP CONTD.



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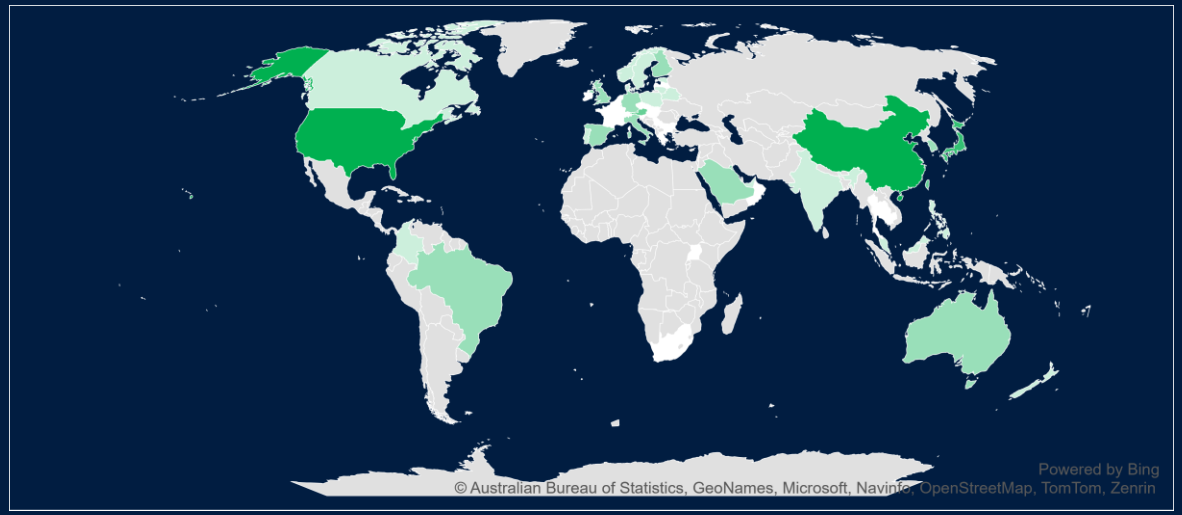
REDCAP DEVICE WORKS ONLY OVER 5G SA NW

578
5G Operators
out of which

- Commercial **299**
  - 5G SA **41**
  - mmW **59**
  - 5G FWA **109**
- Investing **277**
  - Deploying SA **75**
  - 5G FWA investing **45**
- 5G private **1148**
  Deploying/trialing/investing

4G: 2,500

Global status of 5G SA deployments (41 launched, 75 deploying investing)



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Huawei RedCap

Commercial Deployments: Huawei, together with China Mobile, China Telecom, and China Unicom, has implemented the end-to-end commercial deployment of RedCap in more than 10 cities

Usecases: manufacturing, electric power, and V2X

Etisalat UAE, STC Saudi Arabia, Zain KSA, STC Kuwait, Zain Kuwait, STC Bahrain, and AIS Thailand have also completed the technical verification or commercial pilot for RedCap.

More than 50 industry terminals are expected by EOF 2023

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Qualcomm RedCap

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Medaitek RedCap

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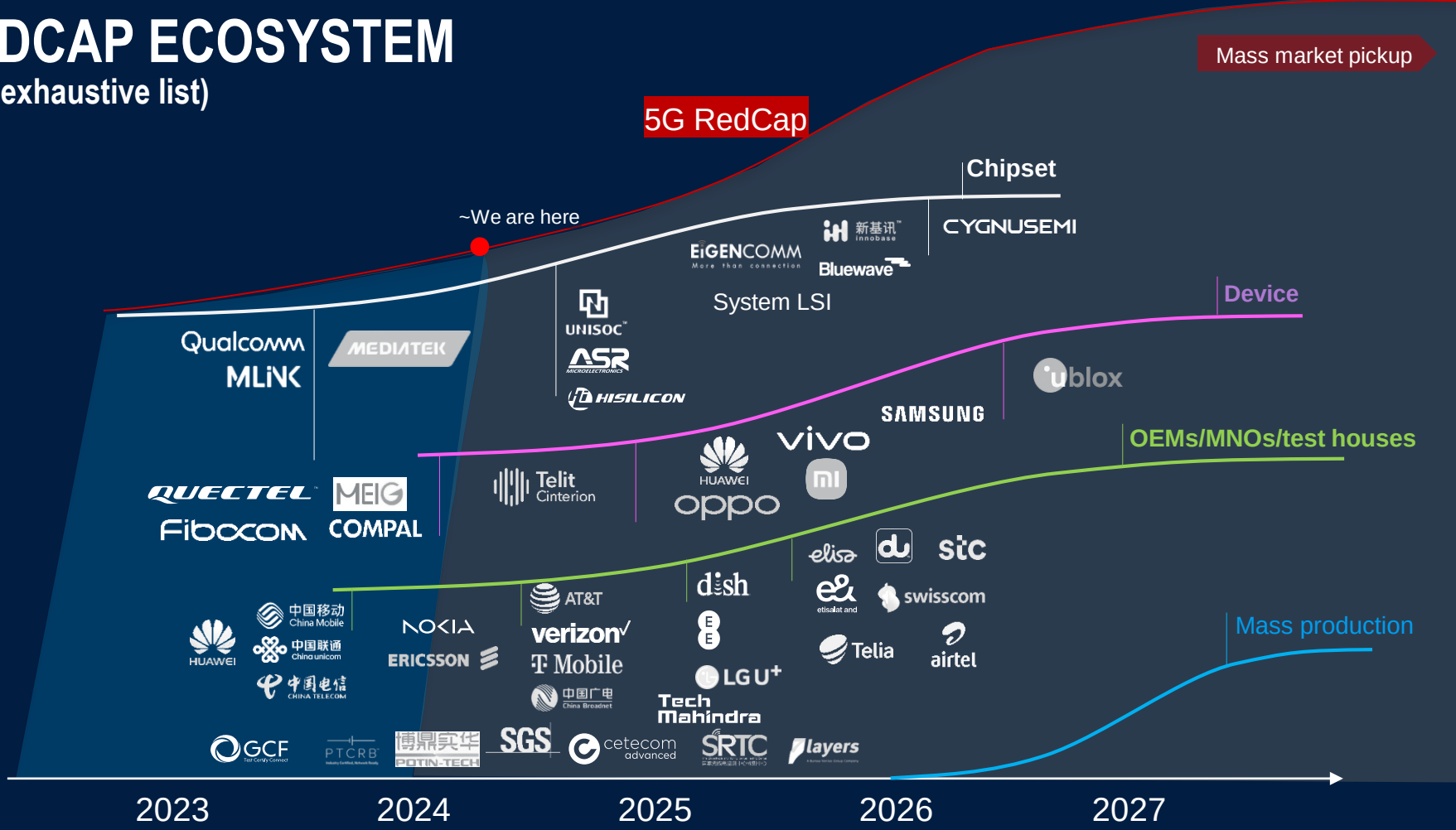
REDCAP ECOSYSTEM

