

RETHINK 5G TESTING – HOW TO IMPLEMENT THE ULTIMATE 5G DEVICE EXPERIENCE FOR SUITABLE USE CASES AND MARKETS

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ROHDE & SCHWARZ

Make ideas real



THE STATE OF THE 5G GLOBAL ECOSYSTEM

Q3 2022 SNAPSHOT



88

CHIPSETS

out of which

COMMERCIAL 82

mmW **44**

SA **68**

ANNOUNCED 6

mmW **4** (FWA)

SA **3**



1521

DEVICES

out of which

COMMERCIAL 1267

mmW **117**

FWA CPE **217** (30 mmW)

SA 175

ANNOUNCED 254

mmW **36**

FWA CPE **89** (20 mmW)

SA 22



502

OPERATORS

out of which

COMMERCIAL 226

5G SA **26**

mmW **59**

5G FWA **90**

INVESTING 276

DEPLOYING **32**

5G FWA INVEST. **52**

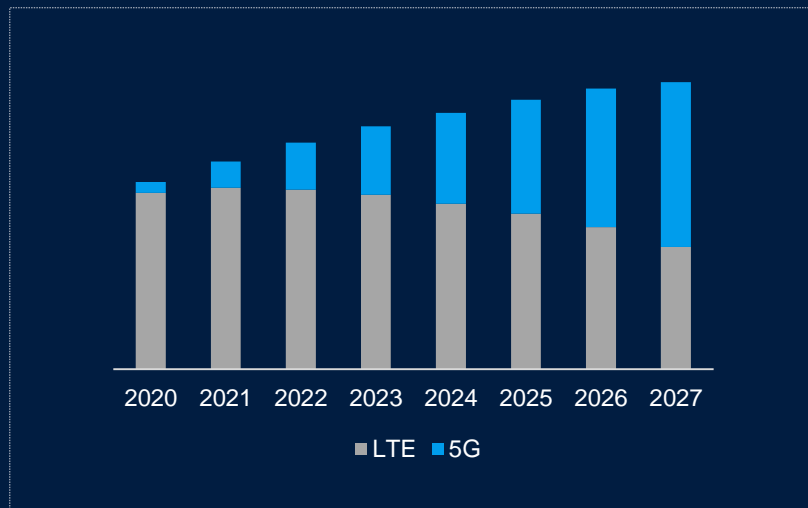
5G PRIVATE 193

DEPLOYING/TRIALING/INVESTING



690M

CONNECTIONS



THE STATE OF

5G users vs. 4G users

- use 40 GB of data every month
- stream 2x more video
- spend 1.5x more time on social media
- play mobile games 3x more often
- eMBB is the most common use case

FUTURE SERVICES

FWA

fixed wireless brings broadband connectivity at home, so users can enjoy the same ultra-fast and reliable 5G experience in the place they spend much of their time across an ecosystem of devices.

IIoT

pushes 5G to other use cases and device types. For example connectivity in 5G smart factories is enabled with 5G routers and other peripheral sensor based devices based on NR-Light/RedCap.

NTN

brings connectivity to areas where there is no service at all today, especially for mission critical messaging

XR

extended reality services are in the making by the biggest companies of the world. The possibility of these devices are endless fueled by 5G and low latency.

5G DEVICE - VALUE CHAIN



Chip vendor



Device manufacturer



Test house



Network operator

Use cases

R&D	Production
RF Signaling Application OTA Pre-conformance	Non signaling RF

R&D	Production
Non-signaling RF Signaling Protocol Application OTA Pre-conformance	Non signaling RF Service and repair

Lab
Conformance approval Carrier acceptance OTA

Lab
Conformance approval Carrier acceptance OTA Operations

Types of mobile devices



Phones



Wearables



Tablets



CPE













IoT



IIoT

TESTING ENGINEERS ARE ESSENTIAL PART OF THE DEVICE ECOSYSTEM, AND THEY NEED THE BEST IN CLASS T&M INSTRUMENTS

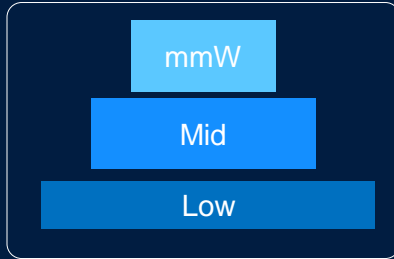
	R&D			Validation and Conformance		Manufacturing
Job	 <p>RF Engineer/Test</p> 	 <p>Signaling Engineer/Test</p> 	 <p>Application Engineer/Test</p> 	 <p>Conform. Engineer/Test</p> 	 <p>Production Engineer/Test</p> 	
Goal	<ul style="list-style-type: none"> Characterize and optimize parametric RF transceiver sub systems Debug and trace 	<ul style="list-style-type: none"> Chipset L1-L4 test plan and verification Investigate and debug modem stack 	<ul style="list-style-type: none"> Validate and optimize end to end performance of IMS/SIP/TCP/IP Investigate and debug app stack 	<ul style="list-style-type: none"> Plan, develop, execute 3GPP/carrier device tests Radiated and conducted testing 	<ul style="list-style-type: none"> High yield of devices with high quality Achieve shortest test time possible (time=money) 	
Tasks	<ul style="list-style-type: none"> Optimization of cellular transceiver systems Meet 3GPP specifications or custom design criteria 	<ul style="list-style-type: none"> Assure robustness/reliability and performance on each layer of the stack L1-L3 Optimize each stack for highest throughput and defined KPIs 	<ul style="list-style-type: none"> Ensure robustness/reliability and performance on IMS, TCP/IP stack and other app protocols Optimize the application according to defined KPIs 	<ul style="list-style-type: none"> Conformance of final product according to 3GPP specs and KPIs Conformance of final product for different carriers 	<ul style="list-style-type: none"> Test framework for new product introduction, passing the pilot production tests Makes sure both HW/SW is working as designed 	
Products	<ul style="list-style-type: none"> SMW/FSW/Oscilloscopes CMX500/CMW500 ATS1800 CMP200/CMP180 	<ul style="list-style-type: none"> CMX500/CMW500 (incl. CMSquares) CMQ/ATS 	<ul style="list-style-type: none"> CMX500/CMW500 (incl. CMSquares applications) CMQ/ATS 	<ul style="list-style-type: none"> CMX500/CMW500 (incl. CMSquares applications) CMQ/ATS Contest (RRM, PQA, LBS, PCT, NPT, RF OTA) 	<ul style="list-style-type: none"> CMP180 CMP200 CMW100 CMX500/CMW500 for signaling CMQ 	

