UNDERSTANDING Wi-Fi 8:
Unmatched reliability, efficiency and speed

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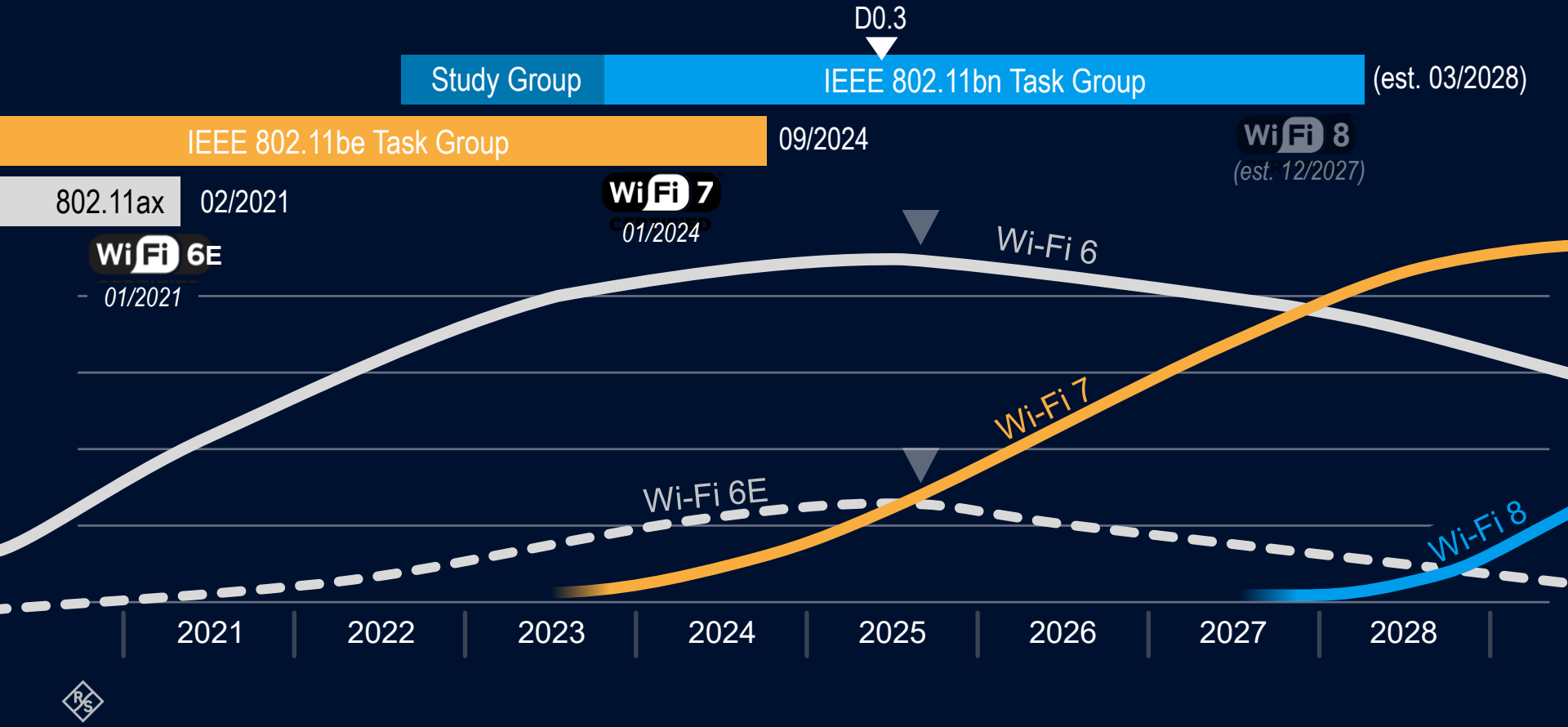
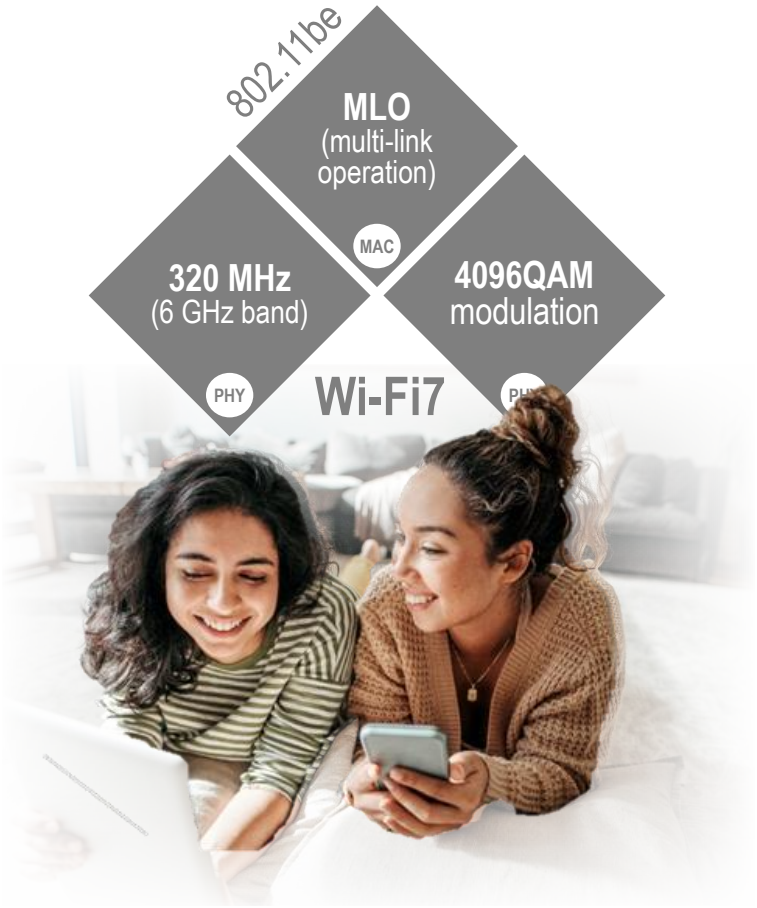
Make ideas real

Wi-Fi technology evolution meets growing market demands



Wi-Fi 7 for extreme high throughput (EHT)



The next generation of Wi-Fi designed for ultra-high reliability

Extended reality | **Factory control** | **Internet of things** | **Enterprise networks**




