Wi-Fi 7 Takes Flight from 2024

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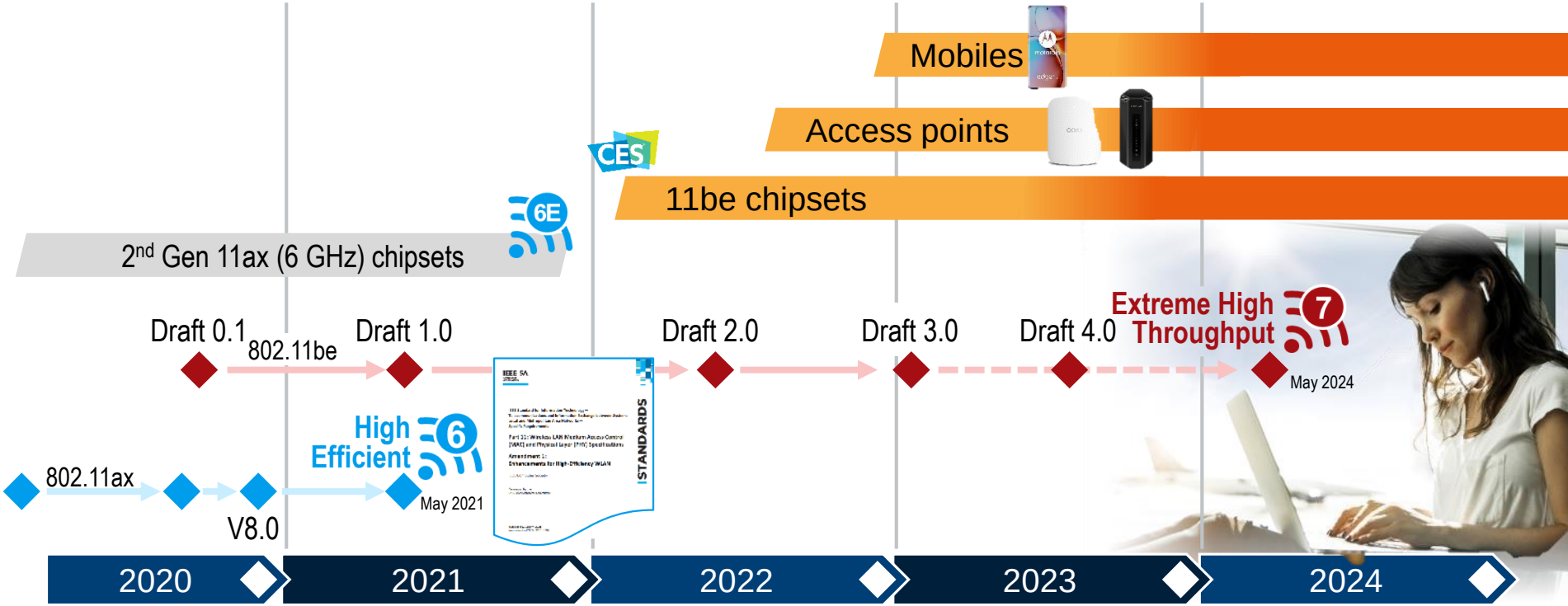
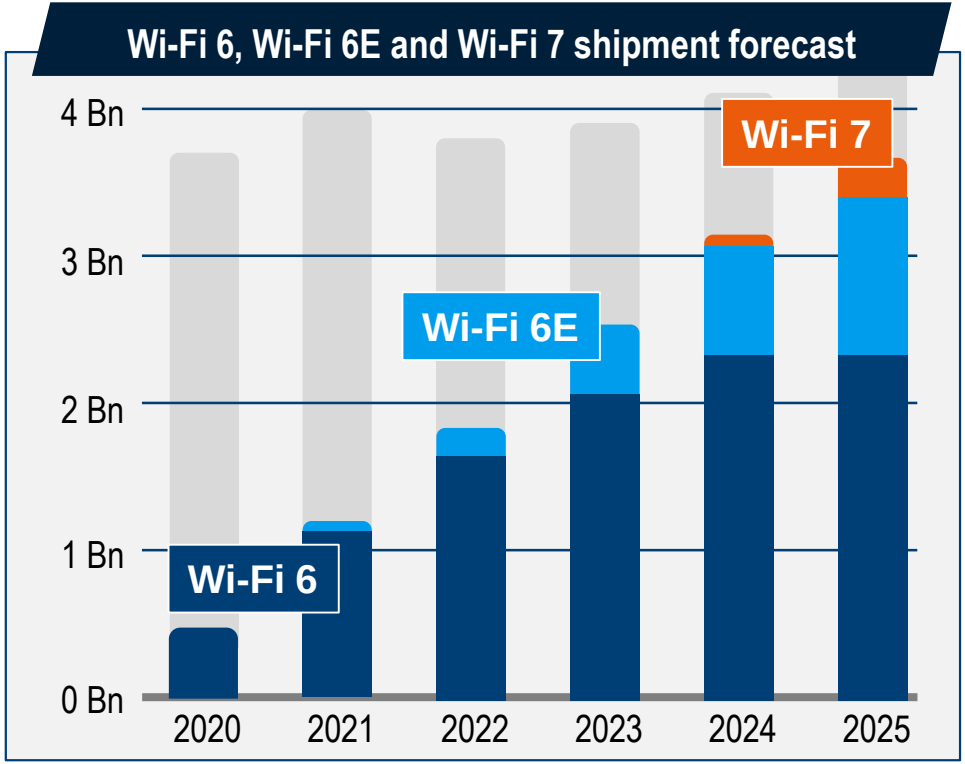
Make ideas real

Extreme high throughput WLAN (EHT – IEEE 802.11be – Wi-Fi7) is entering the market with amazing speed



Wi-Fi 6 enters the market and Wi-Fi 7 will approach fast

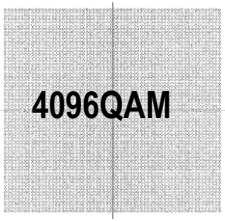
- 19.5 Bn Wi-Fi devices in use (2023)
- 3.9 Bn Wi-Fi devices forecasted to ship
- 18% of all Wi-Fi 6 device shipments in 2023 support 6 GHz band operation



Source: IDC/ Wi-Fi alliance 2023

How to achieve extreme high throughput with Wi-Fi 7?

modulated bits

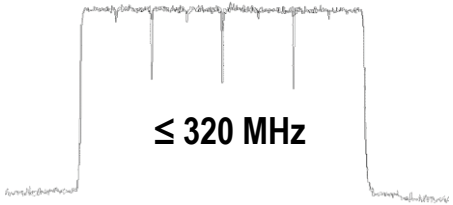


Code rate

$$Max.phy\ data\ rate = N_{SD} \frac{N_{CBPS} \cdot R}{T_{SYM}} N_{SS}$$

Symbol time

# of data carriers

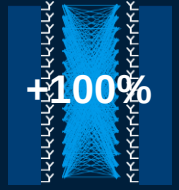


spatial streams

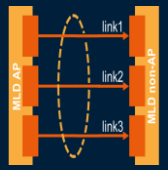
The four cornerstones of IEEE 802.11be to achieve extreme high throughput