R&S® CMX500 – PLATFORM OVERVIEW

- ▶ Future proof 5G signaling test platform
- ▶ Running on Linux: faster & more robust
- ▶ Single web-based GUI for RF, protocol and application testing
- ▶ Modular and scalable HW-Architecture
- ▶ LTE & FR1: up to 8 GHz
- ▶ FR2: 24 – 50 GHz
- ▶ Ready for up to 20 Gbps and more E2E IP performance
- ▶ Extensive IP and Application Test feature set onboard

5G DEVICE REQUIREMENTS

Spectrum & bands



5G enhancements

Battery saving features

C-drx
BWP
WUS
RedCap

5G Rel.16 features
5G SA

SRS antenna switching
MIMO enh.
Wus

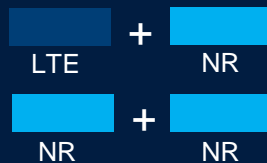
Sub-6 3CC/4CC → 5CC
mmWave 4CC/8CC → 10CC
7.9 Gbps → 10 Gbps
FR1+FR2 ENDC → FR1+FR2 DC/CA

Spectral efficiency features

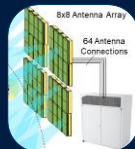


Speed & capacity

Aggregation



Massive MIMO



2x2 → 4x4

Voice & services

EPS Fallback
5G → 4G LTE

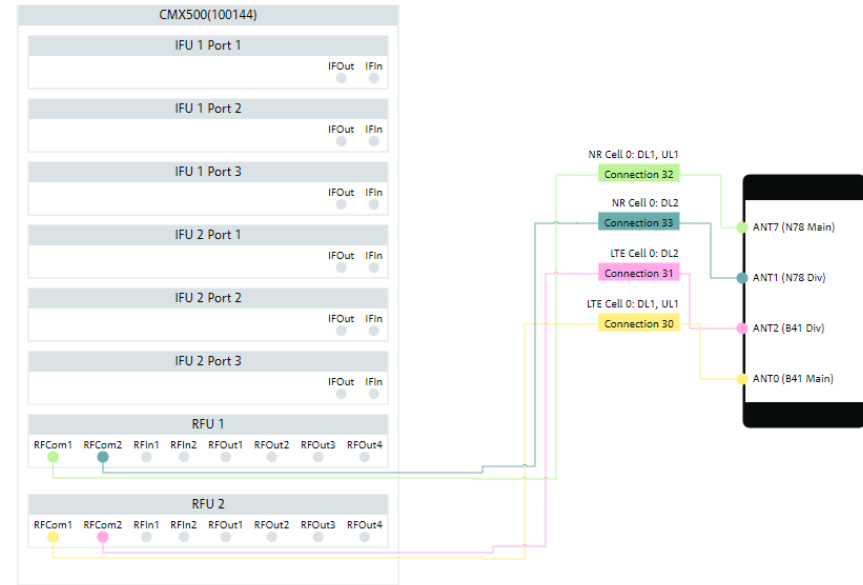
VoNR
5G

R16 positioning

Network slicing features

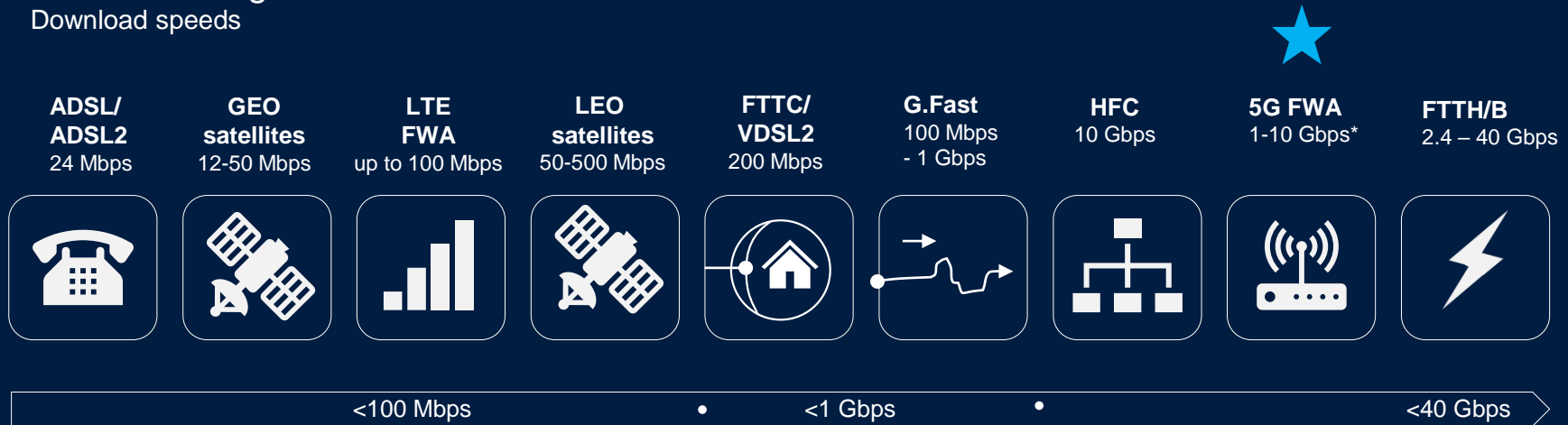
CABLE ROUTING: CONNECTION SELECTION

- ▶ DUT-centric routing approach
- ▶ Idea:
 - Customer will test based on DUT profiles
 - DUT profile contains supported bands and DUT connectors
 - Internal routing makes sure that DUT will work for all use cases
 - Without recabling