UHR ultra high reliability 8

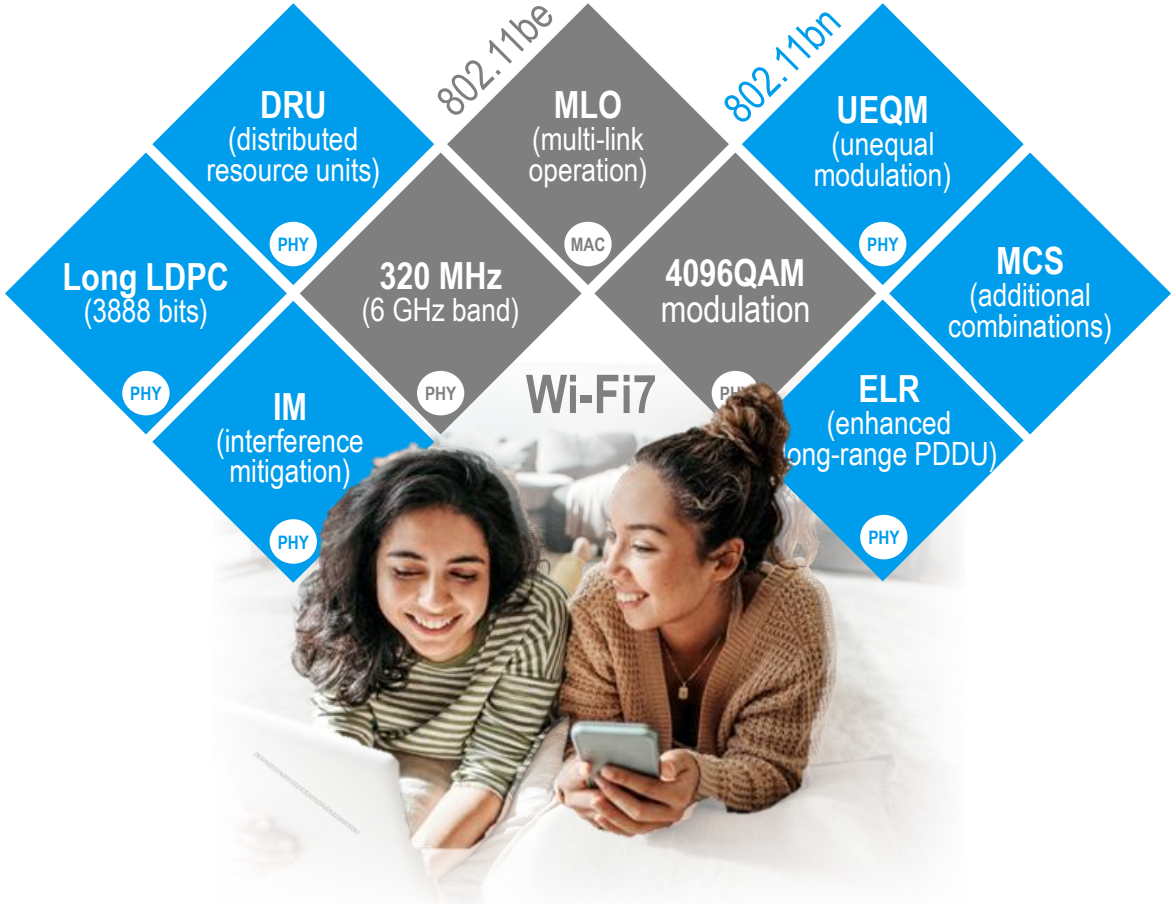
IEEE 802.11bn

Enhancements for **Ultra High Reliability:**

- Increasing throughput by 25%
- Reducing latency by 25%
- Reducing packet loss probability especially for seamless transition between BSS
- Reduce power consumption for APs and improved P2P

*Amendment 802.11bn applies to carrier frequency operation between **1 GHz and 7.250 GHz** and backward compatibility*

Fine tuning Wi-Fi: IEEE 802.11bn – key physical layer essentials

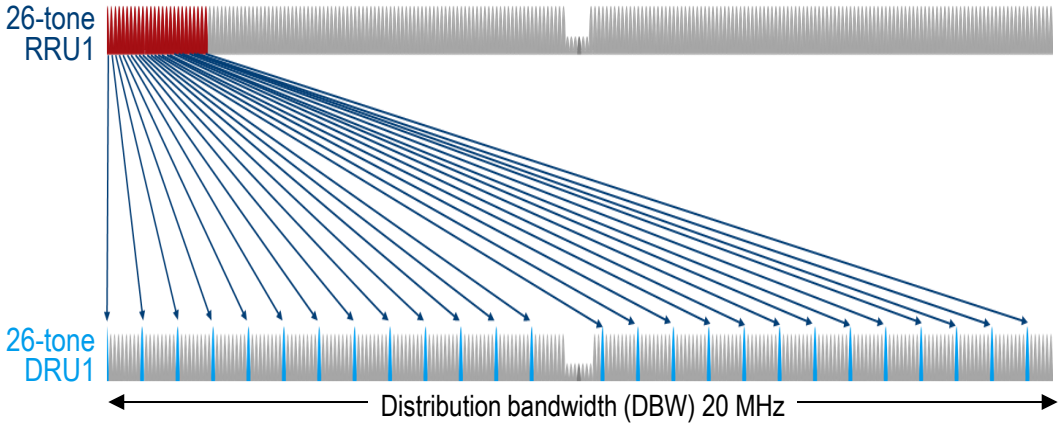


Distributed resource unit (DRU) for trigger-based UL OFDMA transmission enhances maximum transmission power of STAs

Example FCC Low Power Indoor (LPI) Client (6XD)