320 MHz channel

4096QAM modulation

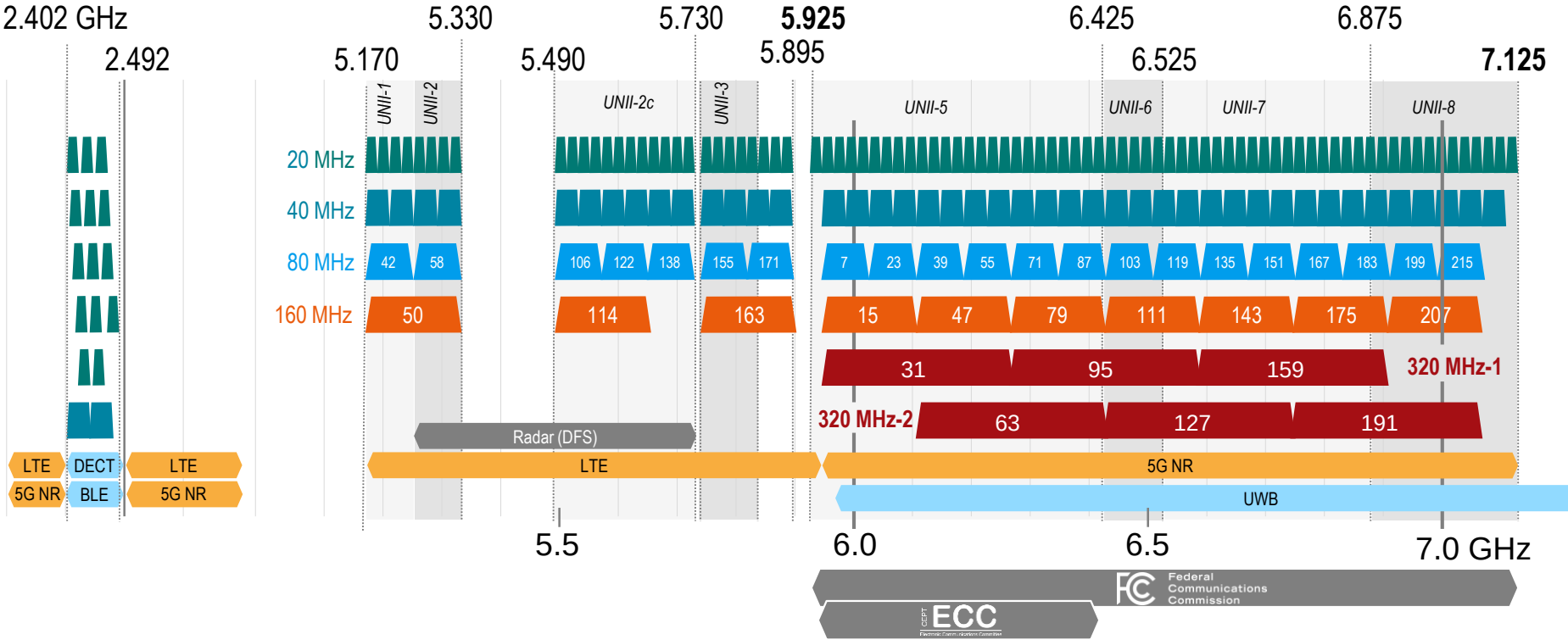


16x16 MIMO

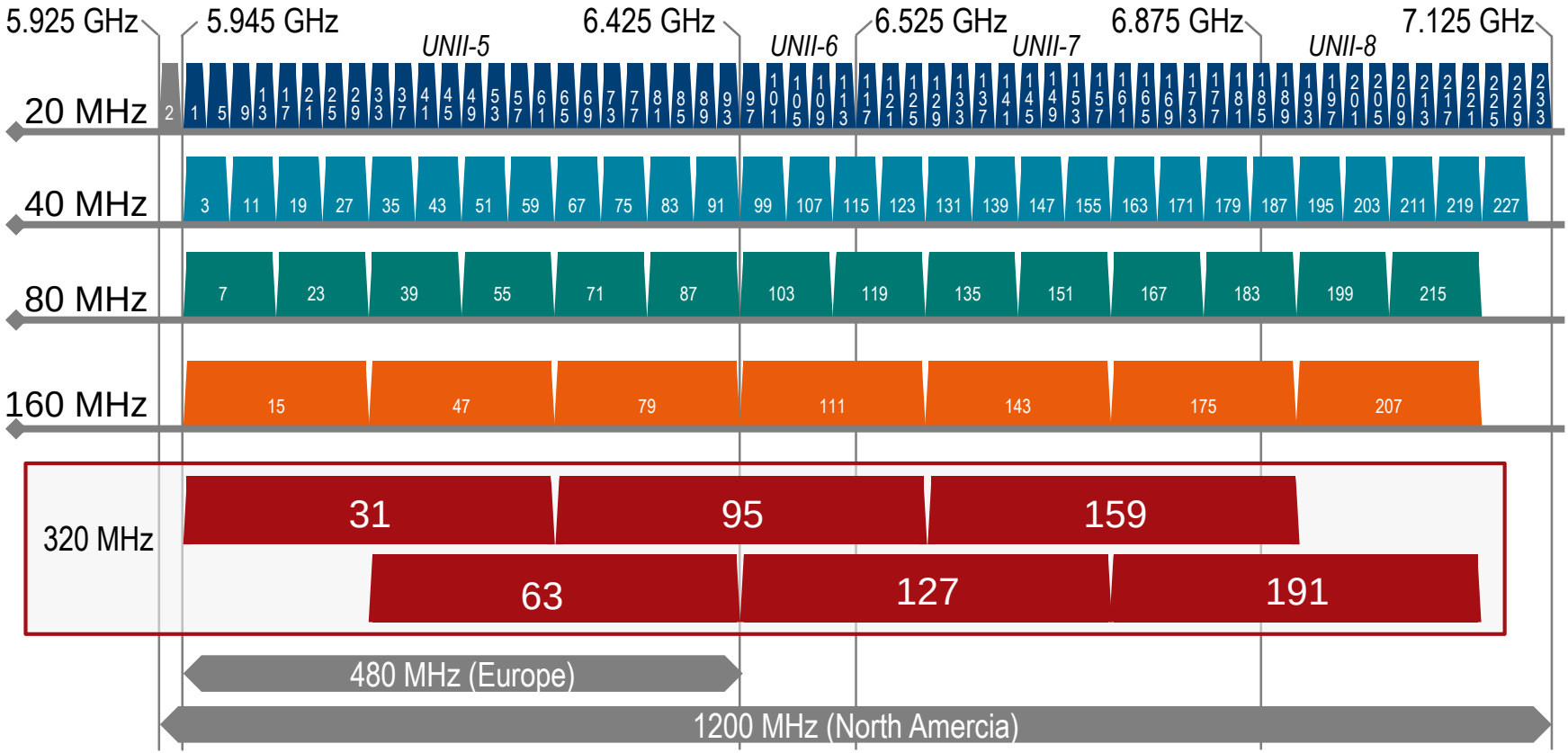


Multi-link operation

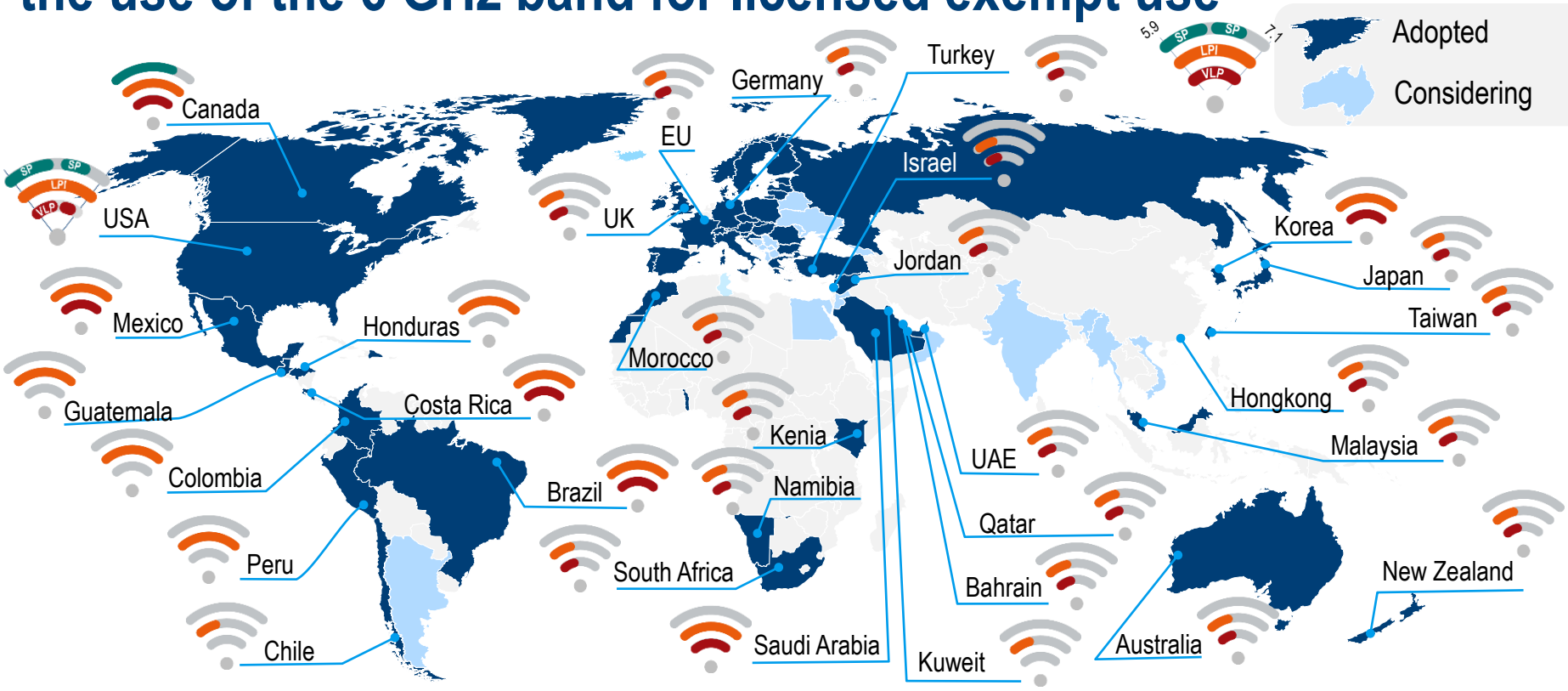
New spectrum allocation allows more and wider channels in a (still) less congested 6 GHz band