5G IS MAKING FWA COMPETITIVE**

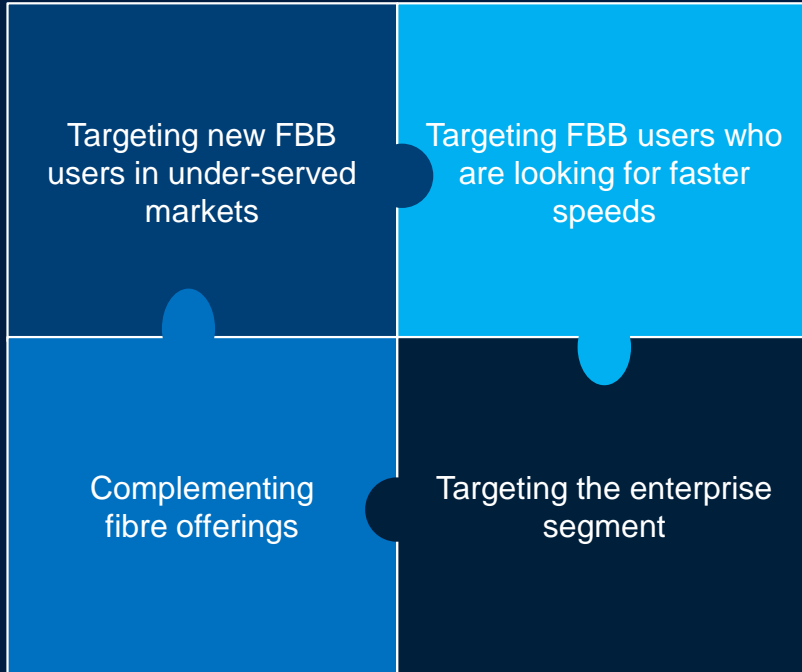
FBB technologies Download speeds



Italian Telco Fastweb has unveiled its latest strategic plan that will see it spend €3 billion on network expansion, including 5G and FWA, over the next three or so years.