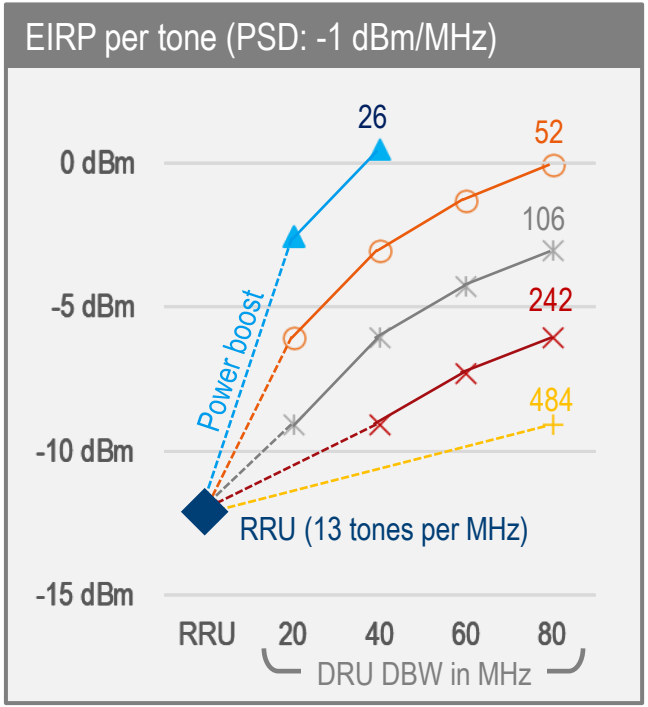
EIRP ≤ 24 dBm, **PSD ≤ - 1 dBm/MHz**

RRU26: 13 tones per MHz ⇨ **-12 dBm per tone** ⇨ $EIRP_{26}$ = 2.1 dBm



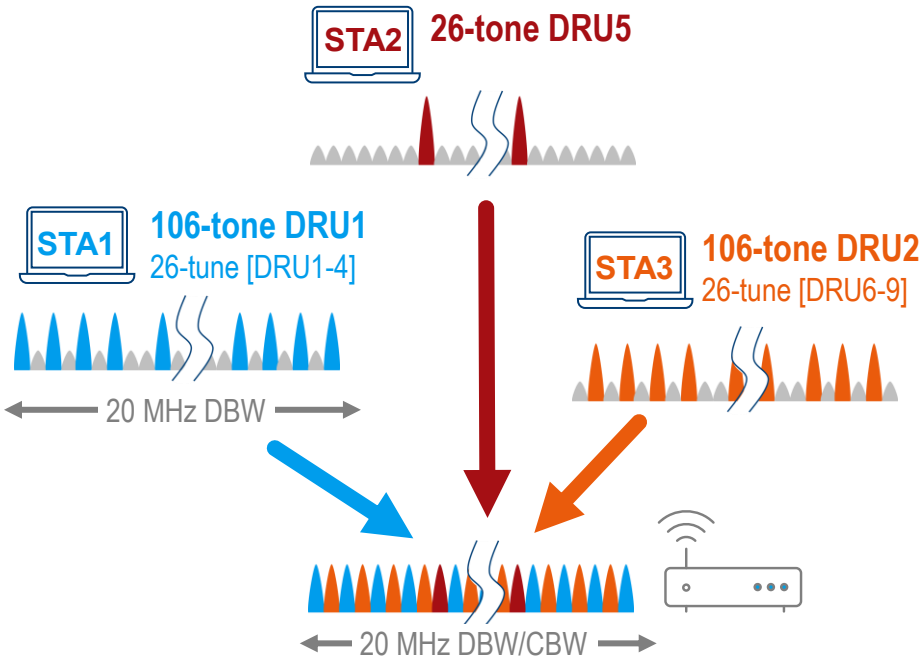
EIRP ≤ 24 dBm, **PSD ≤ -1 dBm/MHz**

DRU26: 2 tones per MHz ⇨ **-4 dBm per tone** ⇨ $EIRP_{26}$ = 10.1 dBm



RRU: regular RU, DRU: distributed RU

Trigger-based UL MU OFDMA communication using DRUs



TRIGGER FRAME (MU-RTS) AP-> STAs

Common Info Field

DRU/RRU Indication Subfield
- B0 lowest 80 MHz subblock
- B1 second 80 MHz subblock
- B2 second highest …
- B3 highest 80 MHz subblock

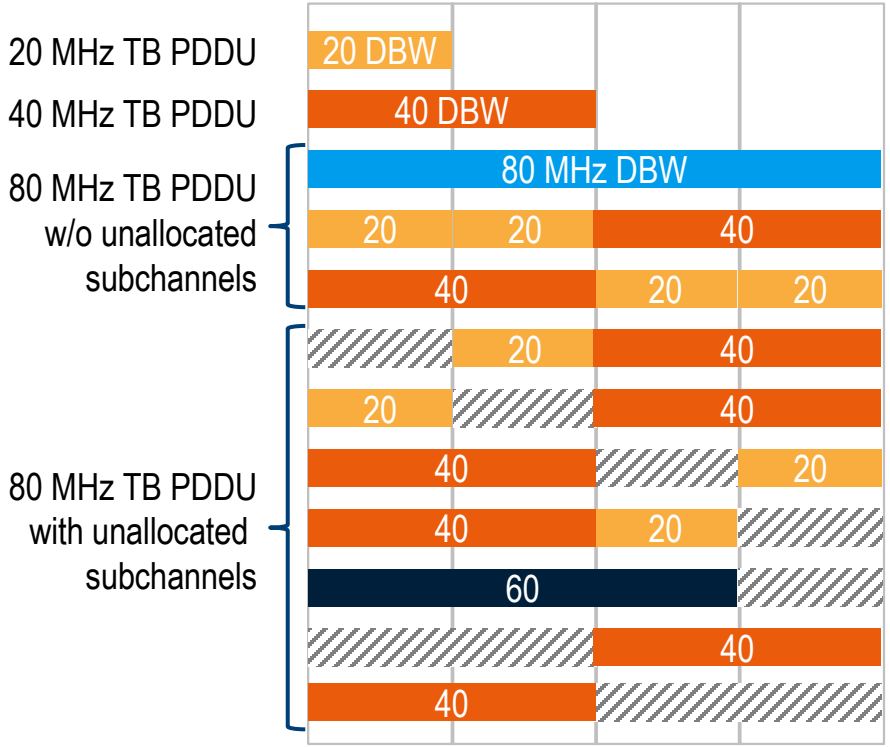
USER INFO Field (per user)

B12..B19 RU Allocation
- STA1:53 (DRU1-106 tones)
- STA2:04 (DRU5-26 tones)
- STA3:54 (DRU-2-106 tones)

B27/28 DBW
- (0: 20, 1:40, 2:60, 3: 80 MHz)

B31 #SS (0:1, 1:2 SS)

Allowed distributed bandwidth (DBW) modes for DRU transmission (DBW: 20, 40, 60, 80 MHz)



- A DRU transmission is allowed only in an **OFDMA UHR TB PPDU (STA⇨AP)**.
- Maximum **two spatial streams** are allowed.
- UHR-MCS 15 (BPSK-DCM) is disallowed in a DRU transmission.
- A **hybrid mode** where DRUs and regular RUs (RRUs) are simultaneously used is allowed only for UHR TB PPDUs with 160 or 320 MHz channel bandwidth (CBW).
  - For a UHR TB PPDU (160/320 MHz) with the hybrid mode, either DRU or RRU are used within each 80 MHz frequency subblock.
  - DRUs and RRUs are not mixed within a certain 80 MHz frequency subblock.
  - The minimum RRU size is 242 tones.

DRU configurations in distribution bandwidths (DBW) 20, 40, 60, 80 MHz

	Data tones	Pilot tones	#RUs @DBW 20	#RUs @DBW 40	#RUs @DBW 60	#RUs @DBW 80
26-tone DRU	24	2	9	18	N/A	N/A
52-tone DRU	48	4	4	8	12	16
106-tone DRU	102	4	2	4	6	8
242-tone DRU	234	8	N/A	2	3	4
484-tone DRU	468	16	N/A	N/A	N/A	2

R&S Vector Signal Generators
Mastering effortless signal creation

Directly on instrument

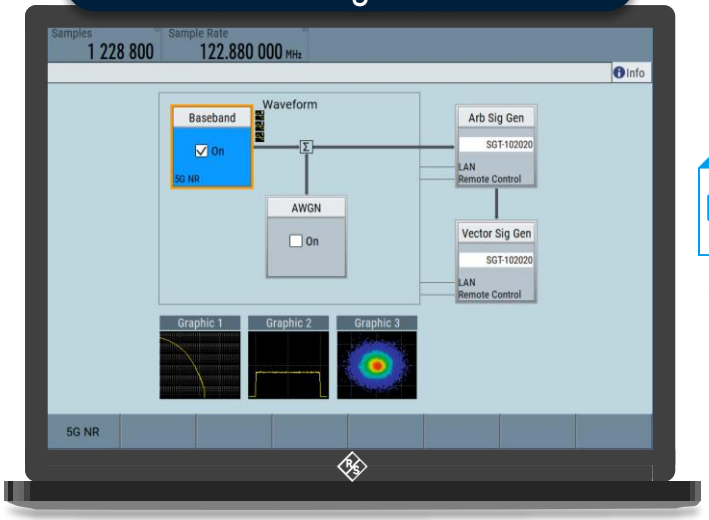

R&S®SMW200A


R&S®SMM100A


R&S®SMBV100B

Using WinIQSIM2 PC software

Waveform generation



Waveform playback


R&S®SMW200A


R&S®SMM100A


R&S®SMBV100B


R&S®SMCV100B


R&S®SFI100A


R&S®SGT100A

R&S Vector Signal Generators
Utilizing the R&S®SMW200A for WLAN/Wi-Fi signal generation