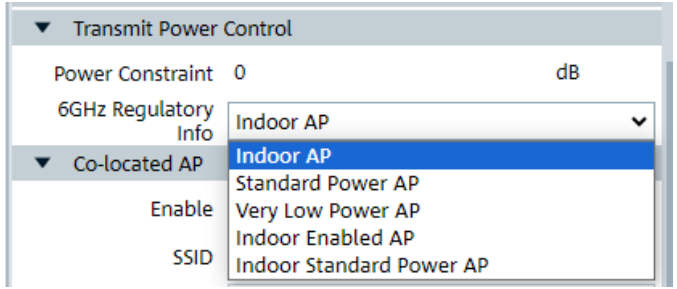
A few overlapping 320 MHz channels in the 6 GHz band



More and more countries allow or consider to allow the use of the 6 GHz band for licensed exempt use

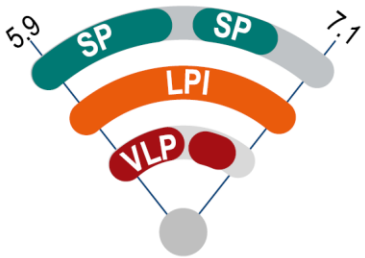


6GHz - Power operating classes

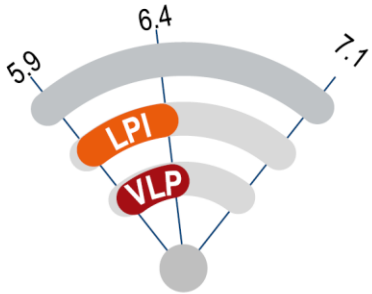


6 GHz Regulatory Info
Sets one of different AP types with different power constraints in the 6 GHz band.

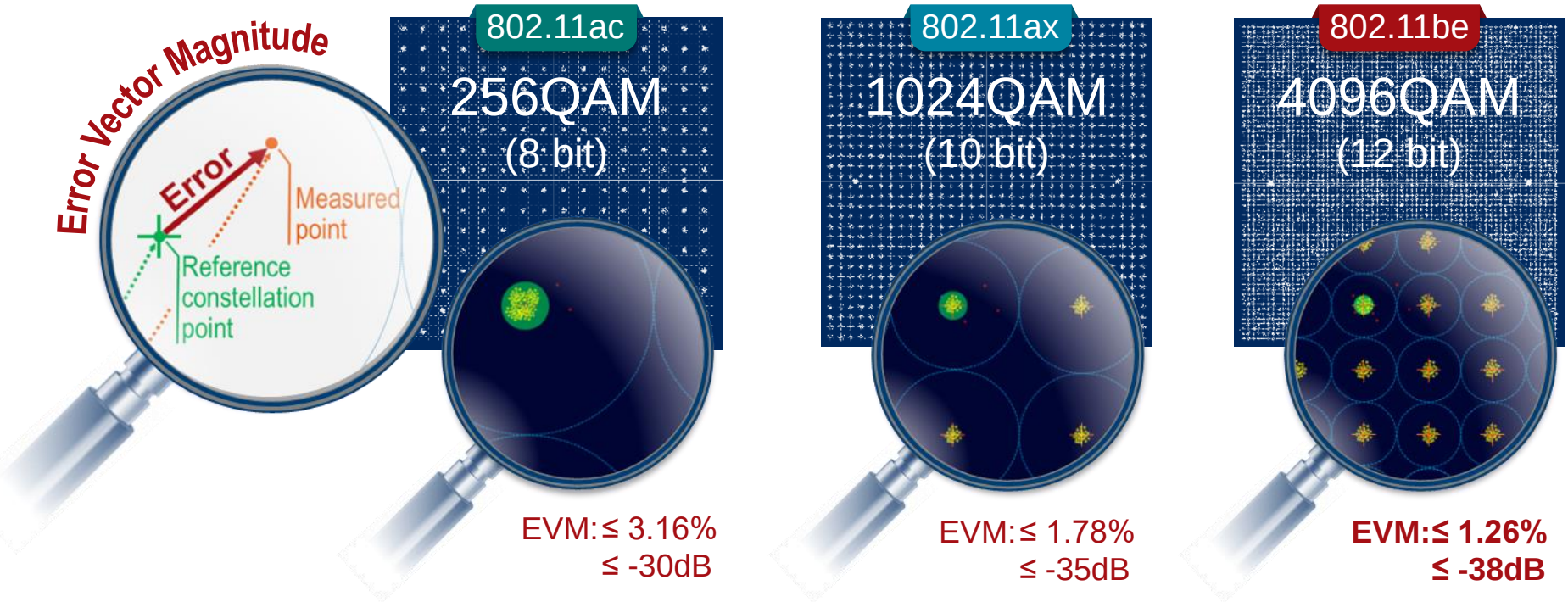
- **Indoor AP**: not controlled, outdoor operation prohibited
- **Standard power AP**: controlled from an external system
- **Very low power AP**: not controlled, restricted to very low transmit power
- **Indoor enabled AP**: enabled from indoor AP or an indoor standard power AP
- **Indoor standard power AP**: controlled from an external system, outdoor operation is prohibited



Federal Communications Commission	CEPT ECC Electronic Communications Committee
Standard Power AP: EIRP: 36 dBm (AFC) UE: EIRP: 30 dBm	
Low Power Indoor AP: EIRP: 30 dBm UE: EIRP: 24 dBm	**Low Power Indoor** AP: EIRP: 23 dBm UE: EIRP: 23 dBm
Very Low Power EIRP: 14 dBm (geofenced VLP AP)	**Very Low Power** EIRP: 14 dBm



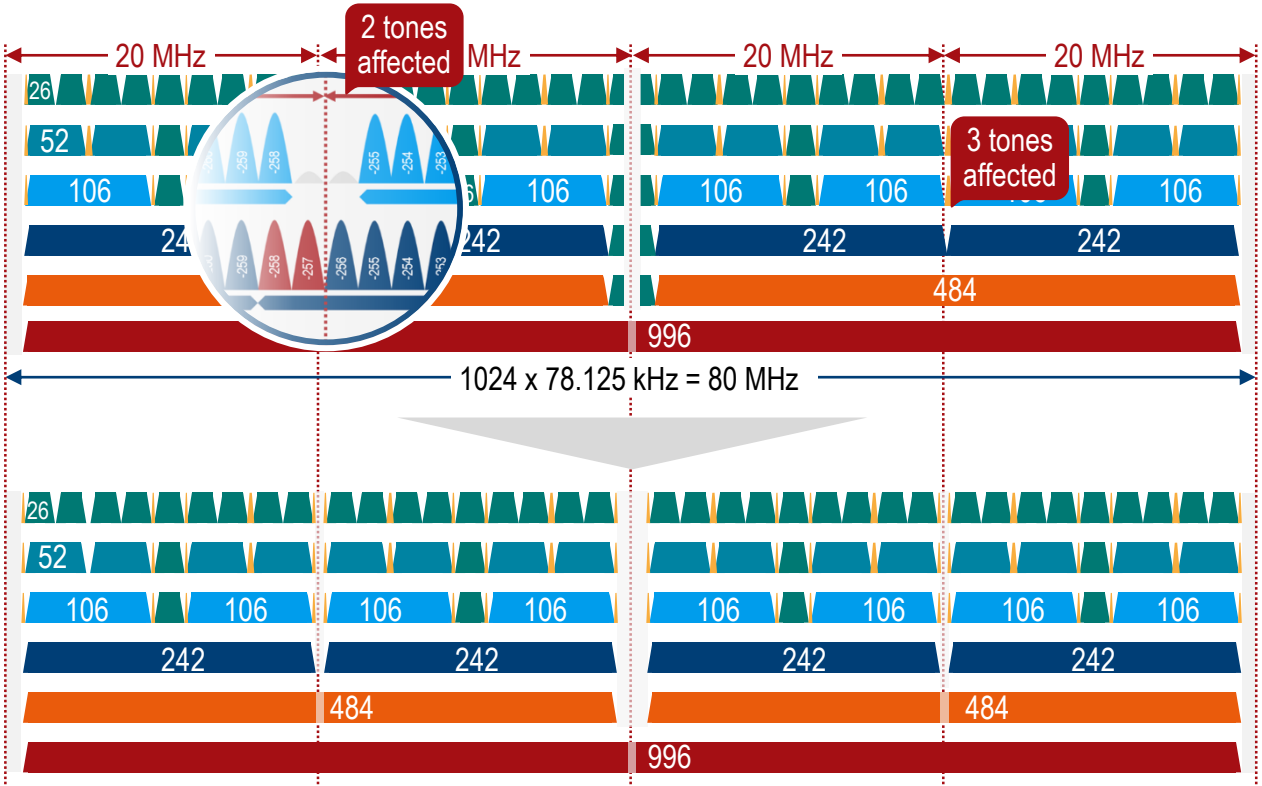
Wi-Fi 7 pushes RF performance requirements and test equipment quality to the next level