THE FWA VALUE PROPOSITION

FWA POSITIONING



FWA TCO

10 Years TCO FWA vs. FTTH

When new ducts/poles are needed

In Rural
up to 65% costs saving

In suburban
up to 45% cost saving

In urban
up to 25% cost savings

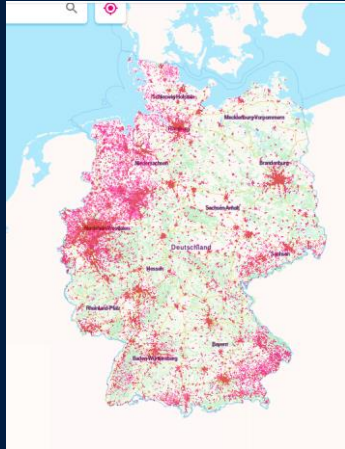
FBB and FWA strategy

1. Fiber where viable
2. FWA where viable
3. Leo as last resort



FWA OPPORTUNITY – EXAMPLE: GERMANY

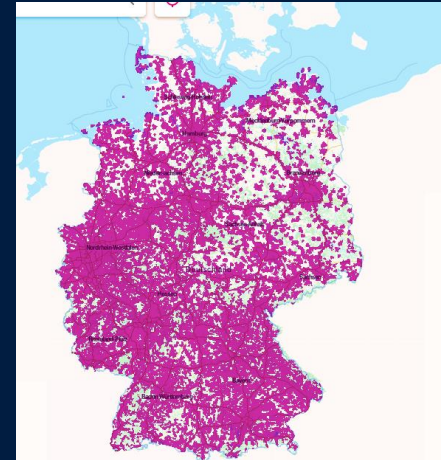
DSL coverage



FTTH coverage

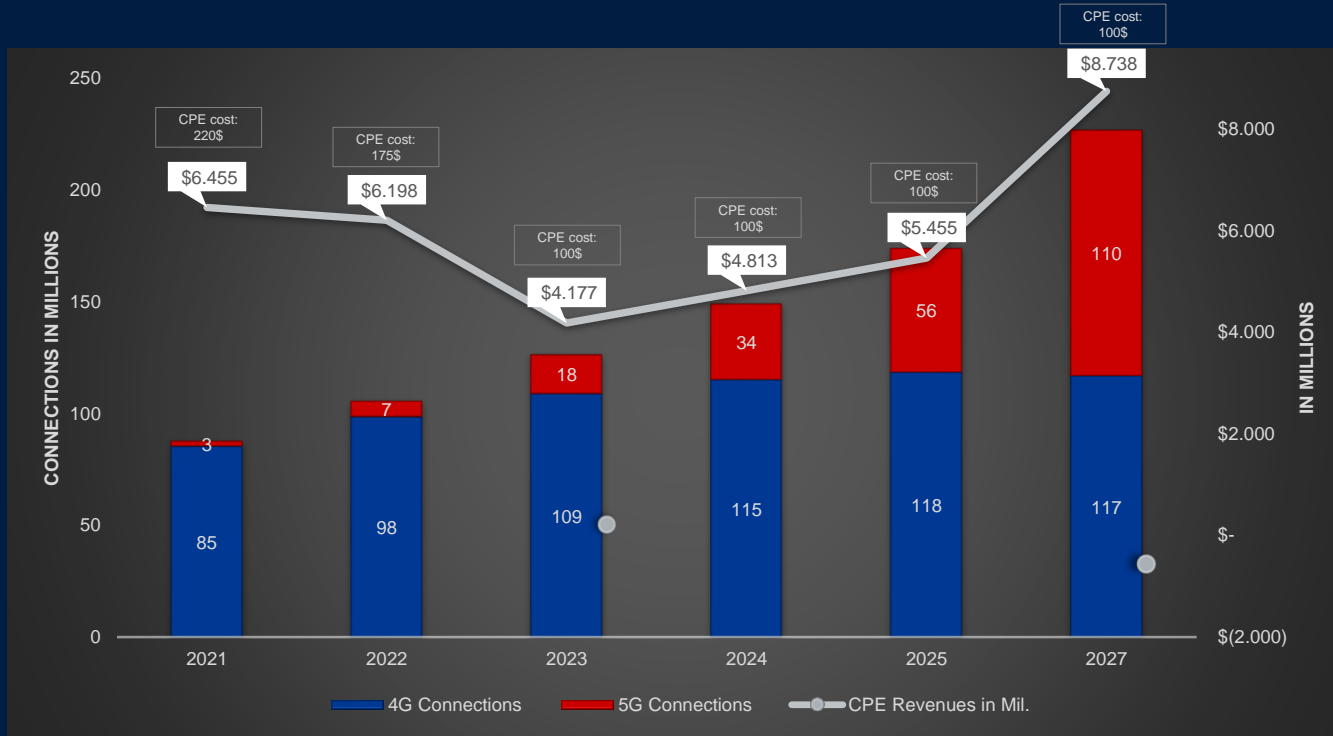


5G coverage



FWA ESTIMATE ON CPE REVENUES*

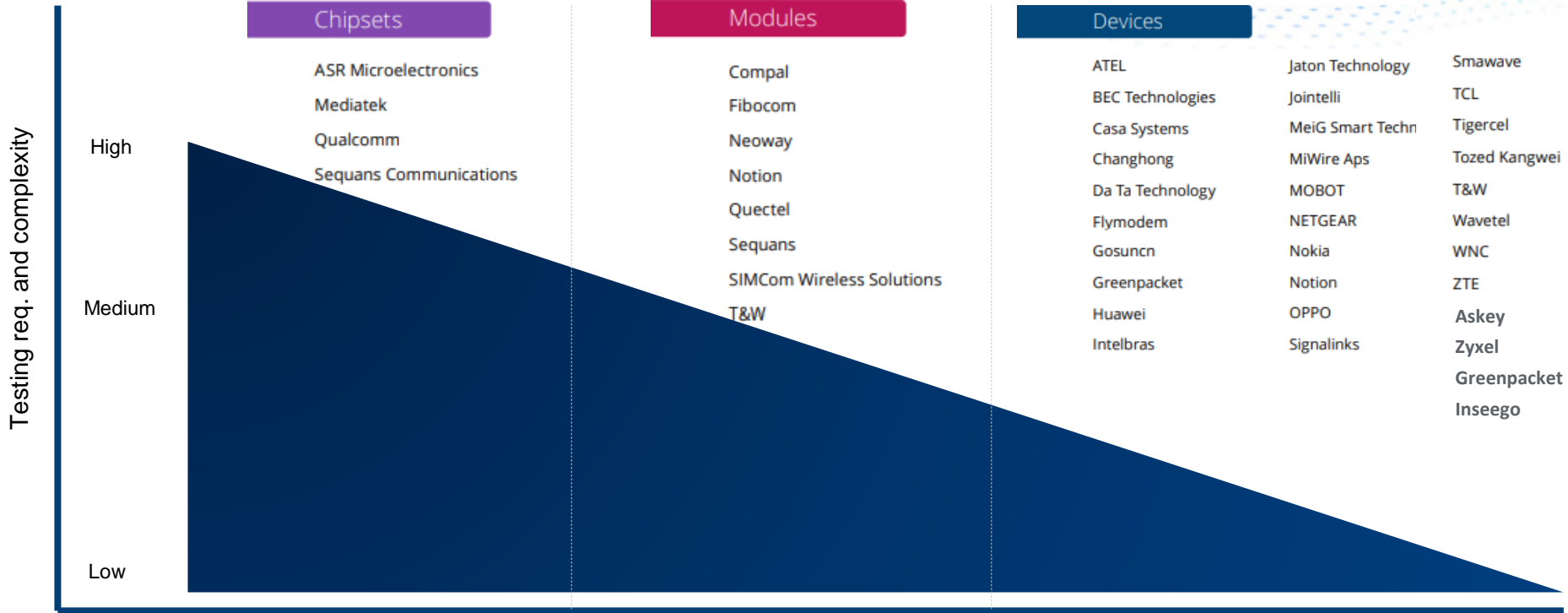
5G CPE vendors estimate



*Source: ABI Research and Ericsson Mobility report 2022



5G FWA ECOSYSTEM*




FWA DEVICES FAMILY EXAMPLE



<p>Indoor Sub 6 GHz CPE (FR1)</p>  <p>4G Cat16 SLT868Q</p>  <p>5G SRT856S</p>  <p>4G Cat6 SLT818</p>  <p>4G Cat4 SLT711</p>	<p>Outdoor Sub 6 GHz CPE (FR1)</p>  <p>4G Cat16 SLT869-A51</p>  <p>4G Cat16 SLT867-A31</p>  <p>4G SLT869-A53</p>	<p>Battery Operated Hotspot</p>  <p>5G Sub6 SRT873</p>  <p>4G Cat6 SLT879</p>
<p>Indoor mmWave CPE (FR2)</p>  <p>5G Sub5 SRT856s</p>	<p>Outdoor mmWave CPE (FR2)</p>  <p>5G SRT853</p>	<p>4G Cat4 SLT778</p>  <p>4G Cat4 SLT778</p>