RF up to 44 / 67 GHz

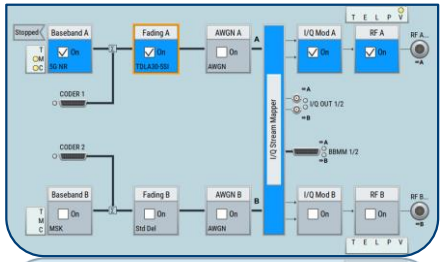
Up to 2 GHz BW

- Signal generation in line with IEEE 802.11a/b/g/n/j/p/ac/ax/be/bn
- Standard compliant full set of UHR-MCSs, up to 4096QAM
- Support of UHR unequal modulations (UEQM)
- Multi-user MIMO and spatial multiplexing
- Simulation of real-time MIMO channel conditions

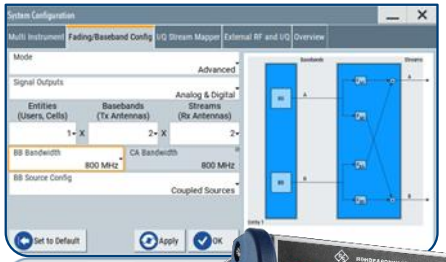
R&S®SMW200A | R&S®SMM100A | R&S®SMBV100B | R&S®SGT100A | R&S®SMCV100B

Comprehensive channel emulation capabilities of the R&S®SMW200A

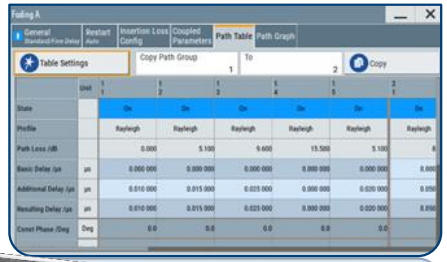
SISO



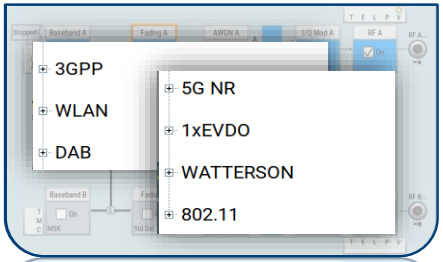
MIMO (incl. correlations)



Flexible definition of profiles



Standards-compliant presets



R&S Signal & Spectrum Analyzers: Unlock the power of precision with WLAN/Wi-Fi signal analysis directly on the instruments

R&S®FSW

- Supports up to 90 GHz
- Up to 8 GHz internal bandwidth
- Unmatched phase noise
- Best sensitivity on the market

R&S®FSVA3000

- Supports up to 54 GHz
- Up to 1 GHz bandwidth
- Best performance in its class
- Mid-range instrument with extremely low phase noise

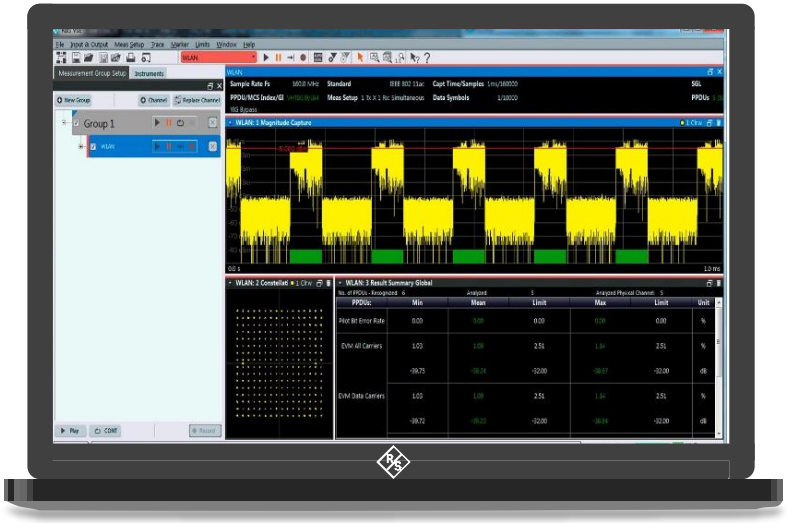
R&S®FSV3000

- Supports up to 50 GHz
- Up to 200 MHz bandwidth
- High measurement speed
- Optimized for production

R&S Signal & Spectrum Analyzers:
Using R&S®VSE vector signal explorer software

The R&S®VSE features analysis of:

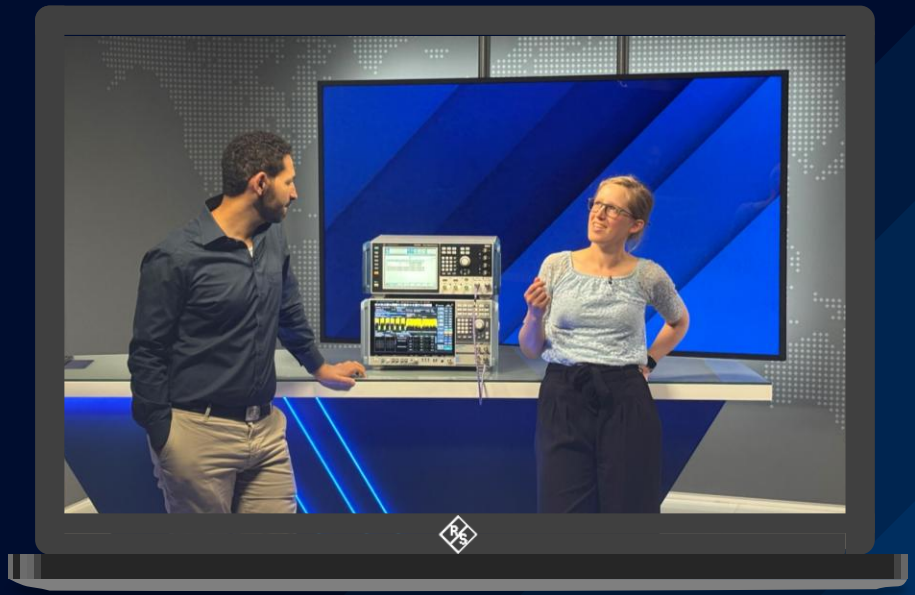
- The same data in various applications simultaneously
- I/Q data files
- Multiple inputs from a single instrument
- Input from different instruments



R&S®FSW | R&S®FSVA3000 | R&S®FSV3000 | R&S®RTx | R&S®PVT | R&S®CMP180

Dedicated options for all relevant WLAN standards

- Supports all WLAN standards IEEE 802.11a/b/g/n/j/p/ac/ax/be/bn
- Automatic signal detection & demodulation
- Enables modulation analysis measurements, including EVM, constellation diagram etc.
- Spectrum and power measurements
- Instantaneous auto level to achieve best EVM



IEEE802.11bn physical layer features **DRU** and **UEQM** demonstrated on

- **R&S®SMW200A** vector signal generator and
- **R&S®FSW** signal and spectrum analyzer