(non-exhaustive list)



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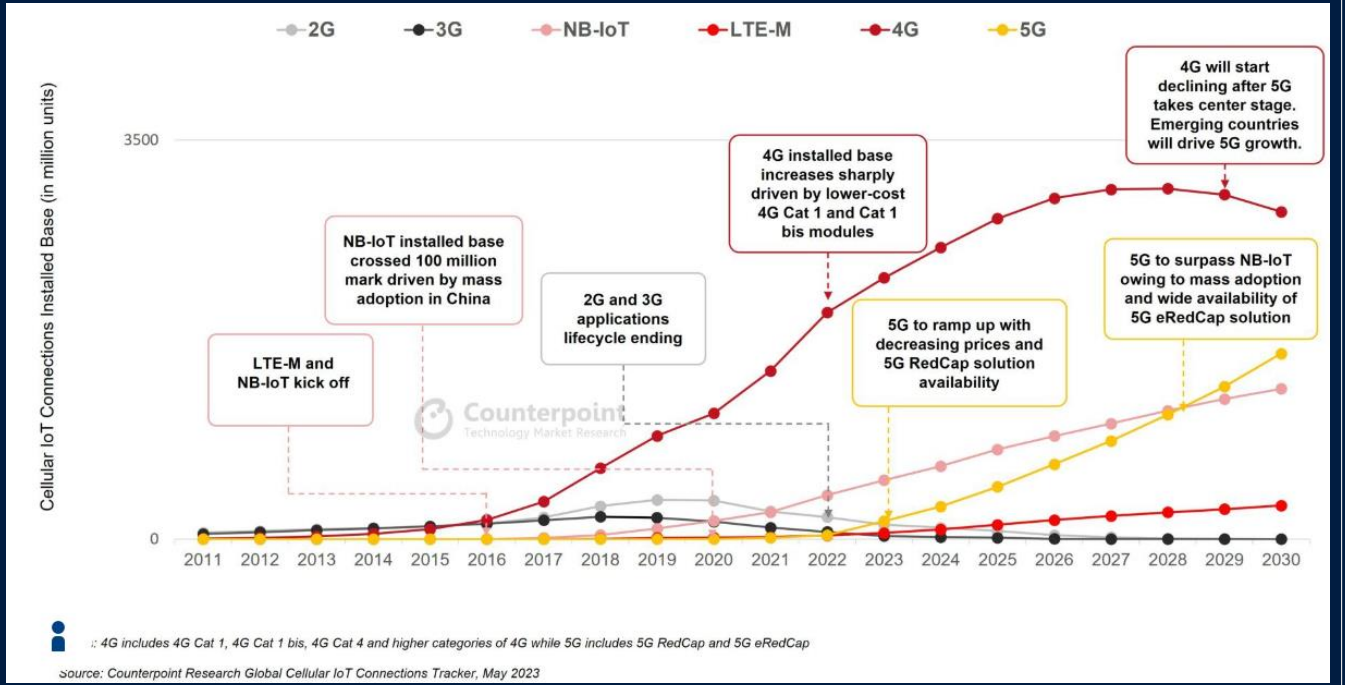
The RedCap connections are expected to exceed 100 million in the next three years



The global cellular IoT connections installed base is expected to surpass 6 billion by 2030 with a CAGR of 10.8%. The growth will be mainly driven by cellular connectivity adoption across various sectors such as utilities, automotive, industrial, retail and healthcare.

Unlike the previous decade, where consumer devices like smartphones and PCs played a significant role in driving cellular connections, this decade will see a shift towards cellular connections propelled by the digital transformation initiatives undertaken by enterprise IoT payers.

Highlights of cellular IoT connections installed base:

- Global cellular IoT connections grew 29% YoY to reach 2.7 billion in 2022 with 4G continuing to grow its majority share.
- China held over two-thirds of cellular IoT connections in 2022, followed by Europe and North America.
- NB-IoT dominates in China, while LTE-M is preferred in Australia, Japan and North America; Europe supports both.
- 4G and NB-IoT are the most preferred cellular IoT applications technologies.
- 5G is nascent as module prices and breadth of applications reflect early-stage dynamics.
- IoT growth drivers are shifting, with the enterprise and transformation initiatives key in propelling IoT connections forward.