<p>Indoor Sub 6 GHz CPE (FR1)</p>  <p>4G Enhanced Hybrid Gateway</p>	<p>Outdoor Sub 6 GHz CPE (FR1)</p>  <p>5G AurusPRO Urban Wide Band</p>  <p>4G AurusPRO High-Gain</p>  <p>5G AurusPRO Remote Rural Low Band</p>		
<p>Outdoor mmWave CPE (FR2)</p>  <p>5G AurusAI</p>	 <p>5G AurusPRO Rural High Band</p>  <p>4G AurusPRO CBRS High-Gain</p>  <p>5G AurusPRO Rural CBRS (CAT B) C-Band</p>  <p>5G AurusPRO Rural Wide Band</p>		

5G FWA UE TEST REQUIREMENTS

Test types	KPIs	Goal	Products
RF parametric	<ul style="list-style-type: none"> NR: 3GPP RF TRx test specification Output power ,EVM, OBW, receiver sensitivity level, etc. 	<ul style="list-style-type: none"> Checks RF TRx performance in accordance with common test specifications Mostly required by operators 	
Operator acceptance	<ul style="list-style-type: none"> Operator-specific test criteria 	<ul style="list-style-type: none"> Verifies whether device meets with operator's test criteria 	
OTA	<ul style="list-style-type: none"> CTIA OTA test specification 	<ul style="list-style-type: none"> Verifies antenna performance, required by operators 	
Functional	<ul style="list-style-type: none"> E2E max. throughput DL/UL NSA/SA attach 1024QAM in stable env. Operational stability during long connection and throughput Latency SMS USIM/eSIM authentication FW versioning 	<ul style="list-style-type: none"> Tests to improve customer satisfaction Tests device behavior to check: <ul style="list-style-type: none"> Battery life, thermal status Firmware regression Benchmark for selecting wireless module CPE under heavy load Generally, end-device vendor-specific parameters (as well as RF parametric, operator acceptance, OTA tests) 	

THROUGHPUT TESTING

▶ **Throughput Wizard:**

- Wizard for network and workspace creation
- Result: Overview with relevant values and graphs for throughput testing

▶ **IP Tune:**

- Problem to overcome: UE with unclear capabilities
- Features: Step-by-step qualification of the current channel UDP/TCP throughput
- E2E traffic with client ↔ server support

→ Testing the KPI is also supported by the shuffler which was introduced before

POWER SAVING

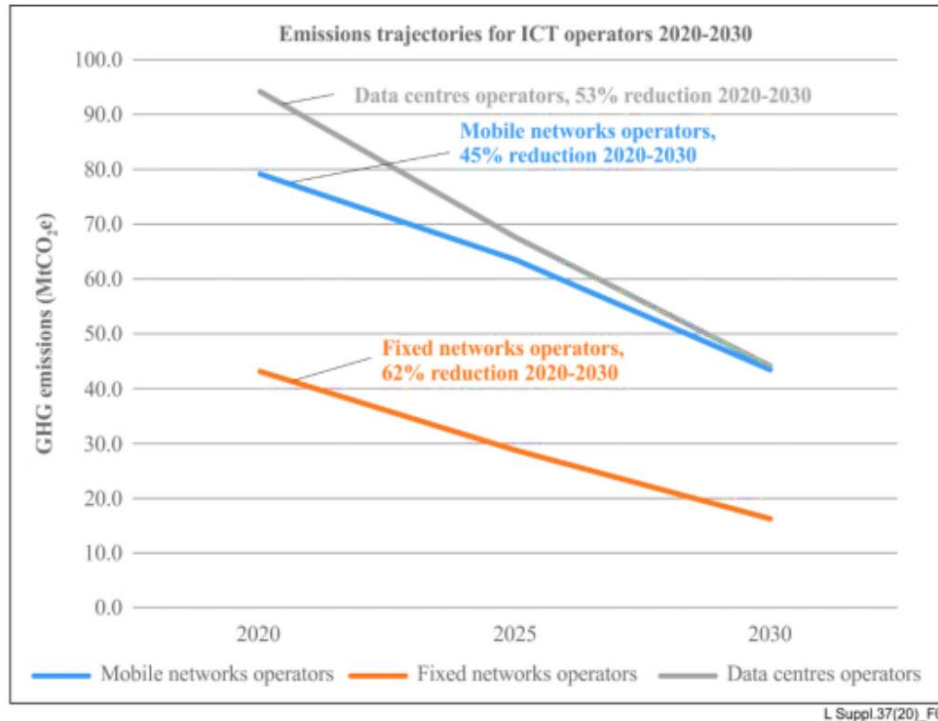
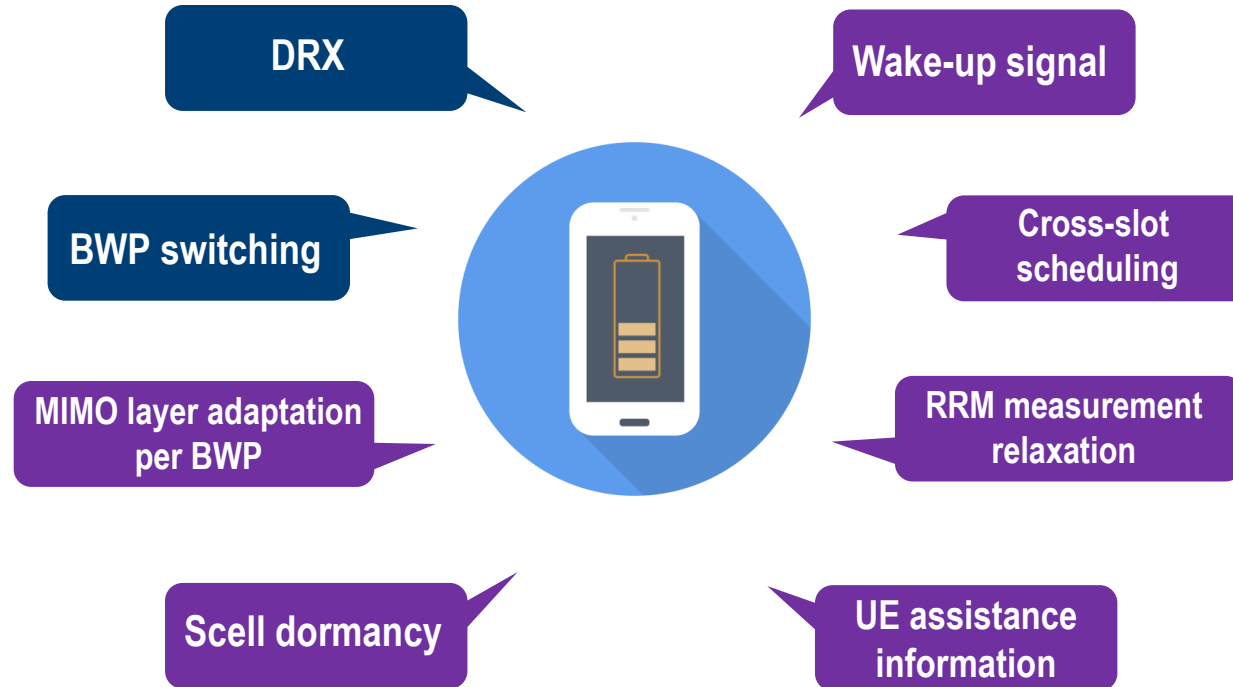