Over two generations a six-fold increase of max. throughput

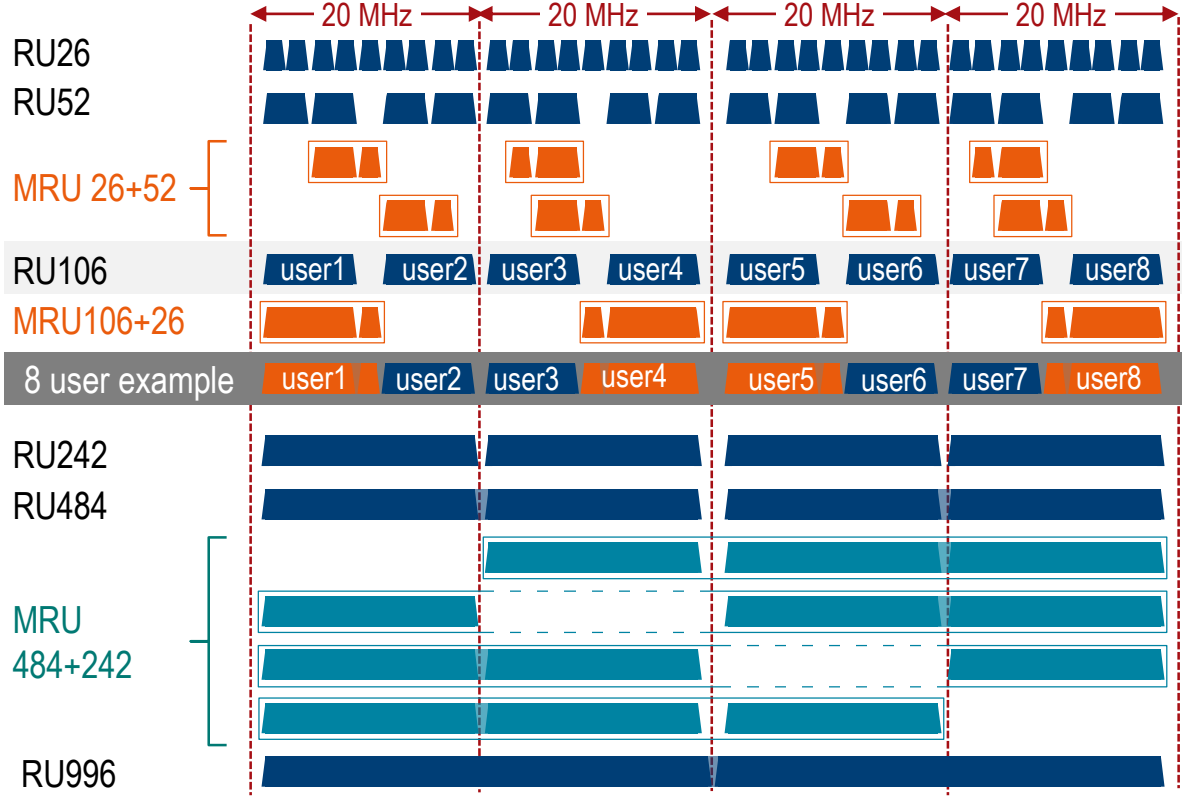
	Wi-Fi 5 (802.11ac) 5 *Very High Throughput (VHT)*	Wi-Fi 6E (802.11ax) 6 *High Efficiency (HE)*	Wi-Fi 7 (802.11be) 7 *Extreme High Throughput (EHT)*
Supported bands	5 GHz	2 GHz, 5 GHz, **6 GHz**	2 GHz, 5 GHz, 6 GHz
Channel bandwidth (MHz)	20, 40, 80, 80+80, 160	20, 40, 80, 80+80, 160	20, 40, 80, 160, **320**
Transmission scheme	OFDM	OFDM, OFDMA	OFDM, OFDMA
Subcarrier spacing	312.5 kHz	78.125 kHz	78.125 kHz
Guard interval	0.4 µs, 0.8 µs	0.8 µs, 1.6 µs, 3.2 µs	0.8 µs, 1.6 µs, 3.2 µs
Spatial streams	8x8 (incl. DL-MU-MIMO)	8x8 (incl. MU-MIMO)	**16x16** (incl. MU-MIMO)
Modulation (highest)	256QAM (8 bit)	1024QAM (10 bit)	**4096QAM (12 bit)**

Please be aware of a modified tone-plan ≥ 80 MHz



- 802.11be tone plan is based on 20/40 MHz PPDU 11ax tone plan
- 802.11be modifies the HE 80 MHz OFDMA tone plan to fix the problems with regulation and puncturing (20 MHz boundary)
- The 80 MHz OFDMA design applies to any RU < 996 for all modes of transmission, SU, DL MU, TB PPDU, with and without puncturing.

Multiple Resource Units (MRU) per user for efficiency



A **small size MRU** (i.e. 26, 52, 106 tone) can only be combined for **efficiency** with another small size RU to form an MRU. RUs in the MRU need to be contiguous and within a 20 MHz channel boundary

The permitted **large size MRU** combinations (i.e. 242, 484, 996 tone) allow additional aggregated bandwidth options (e.g. 60 MHz) per user that don't need to be continuous.

Extended use of preamble puncturing in 802.11be defined for EHT MU PDDU (UL/DL) and EHT TB PPDU (UL)

Non-OFDMA[1)] preamble puncturing

80 MHz	20 MHz
160 MHz	20 or 40 MHz
320 MHz	40 and/or 80 MHz

[1)] *An EHT PPDU that is transmitted using a single RU or MRU that occupies all the non-punctured 20 MHz channels within the PPDU bandwidth.*