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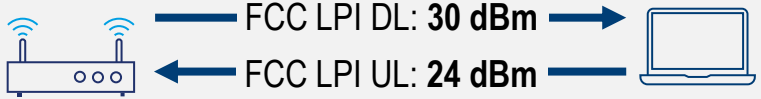
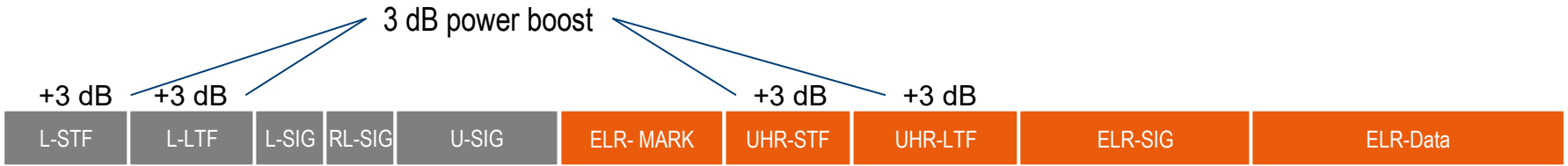
Make ideas real

Addressing regulatory power limits with an enhanced long range (ELR) PPDU

Enhancing uplink range to address link budget imbalance between downlink and uplink (see FCC).



Link budget difference between downlink and uplink can be 6 dB.



ELR could improve link budget by 6 dB and would apply to
- **DL and UL in 2.4 GHz and**
- **UL only in 5/6 GHz bands**

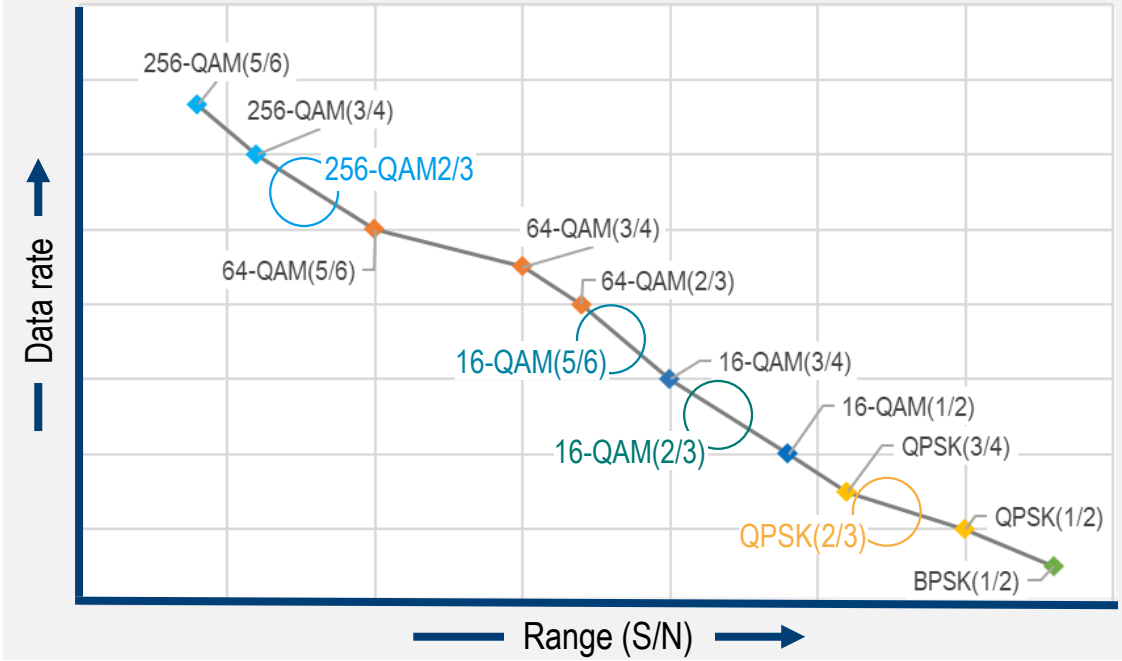
The bandwidth of ELR PPDU is **20 MHz and one spatial stream** is used for ELR transmission only

ELR used **four times frequency domain repetition** over 52-tone regular RUs in 20 MHz

ELR PPDU MCS support:
UHR-MCS0: BPSK, R=1/2
UHR-MCS1: QPSK, R=1/2

Data rate vs. range enhancements by additional MCS options

There are some large gaps



	1/2	2/3	3/4	5/6
BPSK	MCS0			
QPSK	MCS1	**MSC17** *1+16*	MCS2	
16QAM	MCS3	**MCS19** *3+16*	MCS4	**MCS20** *4+16*
64QAM		MCS5	MCS6	MCS7
256QAM		**MCS23** *7+16*	MCS8	MCS9
1024QAM			MCS10	MCS11
4096QAM			MCS12	MCS13

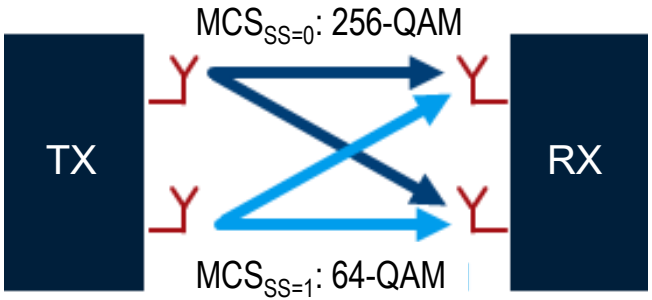
Using now 5 bits for MCS coding

UHR MCS example for 4x499 RUs – 320 MHz – 2x2 MIMO

UHR MCS	Modulation	Coding	EVM	Sensitivity	Guard Interval		
					0.8 µs	1.6 µs	3.2 µs
0	BPSK	1/2	-5 dB	-70 dBm	288 Mbps	272 Mbps	245 Mbps
1	QPSK	1/2	-10 dB	-67 dBm	576 Mbps	544 Mbps	490 Mbps
17		**2/3**	**-12 dB**	**-66 dBm**	**769 Mbps**	**726 Mbps**	**653 Mbps**
2		3/4	-13 dB	-65 dBm	865 Mbps	817 Mbps	735 Mbps
3	16-QAM	1/2	-16 dB	-62 dBm	1 153 Mbps	1 089 Mbps	980 Mbps
19		**2/3**	**-18 dB**	**-59 dBm**	**1 537 Mbps**	**1 452 Mbps**	**1 307 Mbps**
4		3/4	-19 dB	-58 dBm	1 729 Mbps	1 633 Mbps	1 470 Mbps
20		**5/6**	**-20 dB**	**-57 dBm**	**1 921 Mbps**	**1 815 Mbps**	**1 633 Mbps**
5	64-QAM	2/3	-22 dB	-54 dBm	2 306 Mbps	2 178 Mbps	1 960 Mbps
6		3/4	-25 dB	-53 dBm	2 594 Mbps	2 450 Mbps	2 205 Mbps
7		5/6	-27 dB	-52 dBm	2 882 Mbps	2 722 Mbps	2 450 Mbps
23	256-QAM	**2/3**	**-29 dB**	**-48 dBm**	**3 074 Mbps**	**2 904 Mbps**	**2 613 Mbps**
8		3/4	-30 dB	-47 dBm	3 459 Mbps	3 267 Mbps	2 940 Mbps
9		5/6	-32 dB	-45 dBm	3 843 Mbps	3 630 Mbps	3 267 Mbps
10	1024-QAM	3/4	-35 dB	-42 dBm	4 324 Mbps	4 083 Mbps	3 675 Mbps
11		5/6	-35 dB	-40 dBm	4 804 Mbps	4 537 Mbps	4 083 Mbps
12	4096-QAM	3/4	-38 dB	-37 dBm	5 188 Mbps	4 900 Mbps	4 410 Mbps
13		5/6	-38 dB	-34 dBm	5 765 Mbps	5 444 Mbps	4 900 Mbps
15	BPSK-DCM	1/2	-5 dB	-70 dBm	144 Mbps	136 Mbps	123 Mbps