Figure 1: ITU - Emission Trajectories for ICT Operators 2020-2030



- Power consumption is critical in 5G
- Consumers expect longer battery life
- Green future networks initiative
- Need to test power reduction/optimization with transmission and no-transmission

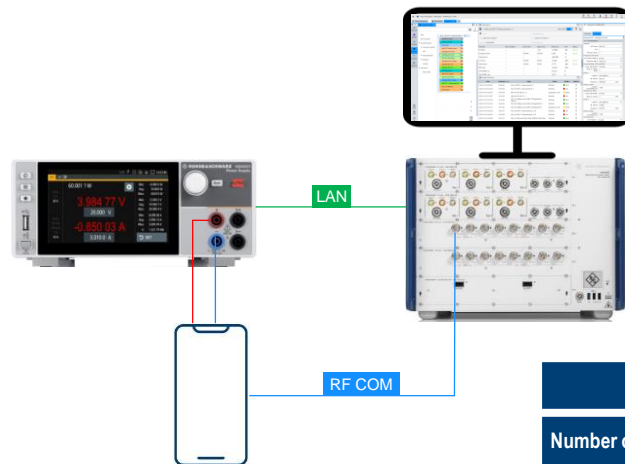
BATTERY DRAIN - UE POWER SAVING ENHANCEMENTS