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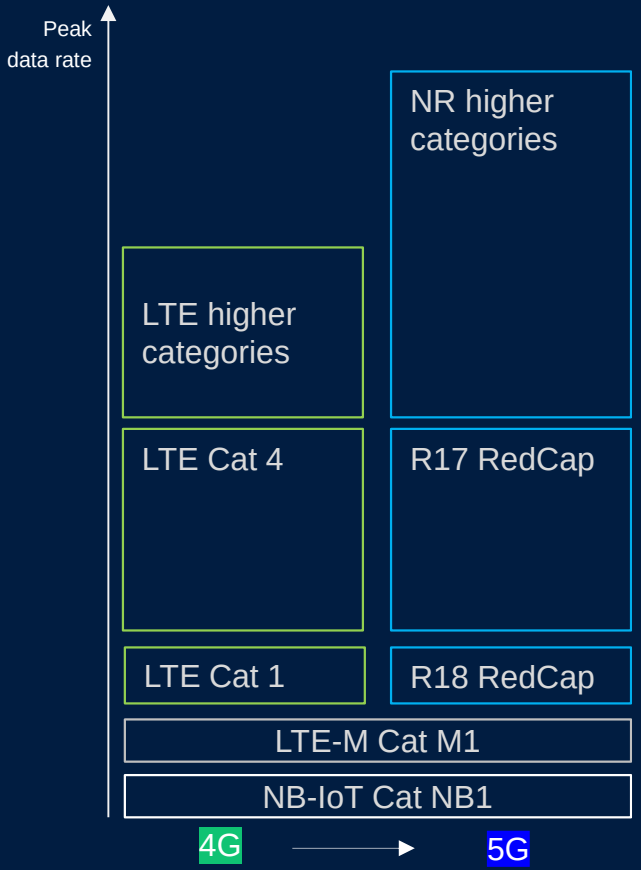
Cellular IoT Evolution



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/URLLC		✓	✓	✓	✗	✗
5G LAN		✓	✓	✓	✗	✗
Voice		VoNR	VoNR	VoNR	VoLTE	VoLTE
Mobility		✓	✓	✓	✓	✓
NTN		✓	Discussed	Discussed	✗	✗
Chipset/modem cost		$80-$150	$20-$40	$5-$20		

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RedCap Device – Optimized Features in R17

	Bandwidth reduction	Max bandwidth: 20 MHz (FR1), 100 MHz (FR2)
	Number of UE RX antennas Number of UE TX antennas	1 or 2 RX antennas (FR1), 2 RX antennas (FR2) Single TX antenna
	Optional support for higher order modulation schemes	Max modulation: 64QAM
	Half-duplex operation	Half-duplex mode
	Reduced capabilities for mobility scenarios and multicarrier operations	No CA, MR-DC, DAPS, CPC
	Early RedCap UE identification by the network UE capability specific network access restrictions	Early RedCap support indication Access restrictions for certain UE capabilities
	RRM measurement relaxation	Relaxation of RRM measurements
	Bandwidth part (BWP) operation Reduced number of data bearers (DRB)	UE-specific or RedCap-specific BWP Max 8 DRBs to achieve the desired throughput
	Shorter RLC and PDCP sequence number	12 bit RLC/PDCP sequence number, saving memory
PC3	Transmit power	Power class 3, extensions for FR2
✕	PUCCH frequency hopping disabled	Reduce uplink resource fragmentation
	Fewer frequency bands	Assumed fewer bands for reduced complexity

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RedCap Device – Optimized Features in R18

Bandwidth reduction to 5 MHz	Max bandwidth: 5 MHz (FR1), enables ~10 Mbps peak data rate
Future railway mobile communications system (FRMCS)	5G-based railway communications system, co-existence with GSM-R
RedCap for mission critical communications (MCX)	Support for direct device to device communications, possible 3 MHz bandwidth UE in NR band n28
RedCap sidelink support	Combines RedCap and NR-V2X features, includes operation on narrow bandwidth, power saving methodologies
RedCap enhancements for narrowband positioning	RedCap-optimized positioning methodologies, includes PRS transmission in narrow bandwidth, time of arrival measurements
Study on further RedCap complexity reduction	Additional complexity reduction techniques, UE processing relaxation, BWP operation with or without SSB and RF retuning

RedCap evolution	5G eMBB	Rel. 17	Rel. 18
Bandwidth	100 MHz	20 MHz	5 MHz
Peak rate	2 Gbps	100 Mbps	10 Mbps
Cost assessment	100%	-60%	-71%

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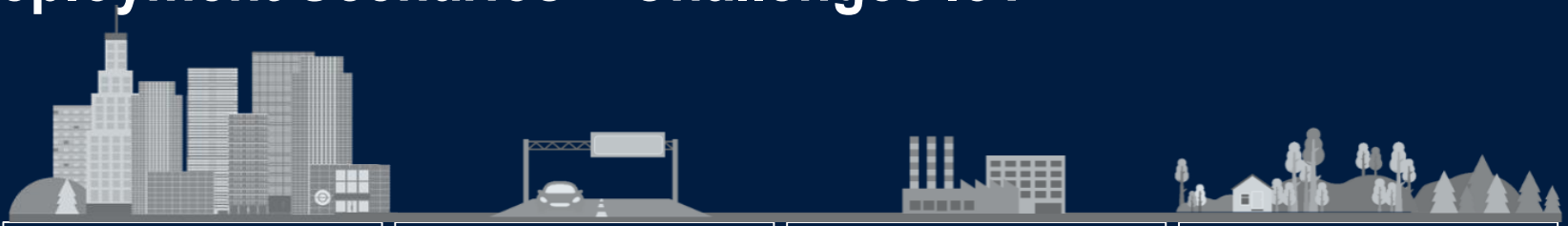
Deployment Scenarios – Challenges IoT



Dense urban	Nomadic/Mobile	Industrial sites / Private Networks	Rural
• Reflective environment with multiple paths • Small cells / hot spots • Frequent Handover • Highly dynamic • Varying network load over day time • Low mobility	• Varying network load over day time • Frequent handover • Roaming • Voice • High mobility + velocity	• Reflective environment with multiple paths • Private networks • High reliability • Long Term stability • Stationary	• Coverage scenario • Large cells • Low Mobility • Stationary
→ Challenge is dynamic environment	→ Challenge is mobility	→ Challenge is the specific use case	→ Challenge is coverage

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A Closer Look at Fallback for REDCAP devices