80 MHz: 484+242-tone MRU 2

160 MHz: 996+484-tone MRU 2

160 MHz: 996+484+242-tone MRU 4

320 MHz: 3x 996-tone MRU 2

320 MHz: 2x 996+484-tone MRU 3

OFDMA preamble puncturing

80 MHz	0..4 20 MHz in 80 MHz sub blocks
160 MHz	
320 MHz	

80 MHz: 484-tone RU + 242-tone RU

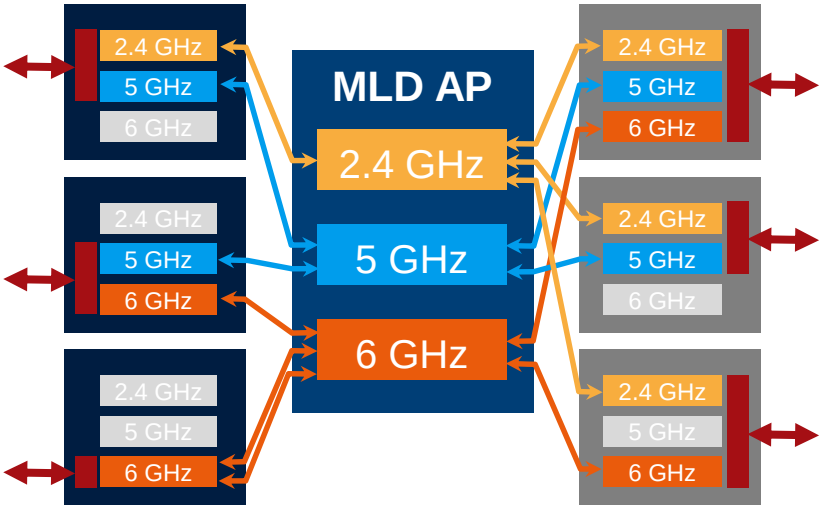
160 MHz: 3x 242-tone RUs + 484-tone RU

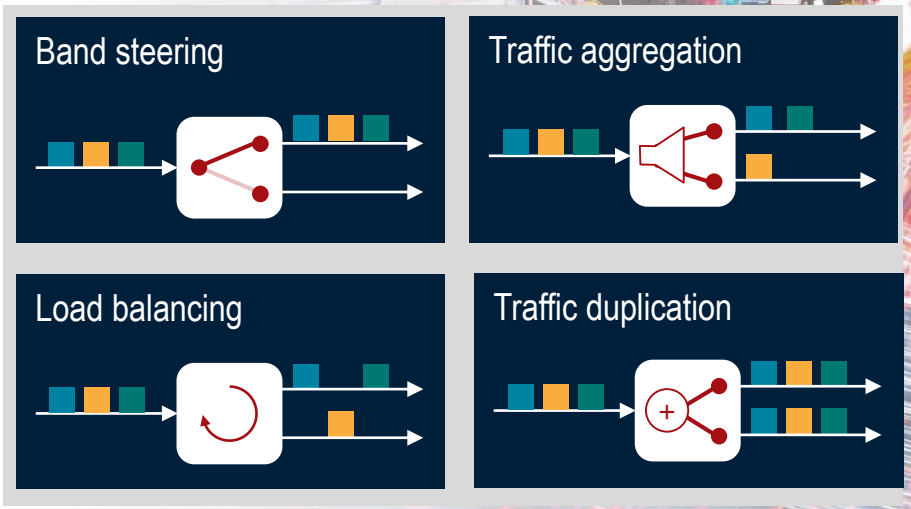
160 MHz: 2x 242-tone RUs + 484+242-tone MRU

320 MHz: 2x 969-tone RUs + 2x 484-tone RUs

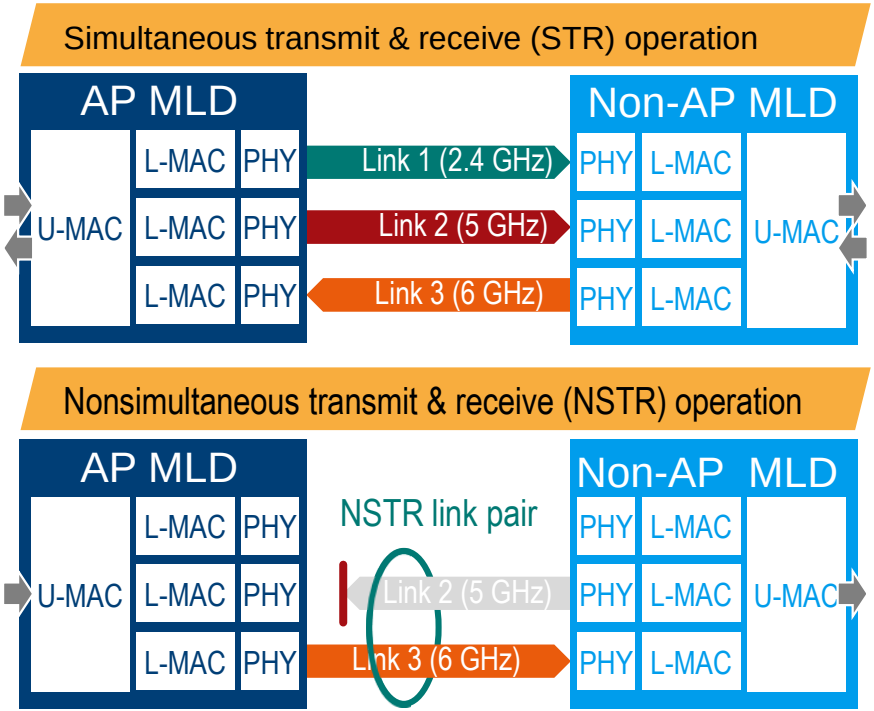
320 MHz: 2x 484+242-tone MRUs +242-tone RU + 2x 484-tone RUs

Wi-Fi 7 will allow multi-link operation





Further improve throughput, latency and efficiency with introducing multi-link operation (MLO)



Multi-radio non-AP MLD:
supports that supports reception or transmission of frames on more than one link at a time.

Single-radio non-AP MLD:
supports operation on more than one link but receives or transmits frames only on one link at a time

Enhanced multi-link single radio (EMLSR)
allows a **non-AP MLD** with multiple receive chains to listen on a set of links for control frames and switch to frame exchange on only the link on which the initial control frame was received

Enhanced multi-link multi-radio (EMLMR)
allows a non-access point (non-AP) multi-link device (MLD) with multiple receive chains to listen on a set of enabled links for initial frame sent by an AP ….

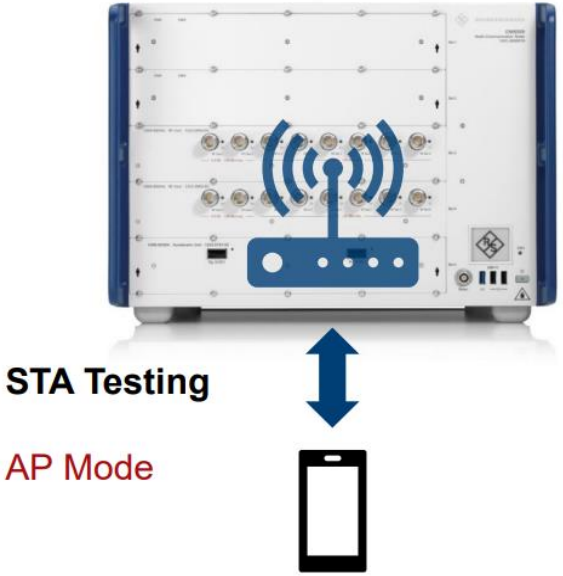
Lets make the reality check, what is Wi-Fi7 about?

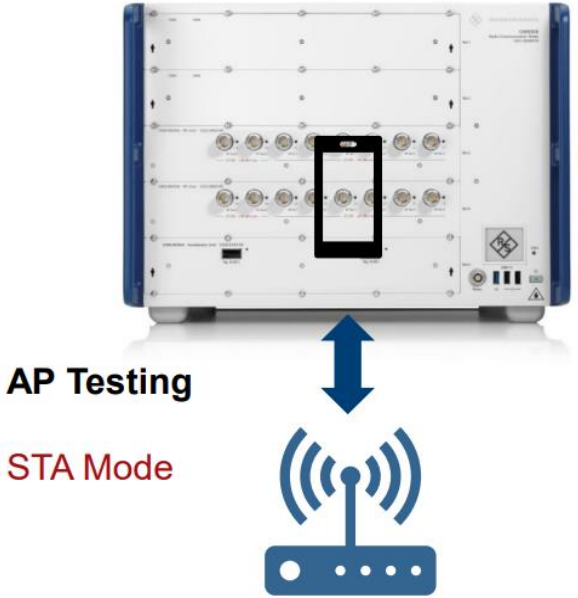
- **Wide Channels (up to 320 MHz)** — Limited # of ch. available in the 6GHz band – preamble puncturing becomes common
- **Multiple Streams (16x16 MIMO)** — Use is limited by the device dimensions and the RF design: 2x2 and 4x4 will be common
- **Modulation: 4096 QAM** — Requires perfect RF conditions and ultimate RF designs, mainly applicable in short D2D
- **MLO** — Multi-Link operation has the potential to largely improve latency, reliability and throughput, but on costs of power and complexity

WIFI 7 on OBT

- CMX500 OBT lite
- 1x RFU and 1x AU
- Supports WIFI7 / FR1 / LTE 4x4 MIMO RF Callbox Testing
- Supports 11a/b/g/n/ac/ax/be
- Up to BW 320MHz
- TX measurement for SU / MU
- RX measurement for SU / MU
- Station / AP Test
- Supports MRU / Preamble Puncturing / MLO (STR,EMLSR)