Re-visiting unequal modulation (UEQM) to improve SU-MIMO performance with beamforming

- UEQM is used to improve performance (overall throughput) by adapting the modulation & coding scheme used on each spatial stream based on its channel quality.
- **Coding stays the same, but modulation can be adapted.**

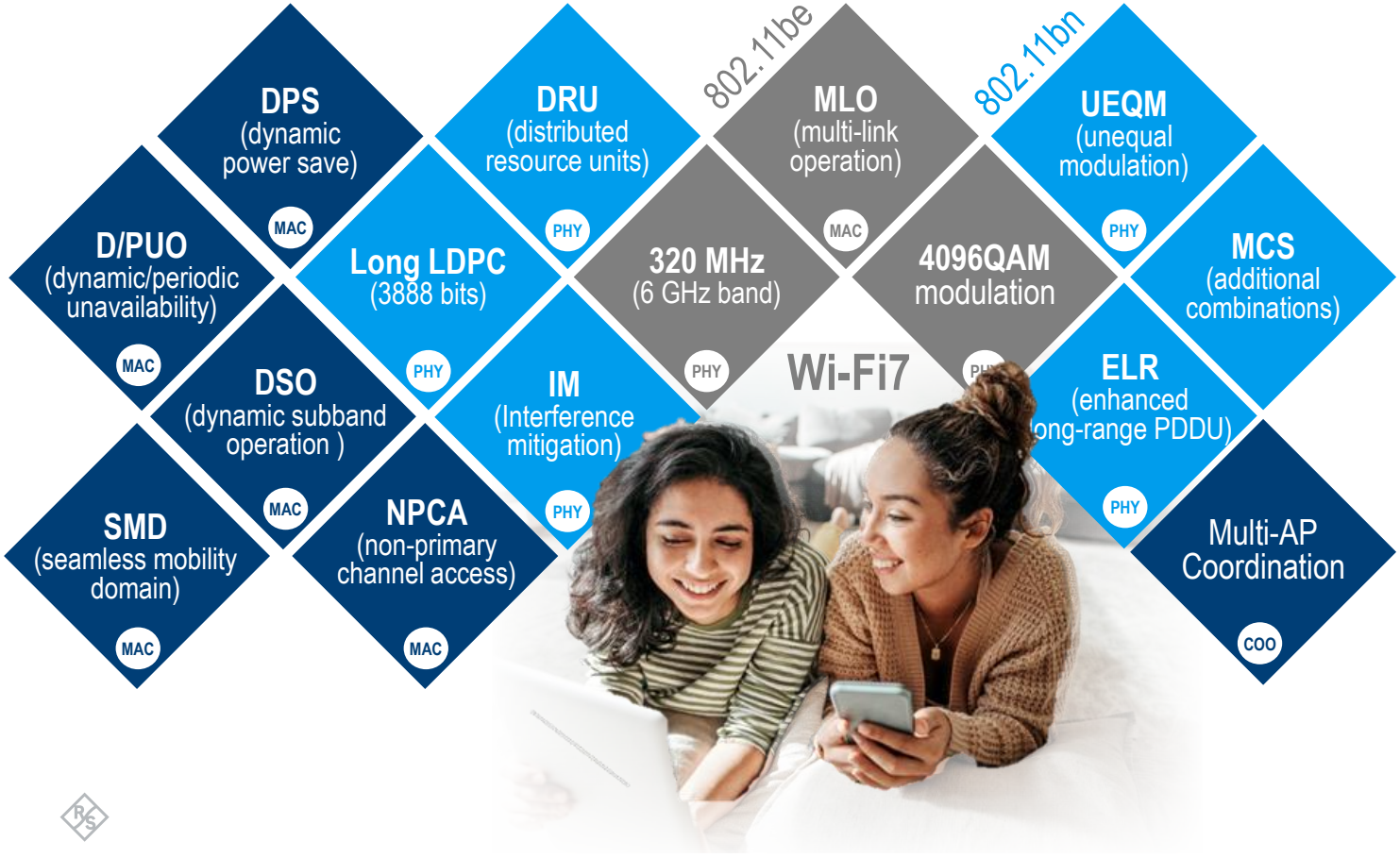


Unequal Modulation (UQAM)
e.g. 2ss, [256-QAM, 64-QAM]
e.g. 4ss, [1K-QAM, 1K-QAM, 256-QAM, 64-QAM]

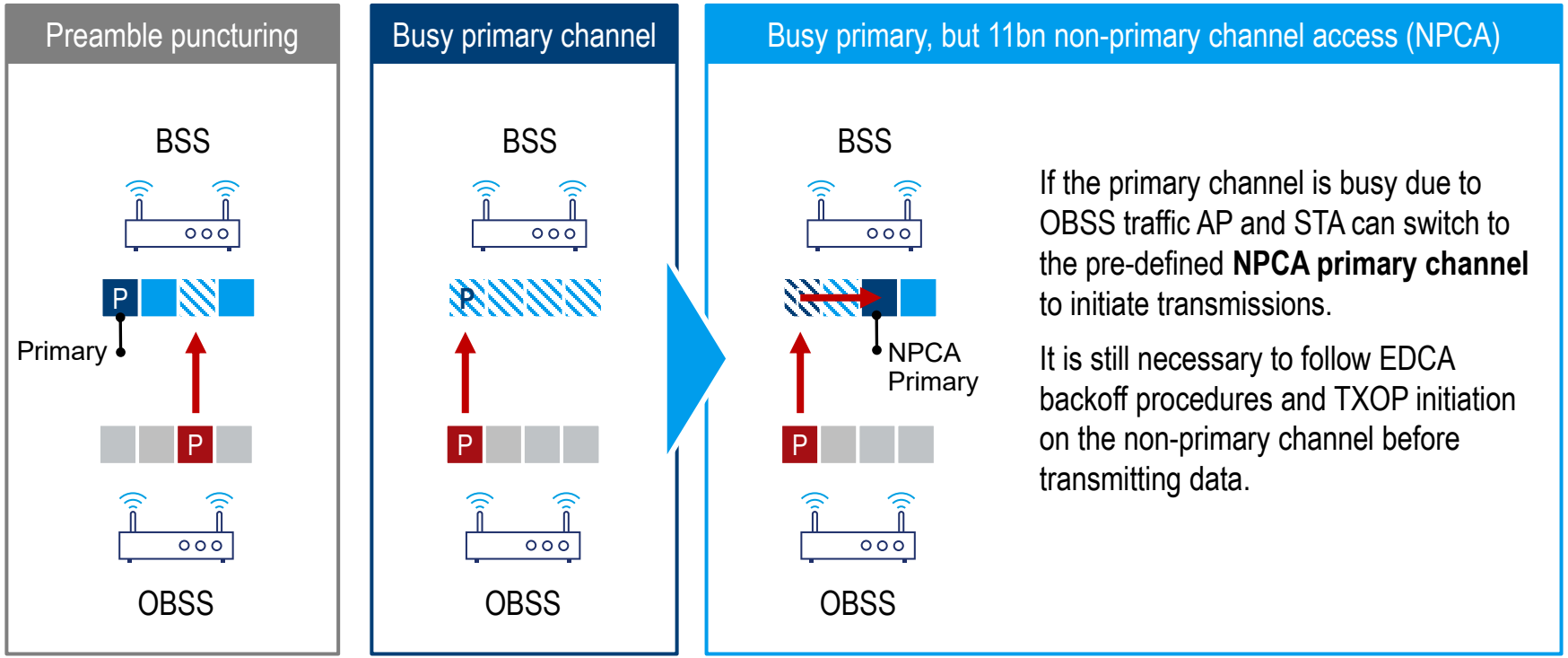
	1st	2nd	3rd	4th
2x2	S	S-1		
	S	S-2		
3x3	S	S	S-1	
	S	S	S-2	
	S	S-1	S-2	
4x4	S	S	S	S-1
	S	S	S	S-2
	S	S	S-1	S-2
	S	S-1	S-1	S-2