Rel. 15
Rel. 16

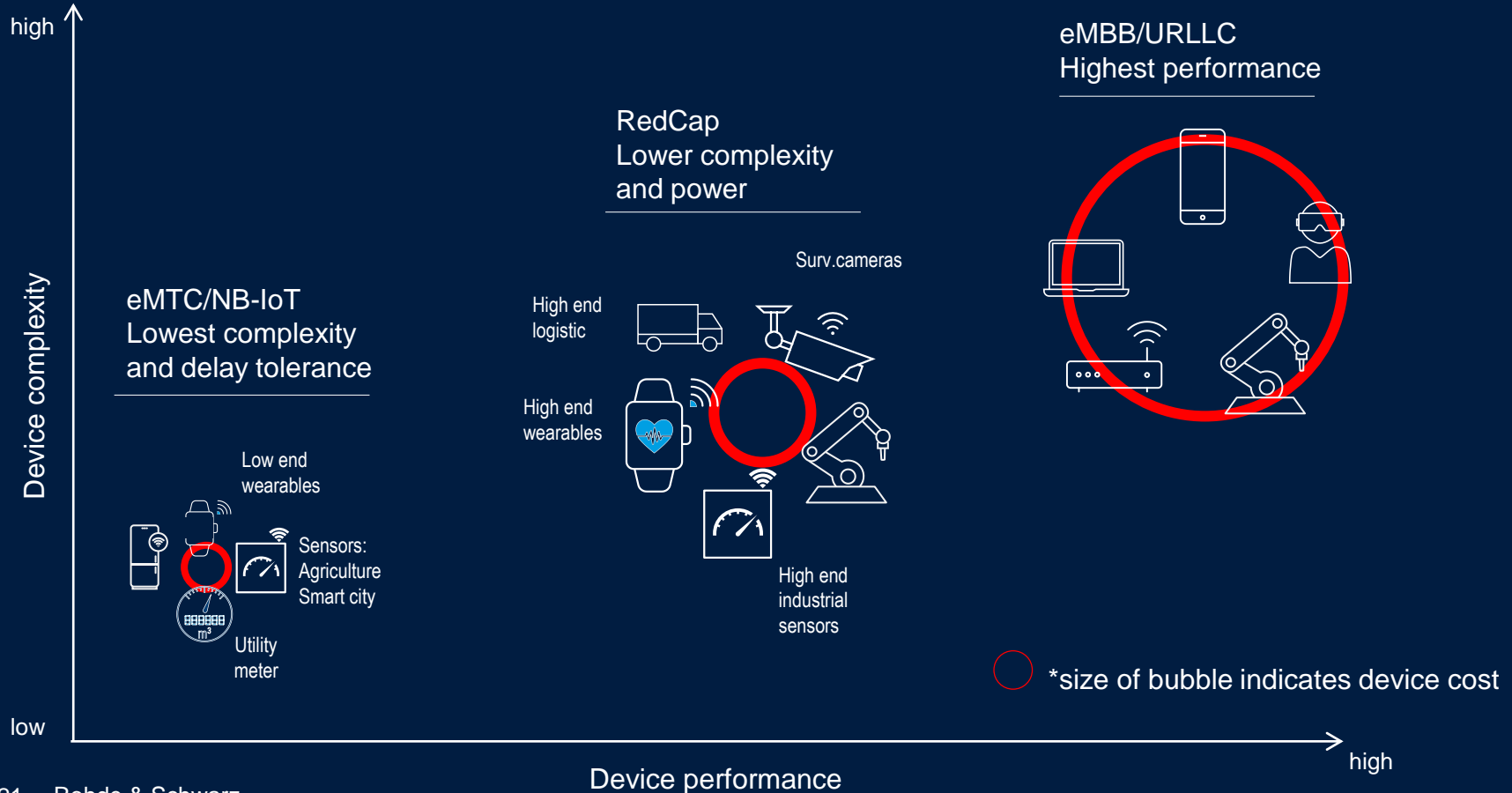
BATTERY LIFE MEASUREMENTS

- ▶ DUT power consumption measurements with R&S®CMX500 and R&S®NGM power supply
- ▶ Up to 2-channel measurements of voltage, current and power
- ▶ Rel.16 power saving features on R&S®CMX500
- ▶ R&S®CMX-KM110 option to enable measurements in R&S®CMsquares



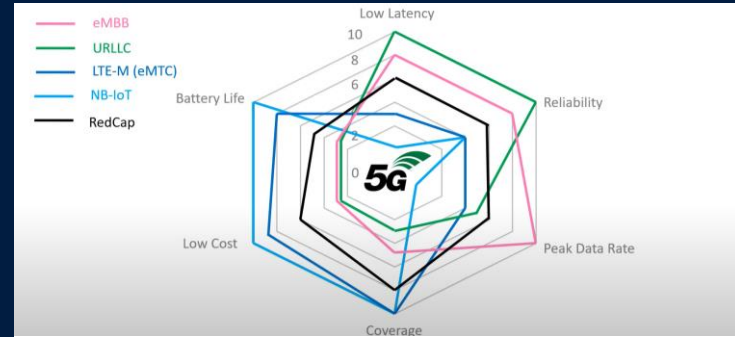
	NGM200
Number of channels	1 or 2
Voltage per channel	0 V to 20 V
Max. current per channel	≤ 6 V: 6 A, > 6 V: 3 A
Max. output power per channel	60 W
Load recovery time	< 30 μs
Ripple and noise	< 500 μV (RMS) / < 1 mA (RMS) (meas.)
Max. Readback resolution	10 μV / 10 μA
Electronic load	60 W / 3 A
Data Logging	10 sample/s

5G DEVICE EXPANSION WITH REDCAP

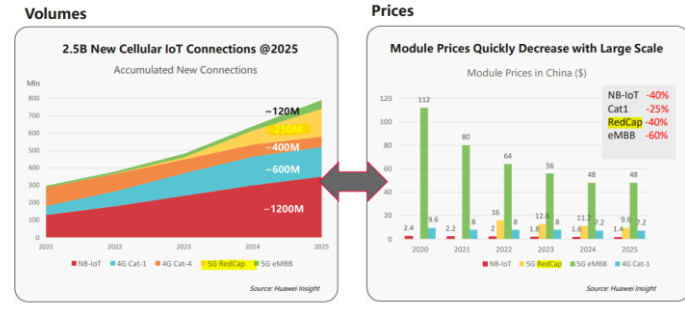


5G REDCAP IS A CONFIRMED PRIORITY ACROSS THE WHOLE 5G ECOSYSTEM - VENDORS AND OPERATORS

- Part of 3GPP Rel.17, specs for low cost, low complexity and small form factor 5G devices
- RedCap devices will be positioned as a lower segment than eMBB devices, but higher than LPWA devices in terms of technical features
- Migrating LTE-Cat-1 devices to generic 5G SA access. Expanding 5G SA use cases to wearables, health care, IIoT, surveillance etc.
- Reduced complexity and cost by:
 - Targeting lower throughput 150 Mbps DL/50 Mbps UL
 - Reduced carrier BW support (up to 20 MHz for FDD SA)
 - 64QAM DL/UL
 - 1 TX antenna for uplink and 2 RX antennas for downlink
 - Battery saving and heat dissipation features
 - 1CC
 - FR1 FDD ~65% reduction, FR1 TDD ~71% reduction, FR2 48% reduction
 - RedCap modules is five times lower than that of eMBB modules
 - More optional functions available: low latency, slicing, positioning