WLAN TEST SCENARIOS





5 GHZ, 160 MHZ, MIMO2X2, TX MEAS: EVM & IQ CONST. EHT-MU (SU)

TX Measurement - WLAN 1

TX Measurements

Burst Info			
MCS Index	8.00	Guard Interval	0.8 µs
Modulation	256QAM 3/4	LTF Size	2xLTF 6.4 µs
Payload Symbols	3.00	Burst Type	EHT_MU
Measured Symbols	3.00	Spatial Streams	2.00
Payload Bytes	6616.00	Space Time Streams	2.00

Statistics

Overview	Current	Average	Max	Std Dev
EVM All (dB)	-47.62	-46.53	-33.86	2.39
EVM Data (dB)	-47.81	-46.94	-35.94	12.13
EVM Pilot (dB)	-41.92	-38.36	-20.01	2.15
Total Power (dBm)	4.48	4.47	4.51	0.01
Center Frequency Error (Hz)	890.41	982.72	1660.12	148.04
Symbol Clock Error (ppm)	0.13	0.09	0.36	0.07
Timing Error (µs)	NCAP	NCAP	NCAP	NCAP

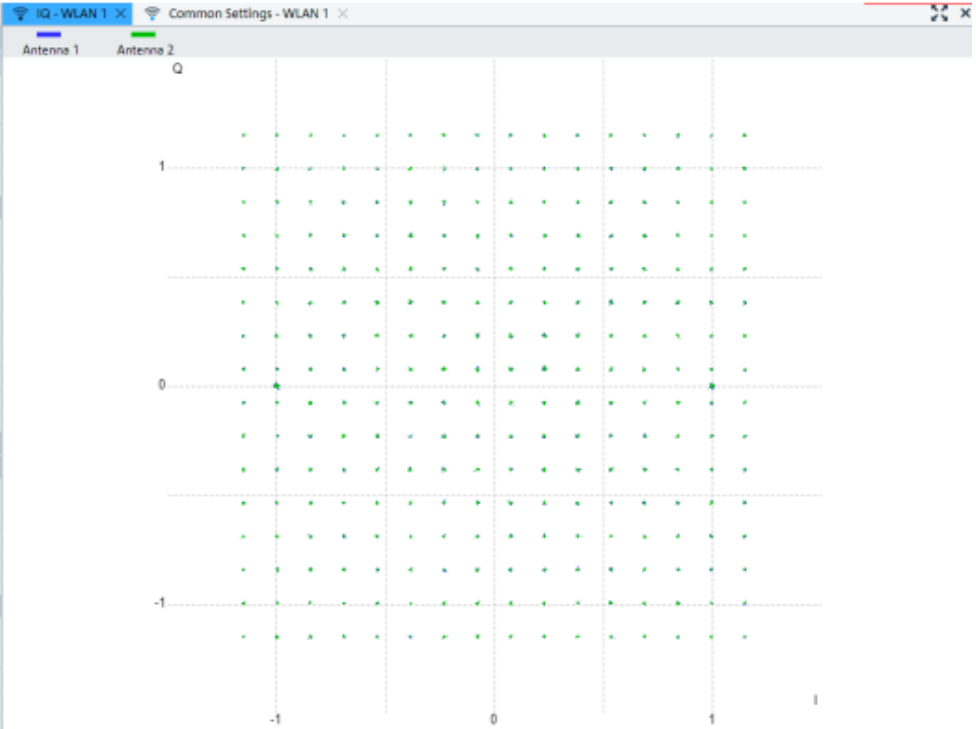
Streams

Stream. 1

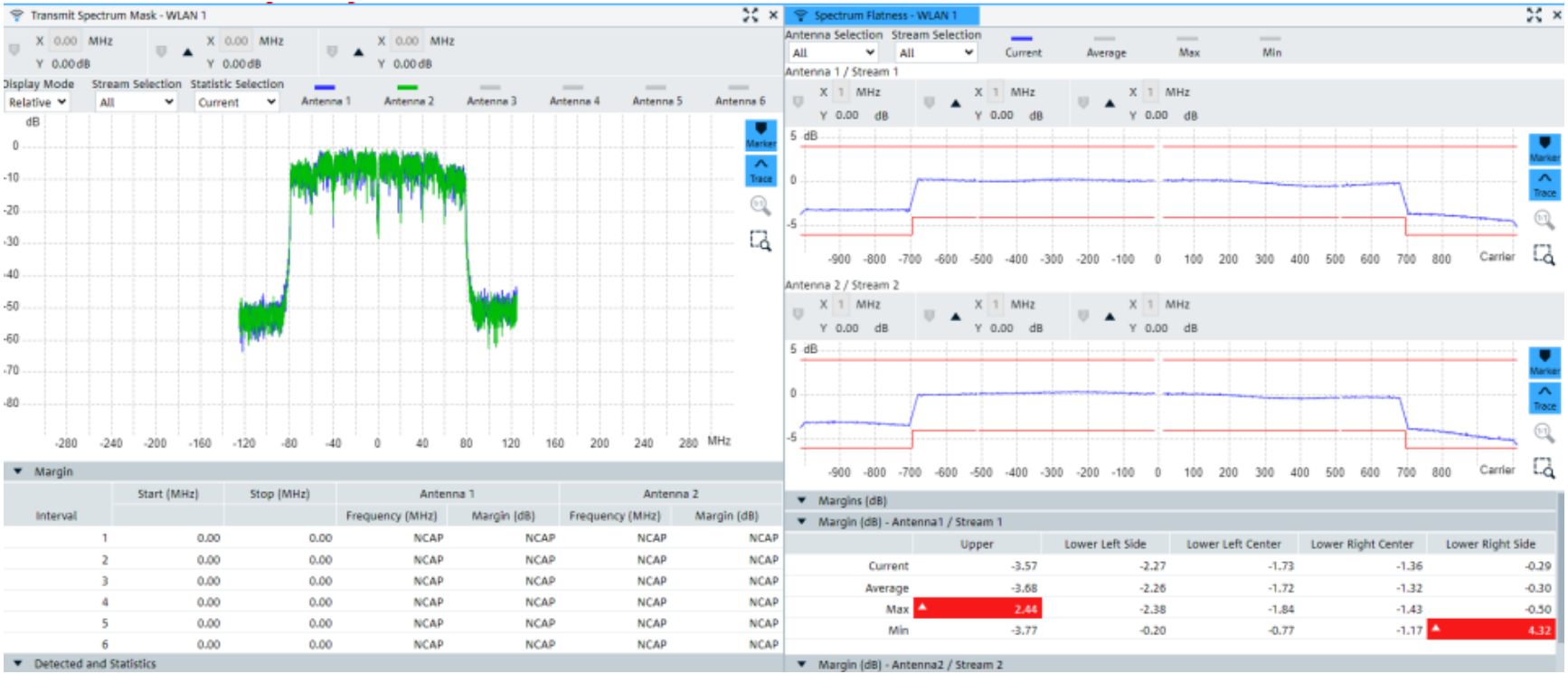
	Current	Average	Max	Std Dev
EVM All (dB)	-47.99	-46.96	-36.81	2.18
EVM Data (dB)	-48.23	-47.17	-36.78	12.02
EVM Pilot (dB)	-41.68	-41.01	-32.12	1.44