NR RedCap will be introduced with LTE fallback

- REDCAP/eRedCap is non backwards compatible, it requires 5G SA of Rel. 17/18
- Especially in early phase REDCAP will often operate in fallback mode, due to absence of NR SA network
  - LTE category depending on UE/HW configuration
  - Simple eMBB device „band restricted“
- Need for fallback will also impact REDCAP configuration
- Operating in fallback mode has implications on customer deployments due to availability / non-availability of certain features

Resulting Challenges

- Impact on test
  - LTE fallback needs to be considered on all test setups - Availability
  - Test solution as close as possible to customer scenario – Remote/Mobile solutions

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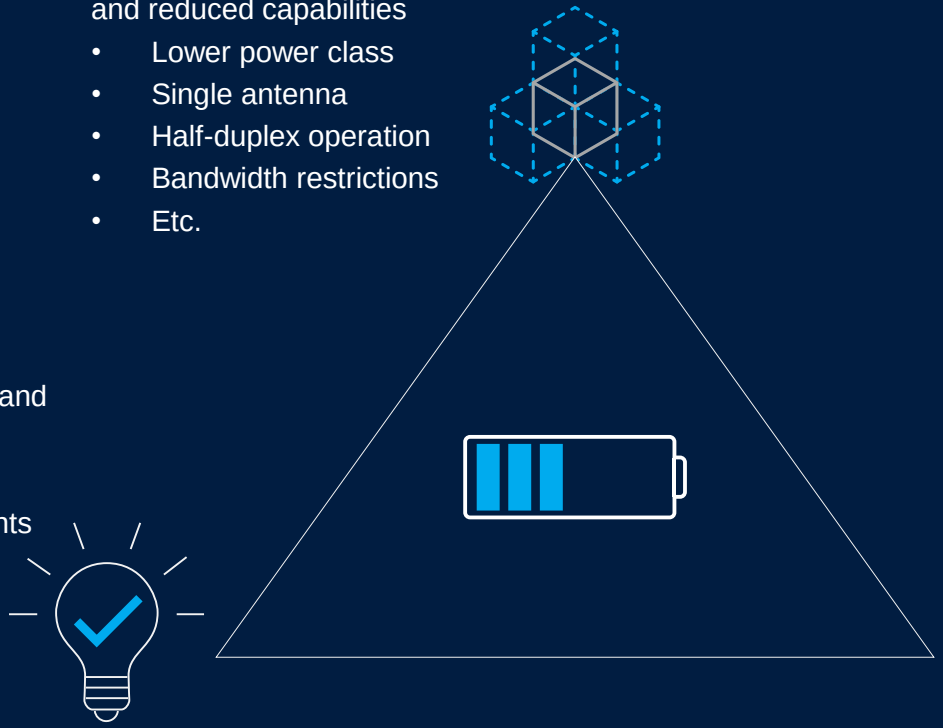
RedCap Device Power Saving Cluster

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.

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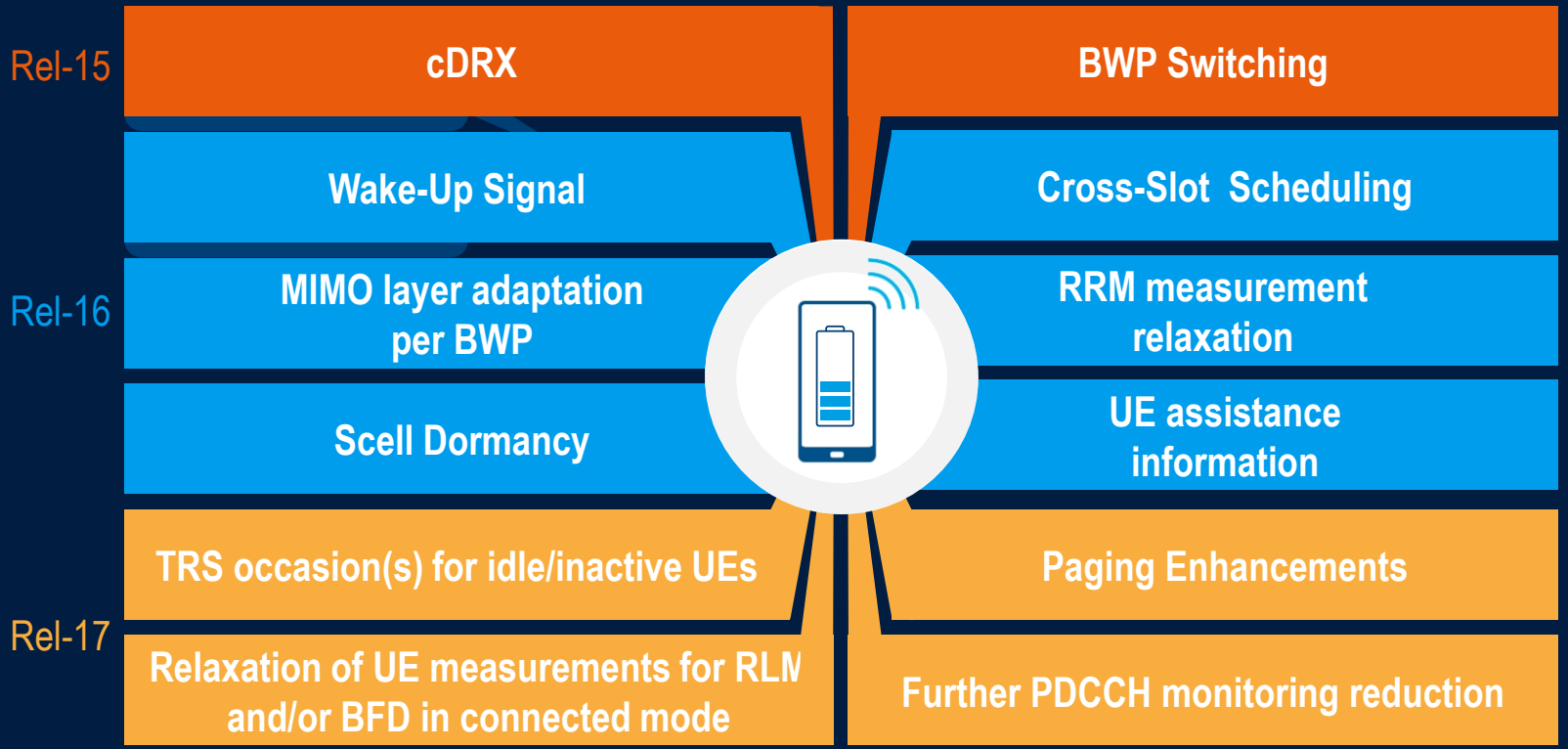
3GPP features to improve 5G NR power consumption