S	Constellation index
6	4096-QAM
5	1024-QAM
4	256-QAM
3	64-QAM
2	16-QAM
1	QPSK

Optimizing operation: IEEE 802.11bn – MAC layer essentials

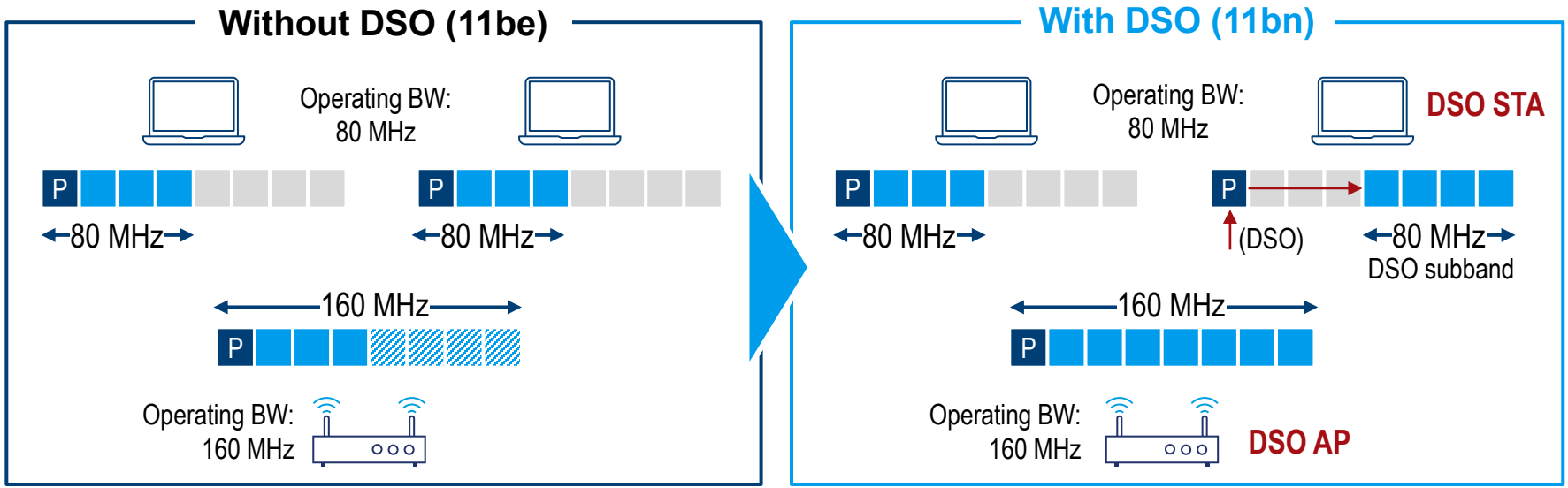


Mitigate congestion and improve spectrum efficiency in case of busy primary channel due to OBSS traffic



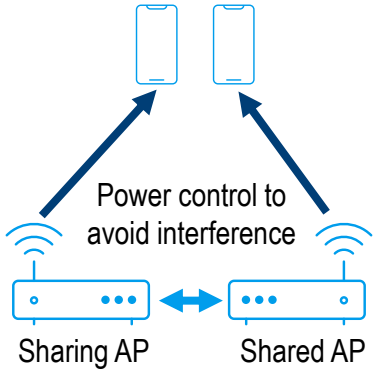
More efficient use of spectrum in case of non-AP STAs with narrower bandwidth than BSS operating bandwidth

Dynamic sub-band operation (DSO) is a mechanism where **narrower bandwidth DSO STA (80 or 160 MHz)** can dynamically, on a per-TXOP basis, be allocated resources **outside of its current operating bandwidth** within the DSO AP's BSS bandwidth.



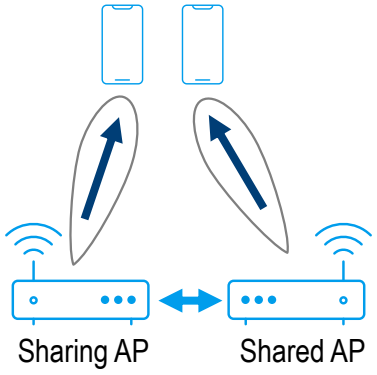
New multi-access point coordination framework

Spatial reuse (Co-SR)



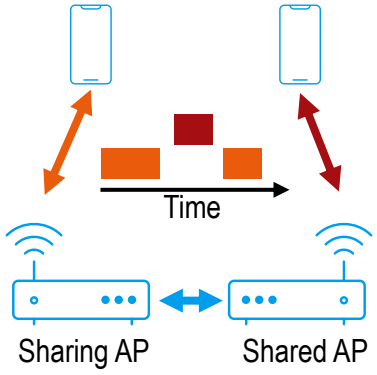
Two APs transmit simultaneously to a single STA each with up to 4 spatial streams

Beamforming (Co-BF)



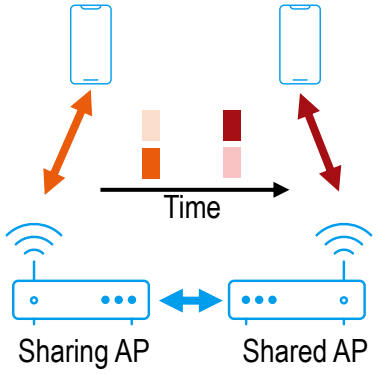
Two UHR APs with up to 2 spatial streams per STA in non-OFDMA DL transmission to up to 2 STAs

Transmission (Co-TDMA)