Stream. 2

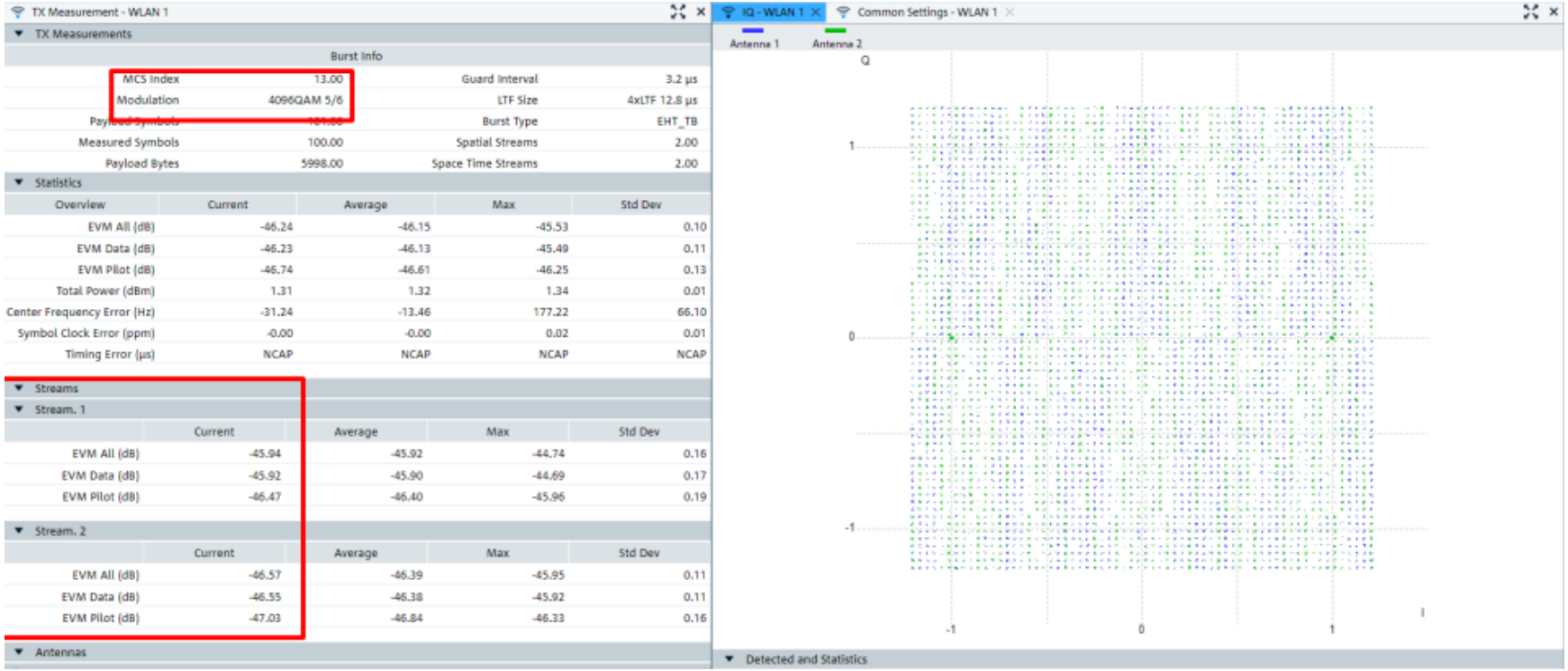
	Current	Average	Max	Std Dev
EVM All (dB)	-47.27	-46.14	-31.03	2.48
EVM Data (dB)	-47.44	-46.73	-33.14	12.27
EVM Pilot (dB)	-42.18	-36.73	-17.14	2.41



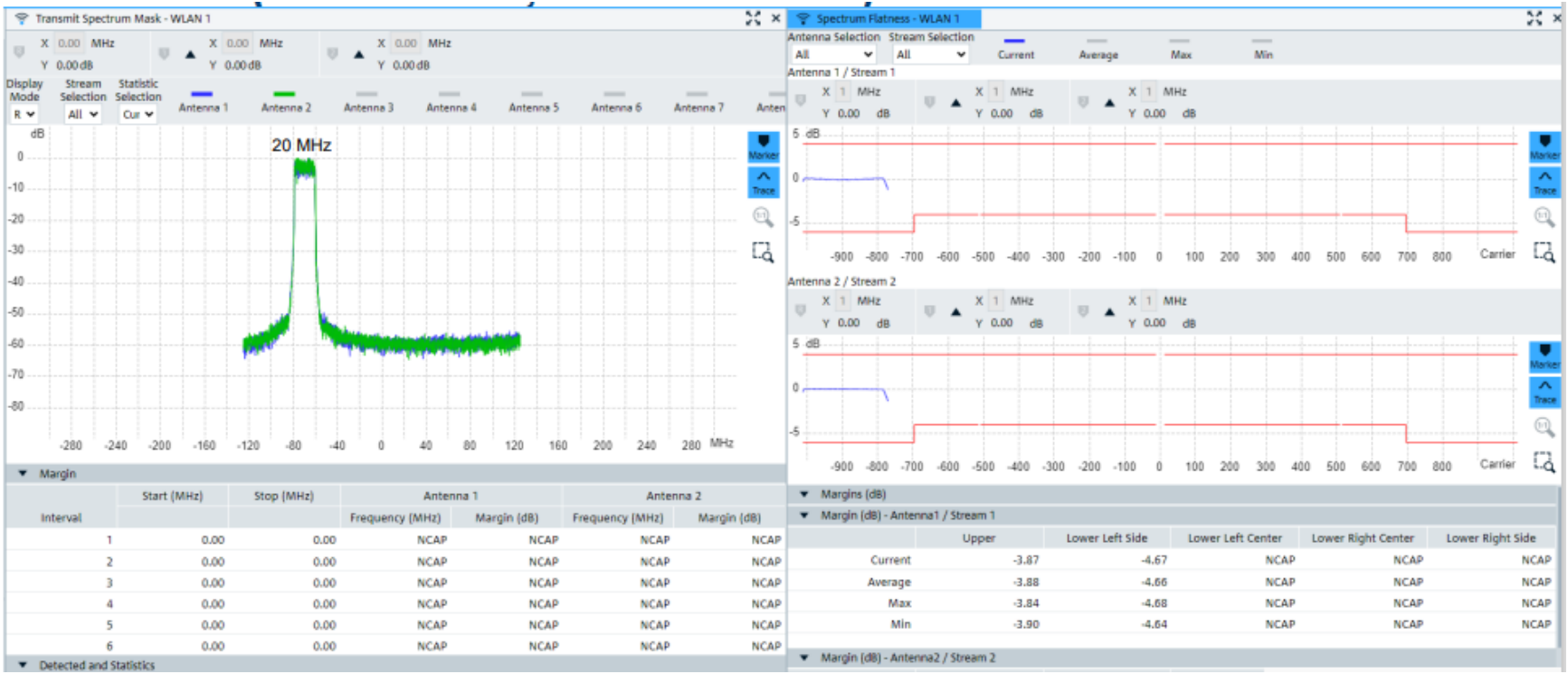
5 GHZ, 160 MHZ, MIMO2X2, TX MEAS: SPECTRUM EHT-MU (SU)



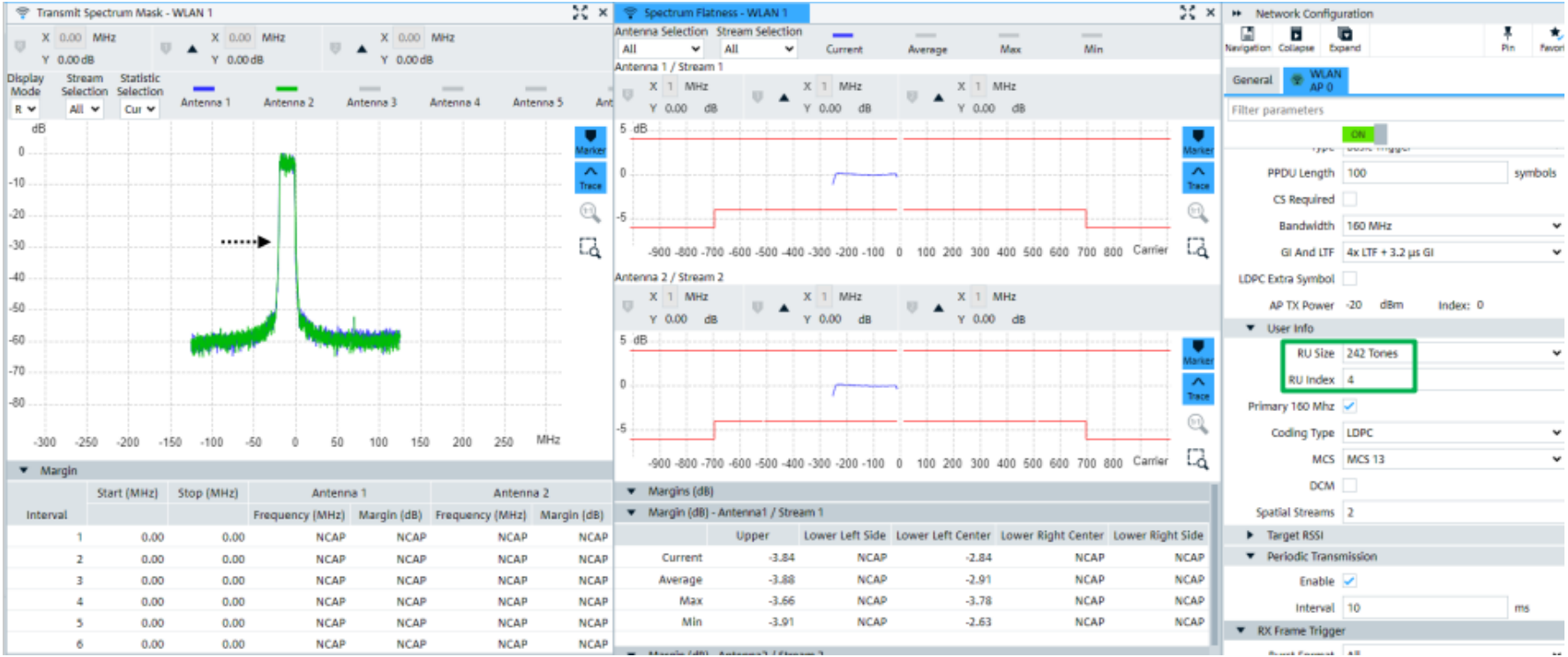
5 GHZ, 160 MHZ, MIMO2X2, TX MEAS: EVM & IQ CONST. EHT-TB