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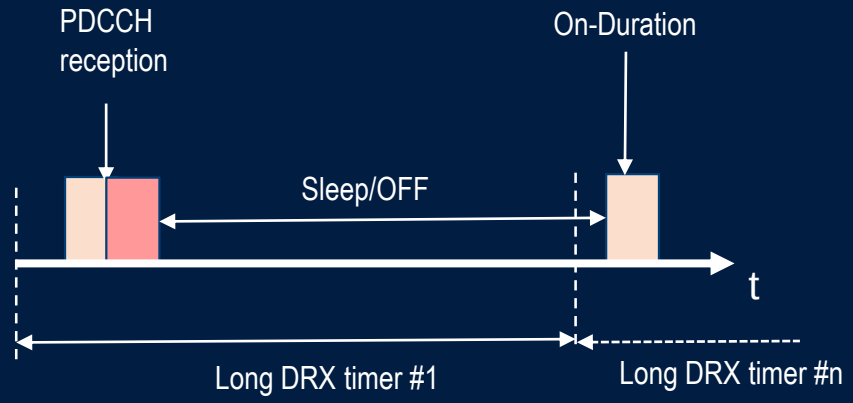
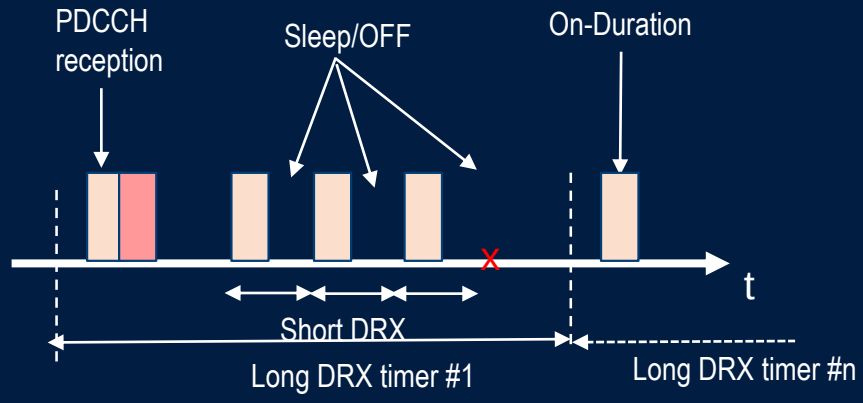
cDRX is a key feature to improve UE power consumption

Challenge
A UE is required to frequently monitor PDCCH for e.g. possible DL data transmission assignments or UL grants. Decoding the PDCCH is one main source of UE power consumption

Solution
Discontinuous reception configures periodic “on-durations” e.g. 10ms once every 160ms in long DRX. Only during the on-duration time the UE is required to monitor the PDCCH. The rest of the time the device can remain in sleep mode, turning off its receiver and thus save power.





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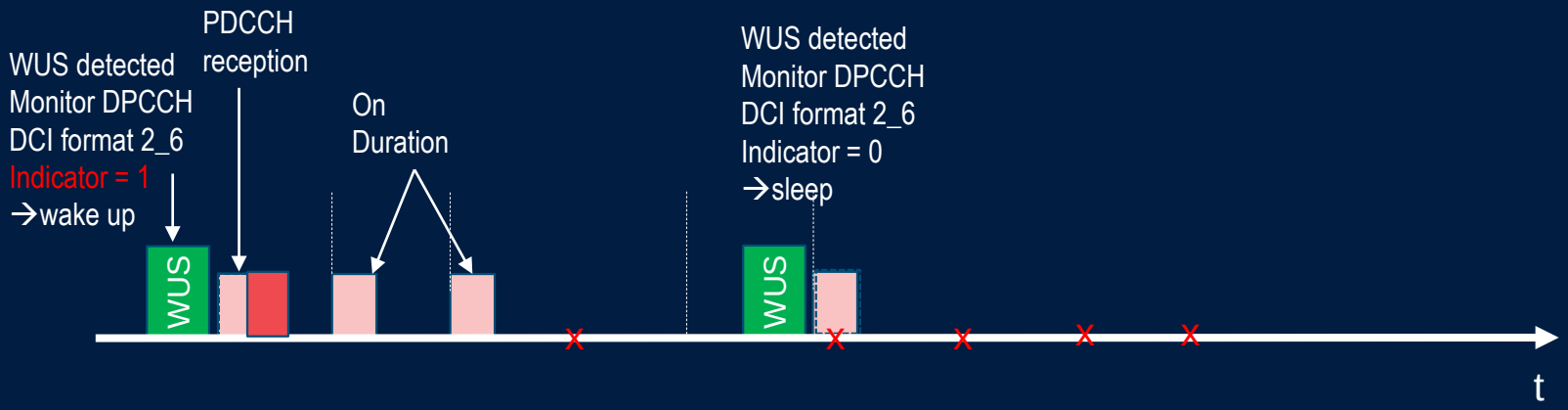
WUS (Wake-up Signal) Connected mode DCI format 2_6

Challenge
UE consumes power, when it periodically wake up to monitor PDCCH during the DRX OnDuration (MO).