Consumer IoT - Five Years Prediction by Huawei



REDCAP WITH THE R&S[®]CMX500

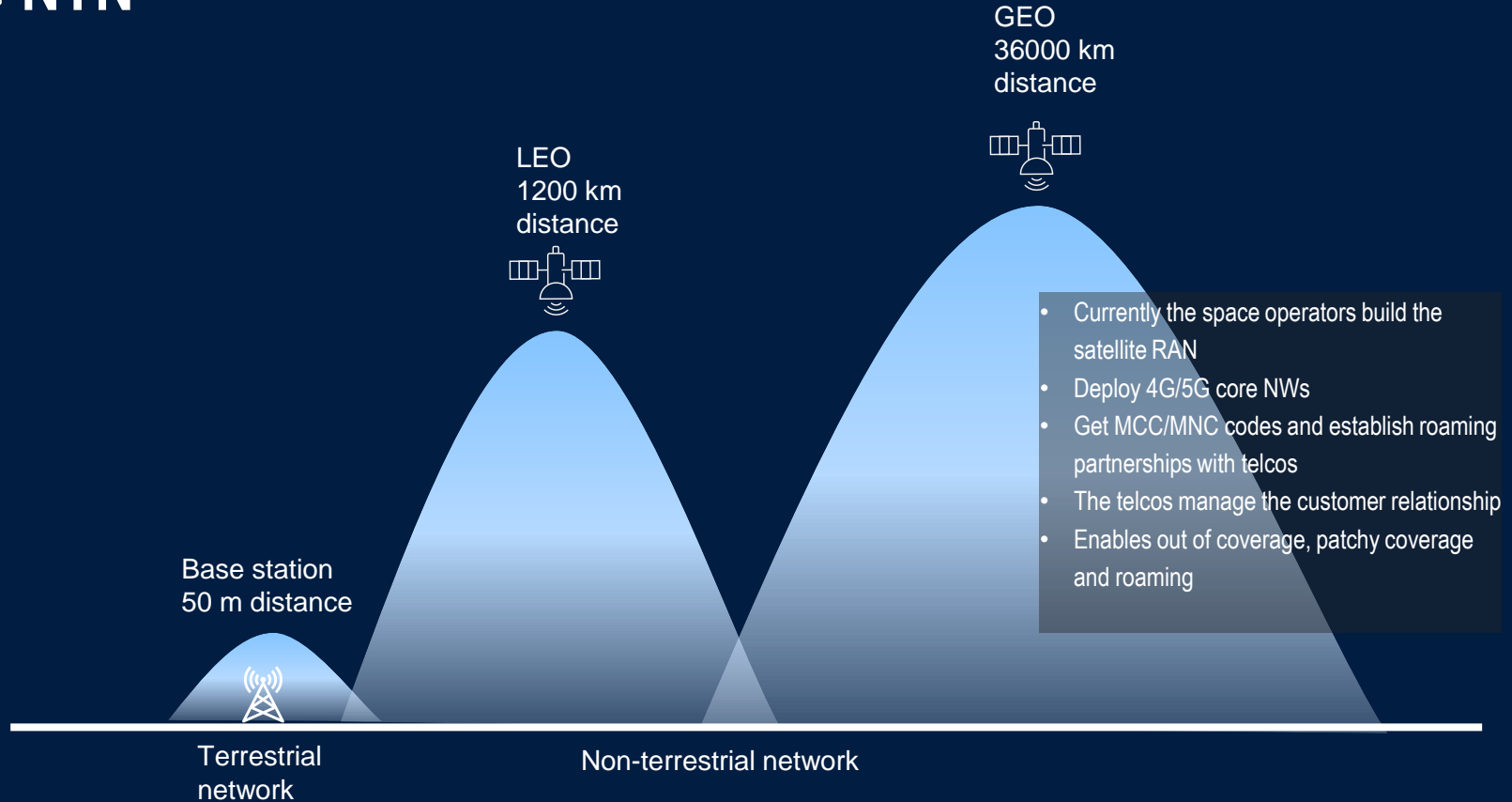
► **First step**

- Check UE for RedCap functionality
- Setup the cells based on RedCap capabilities
 - Test cell selection criteria for the RedCap devices
- With the Rel. 16 power saving capabilities of the R&S[®]CMX500, we are already able to address the RedCap requirements in terms of battery life testing

► **Second step**

- Addressing the advanced features of RedCap

5G NTN



5G NTN HAS ADDRESSABLE REVENUE OF \$35B WORLDWIDE BY 2035*

5G NTN-NR

Extended coverage that complements terrestrial networks

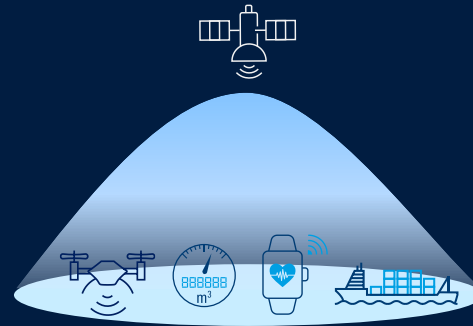


Direct link to smartphones for mission critical and low data services e.g.

- Disaster recovery
- Emergency services
- Small data when out of coverage – messaging, telemetry
- Financial services – payments
- Predominantly operates at LEO altitude

5G NTN-IoT

Expand to global reach for IoT use cases across land, sea, and air



Diverse set of use cases across all verticals e.g.

- Higher resolution of data points in asset tracking and logistics
- Ubiquitous drone connectivity
- Boat position information
- Wearables connectivity
- Operates for both GEO and LEO altitudes, but predominantly GEO
- 8% of IoT market is addressable by NTN-IoT

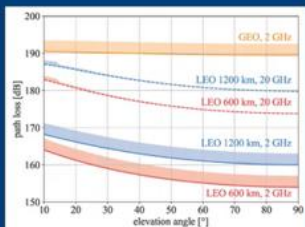
NTN-IoT INDUSTRY SUPPORT IN STANDARDIZATION



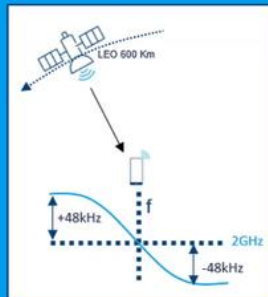
NTN DEVICE CHALLENGES

Propagation losses

- Free-space path loss
- Absorption due to atmospheric gasses
- Ionospheric losses
- Tropospheric losses



Doppler shift



Large delays

- Propagation delays
- Differential delays

Cell movement

- Short serving times
- Frequent HOs
- Frequent TA update
- Discontinuous coverage

TR 38.821:
UEs in the S-band can be served (2GHz - 4GHz).

TR 36.763:
Specific IoT-NTN results for UE PC3, PC5 in S-band.

UEs with GNSS capabilities and provisioning of satellite orbits (ephemeris) in new SIB31 (SIB31NB).
Knowing its own position and speed, and satellite location and speed, the UE can pre-compensate for the doppler shift. TR 38.821

THANK YOU

The background of the slide is a dark navy blue. On the right side, there are several diagonal stripes in a slightly lighter shade of blue, creating a sense of movement and depth. The stripes are parallel and run from the top-left towards the bottom-right.