5 GHZ, 160 MHZ, MIMO2X2, TX MEAS: SPECTRUM EHT-TB (242 TONES, RU INDEX = 1)



SPECTRUM
EHT-TB (242 TONES, RU INDEX = 4)

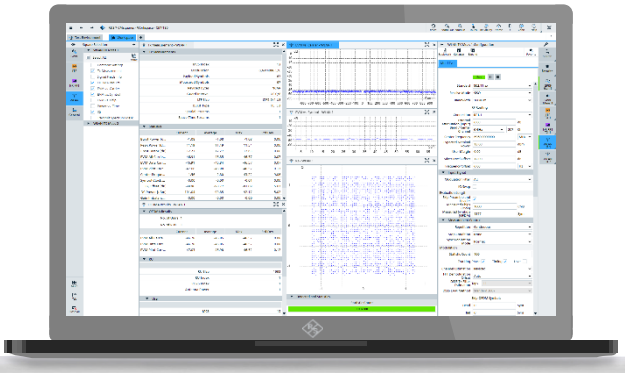


R&S®CMP180 - The future integrated.

Enhanced frequency and bandwidth for the next wireless gen.

Futureproof design	Compact (2 HU x 19”)	Advanced testing	Common platform
◆ 400 MHz up to 8 GHz	◆ 2x 8 RF (in/out) ports	◆ 5G FR1 devices	◆ Linux OS
◆ 320 MHz bandwidth	◆ 2 VSA + 2 VSG	◆ Wi-Fi 6E/7 STAs & APs	◆ R&S®CMsquares
◆ High output power	◆ Build-in controller	◆ BLE and many more	◆ Systemwide license

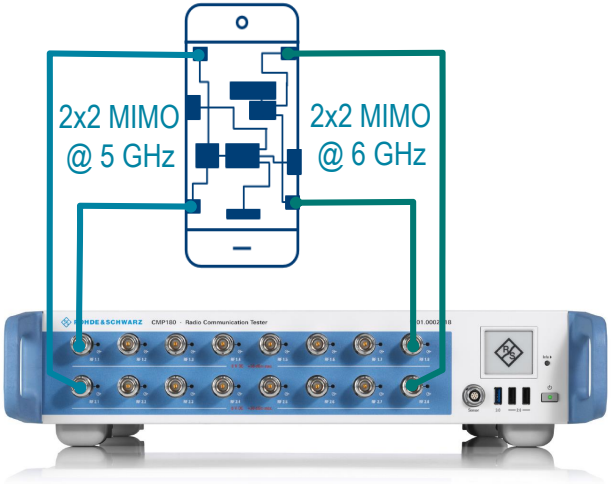
R&S®CMP180



The ideal solution for comprehensive RF testing in engineering validation (EVT), design validation (DVT) and prototyping

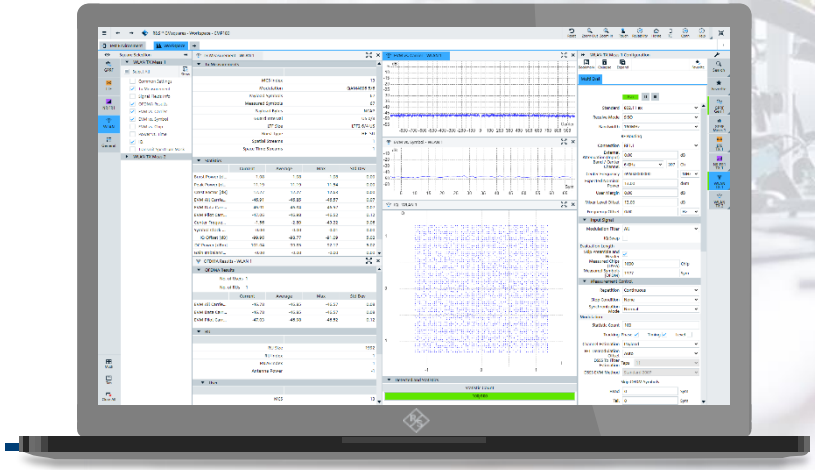
R&S®CMP180

Excellent RF performance combined with flexibility, speed and broad technology support.

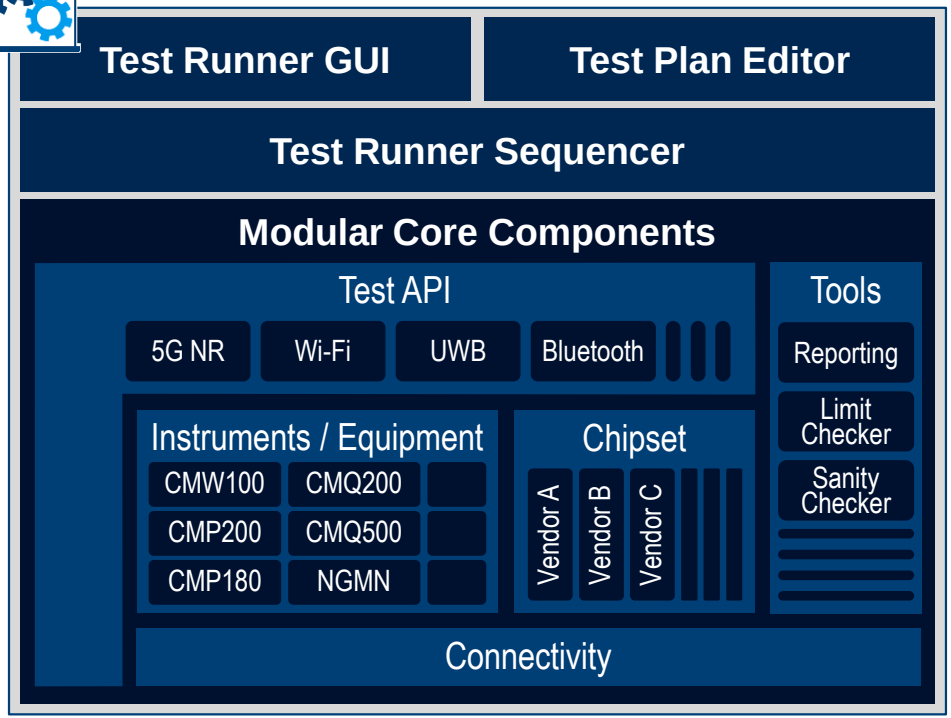


R&S®CMsquares

Powerful control center with an intuitive web based user interface and graphical sequencer.



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



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

- Fully customizable from a basic test tool to a full-blown turnkey solution
- Flexible integration into any automated testing environment (ATE)
- Field-proven speed of test execution
- High efficiency by simultaneous testing (smart channel)
- Insightful and easy customizable GUI for sequencing and test plan creation

Wi-Fi test solutions for today and tomorrow

Conformance

R&S®TS8997

RF performance

R&S®CMW500/270

R&S®CMX500 OBT

R&S®CMP180

Production

R&S®CMW100

R&S®TS7124

R&S®ZNA

R&S®FSW

R&S®SMM100A

R&S®VSE

RF design and compliance

R&S®NGU

R&S®RTP

Embedded design & power


THANK YOU
VERY MUCH
ROHDE&SCHWARZ
Make ideas real