Solution
A wake-up signal indication (WUS) conveyed by DCI signaling with a new DCI format 2_6. This WUS informs UE whether or not to start the DRX OnDuration timer for the next DRX cycle for potential data scheduling.



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Webinar January 24, 2024 by Lothar Walther

Power Saving Techniques for User Equipment in 5G Releases 16/17 (Asia/Europe)

Broadcast Time:

Wednesday, January 24, 2024 Duration: 1 hour

Summary:

This webinar focuses on user equipment (UE) power saving techniques introduced by 3GPP Releases 16 and 17 and how to measure the battery lifetime of 5G devices. Since the beginning of mobile communication, UE power consumption has been a key performance indicator (KPI). UE power consumption converts directly to battery lifetime, which extends to user experience and 5G device usability. Every generation of phones and mobile communication standards have added new services, more computing power and larger displays - all of which increase UE power consumption. To address this, every 3GPP release also introduces new sophisticated techniques to reduce UE power consumption. This usually entails finding a balance between power consumption and power throughput and/or latency.

Attendees will learn:

- Main drivers of UE power consumption
- Power saving techniques introduced by 3GPP Rel16/17
- How to measure the UE battery lifetime

Speaker:

Lothar Walther
3GPP RAN2 Delegate, Rohde & Schwarz

Register for our alternative time slots:

4:00PM SGT (Asia/Singapore) / 9:00AM CET (Central Europe)

2:00PM CET (Central Europe) / 8:00AM EST (North America)

1:00PM EST (North America) / 7:00PM CET (Central Europe)

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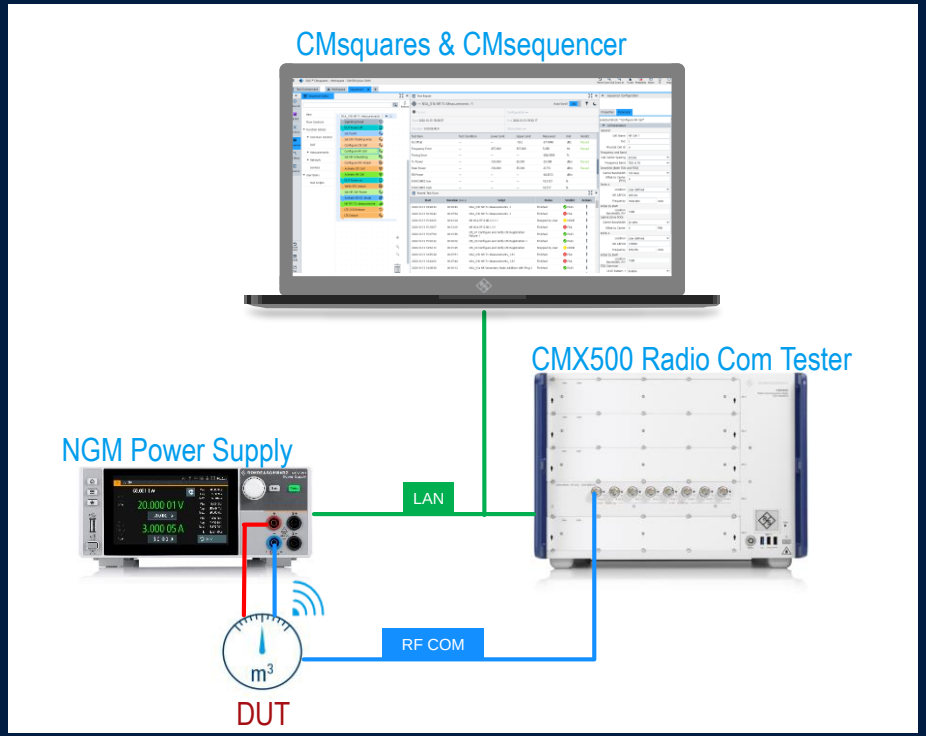
R&S®CMX500 – Power consumption testing



The R&S®CMX500 Battery Life Testing solution offers seamless power consumption measurements in parallel to:

- RF measurements: power consumption vs. max. RF Power (FR1, FR2, multiple CC combinations)
- Protocol testing: power consumption vs. Power saving features (c-DRX, PDCCH WUS, etc.)
- Application testing: power consumption vs. E2E TP testing, web browsing, video streaming, gaming, etc.
- Multi-technology solution for all standards supported by the R&S®CMX platform
  - LTE, 5G FR1/FR2 incl. RedCap

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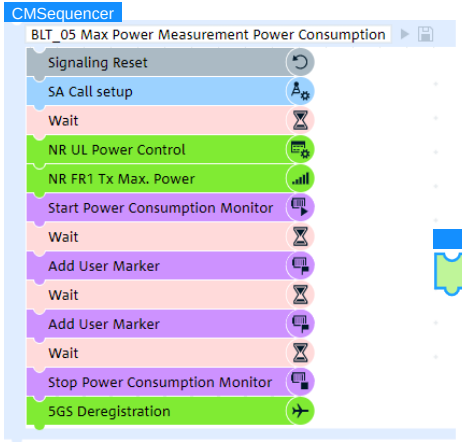
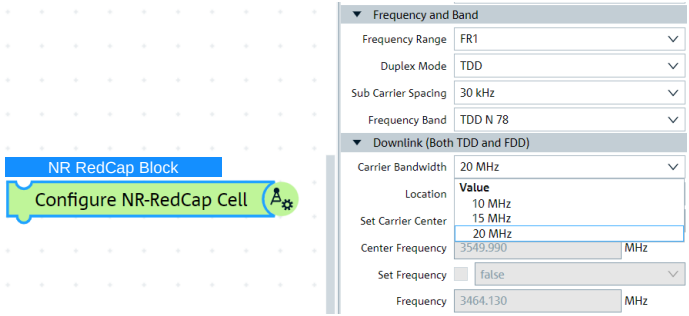
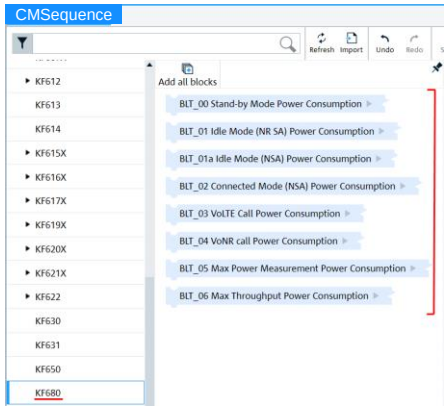
CMsequencer Power Consumption Scripts

- Test script package for Power Measurements
- Rel.15 / 16 / 17 UE power saving features covered
- Dedicated block for RedCap Cell configuration
- Test Reports summarizing power consumption at various events in test script







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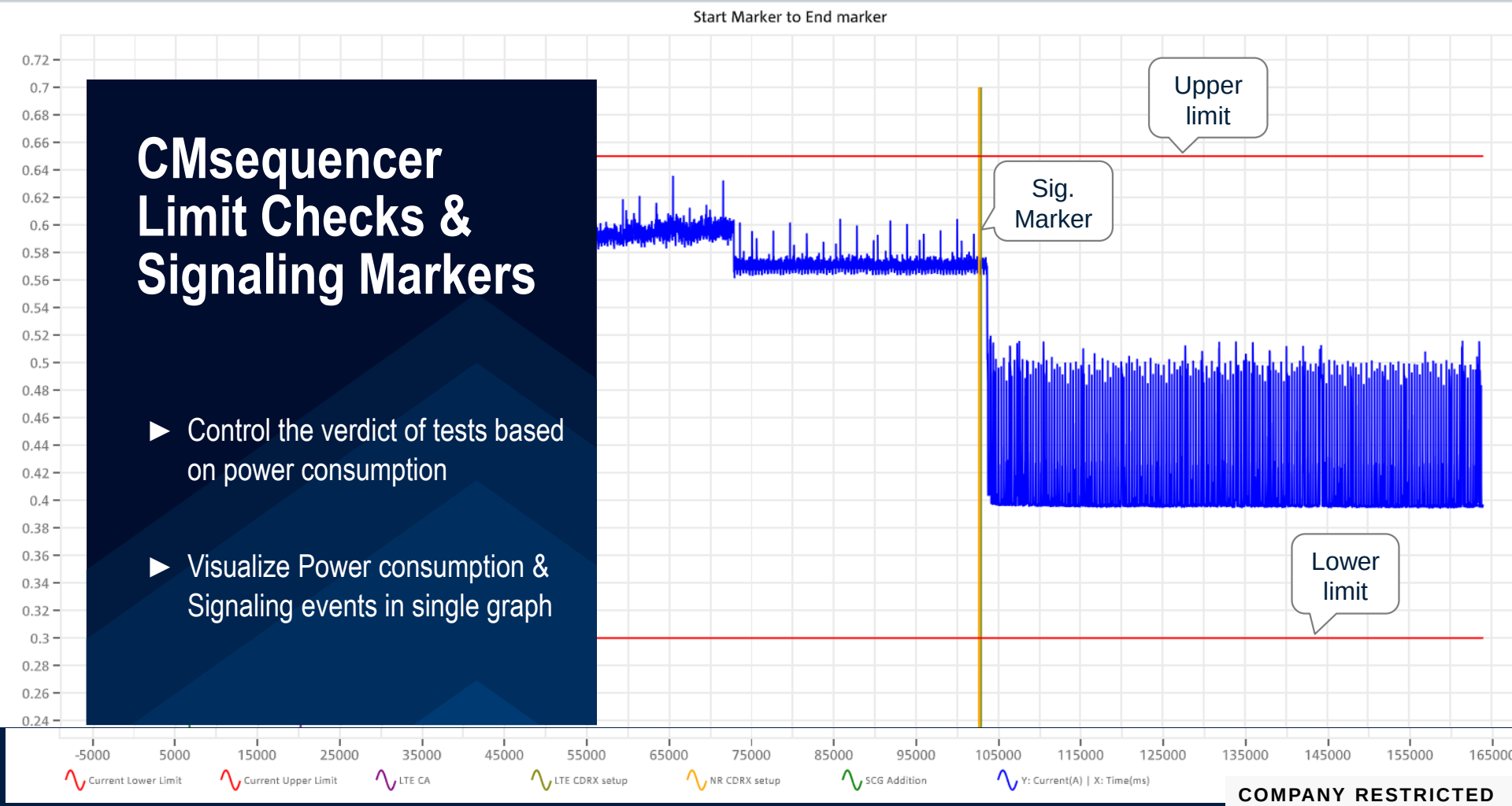
CMsequencer Limit Checks & Signaling Markers

- Control the verdict of tests based on power consumption
- Visualize Power consumption & Signaling events in single graph



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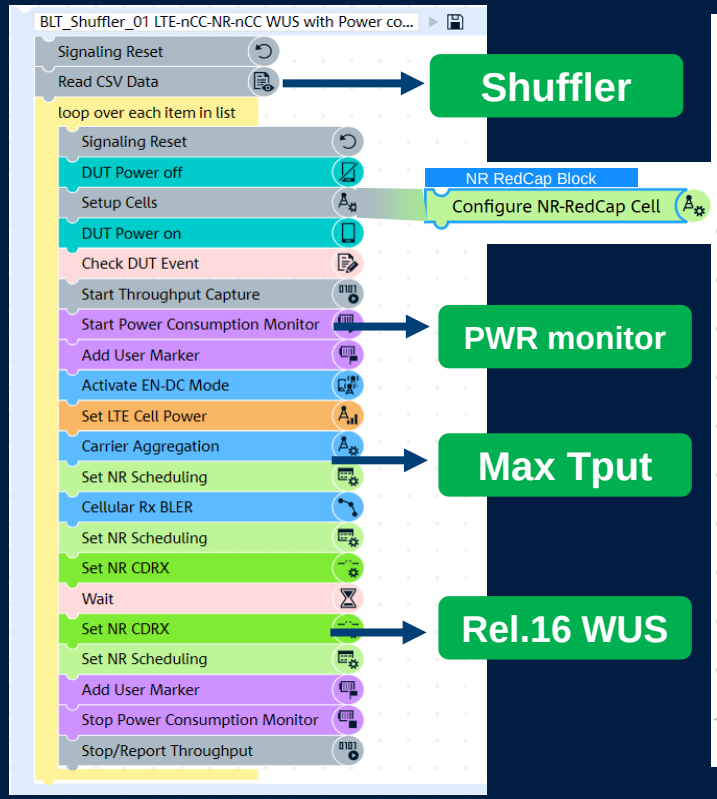
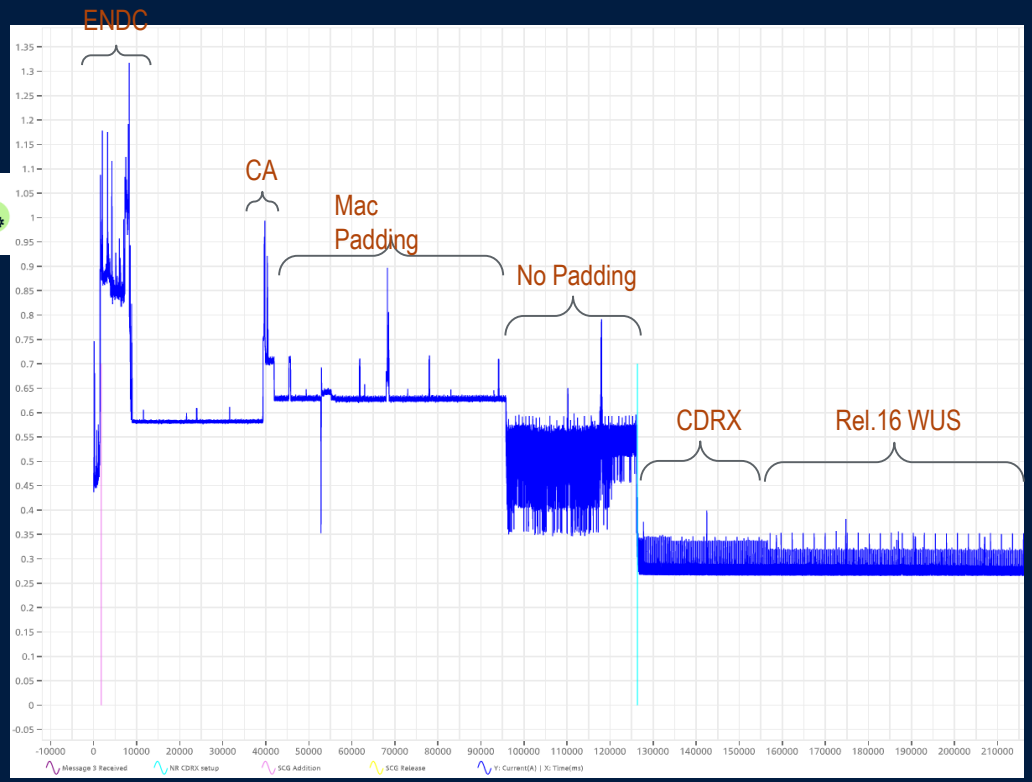
Demo – Many use cases, ONE script





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RedCap PRs

UNISOC

ASR MICROELECTRONICS

HISILICON

MEDIATEK

Qualcomm

QUECTEL

Munich / 14-Feb-2023

Leading chipset manufacturers test and verify 5G RedCap using R&S CMX500 in R&D and type approval stages

Rohde & Schwarz helps Tier 1 chipset manufacturers around the globe to verify 5G RedCap (Reduced Capabilities) and other 3GPP Release 17 features of their products. The tried and tested R&S CMX500 5G one-box signaling tester (OBT) can be used across the whole value chain, from early R&D to type approval conformance testing. At Mobile World Congress 2023 in Barcelona, Rohde & Schwarz is showcasing its radio communication tester in the new R&S CMX500 OBT lite hardware configuration, tailored specifically for lower data rate applications like 5G RedCap.

Munich / 01-Jun-2023

Rohde & Schwarz takes lead in number of GCF-validated 5G RedCap conformance test cases

Rohde & Schwarz has successfully validated 5G RedCap (reduced capability) test cases for its R&S CMX500 one-box signaling tester and R&S TS8980 conformance test system for the recent Conformance Agreement Group (CAG) #74 meeting, allowing the Global Certification Forum (GCF) to activate the respective work items in their device certification program. Manufacturers of IoT chipsets, modems and end devices as well as test houses can now rely on tried-and-tested Rohde & Schwarz solutions for 387 5G RedCap test cases in all device production stages, from early R&D to type approval conformance testing.

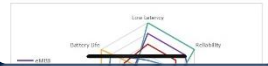
R&S联合紫光展锐在MWC共同展示RedCap测试方案

原创 罗德与施瓦茨中国 罗德与施瓦茨中国

2023-06-29 11:54 发表于上海

3GPP Rel17核心规范已经于2022年6月冻结，而RedCap无疑是Rel17非常重要的特性之一。RedCap定义的初衷是为了进一步降低终端复杂度和成本。

RedCap在功耗，成本以及覆盖方面略逊与NB-IoT和LTE-M，但是在速率，可靠性和延迟方面都要优于NB-IoT和LTE-M。因而RedCap的应用适用于较低复杂度和较低功耗要求的场景，比如工业无线传感器，视频监控和可穿戴设备等。



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Find out more

www.rohde-schwarz.com/redcap

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