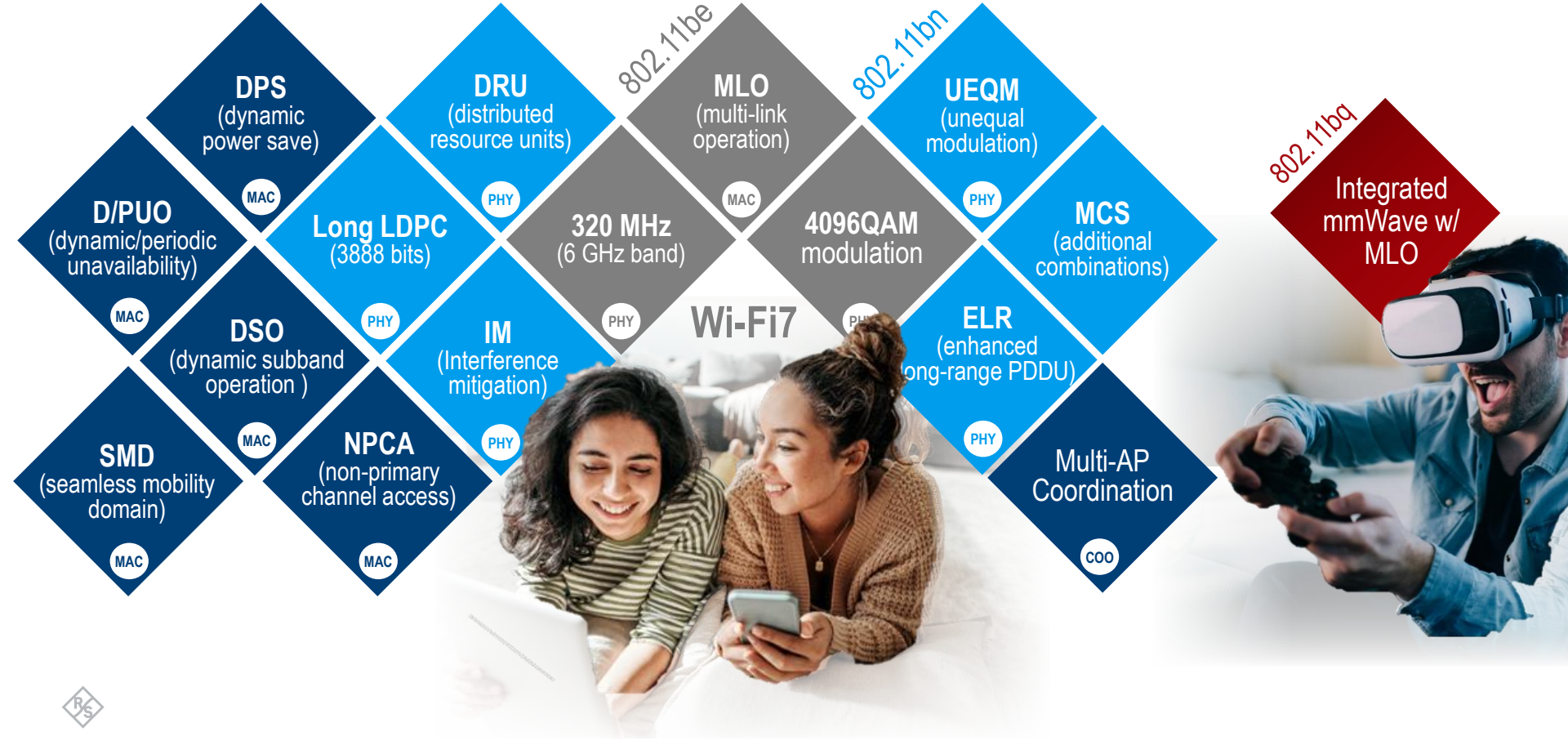
Two APs coordinate time resources to avoid medium contention

Restricted TWT (Co-RTWT)

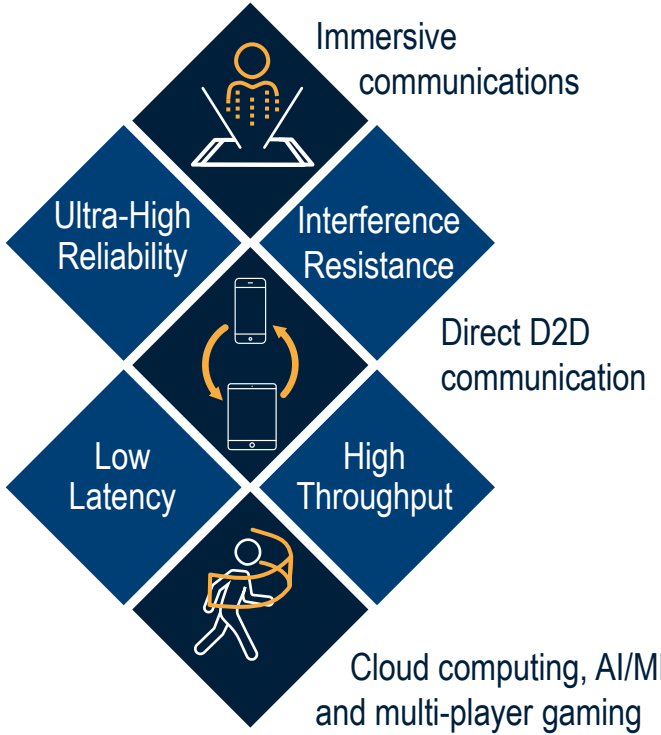


APs coordinate their restricted TWT schedule(s) and/or to protect RTWT of other APs

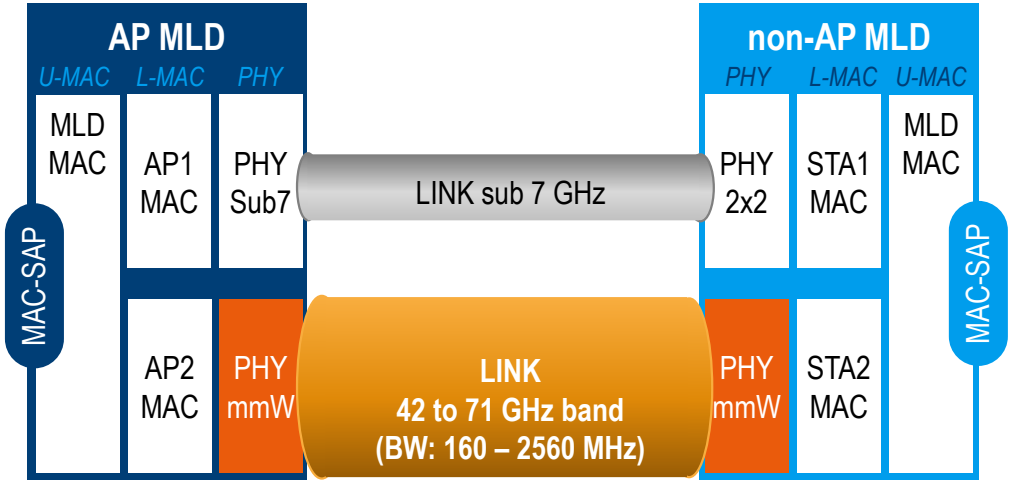
Wi-Fi goes mmWave – again (not part of 11bn and Wi-Fi 8)



Wi-Fi goes mmWave: Integrated mmWave (IMMW) as part of a new IEEE 802.11bq task group

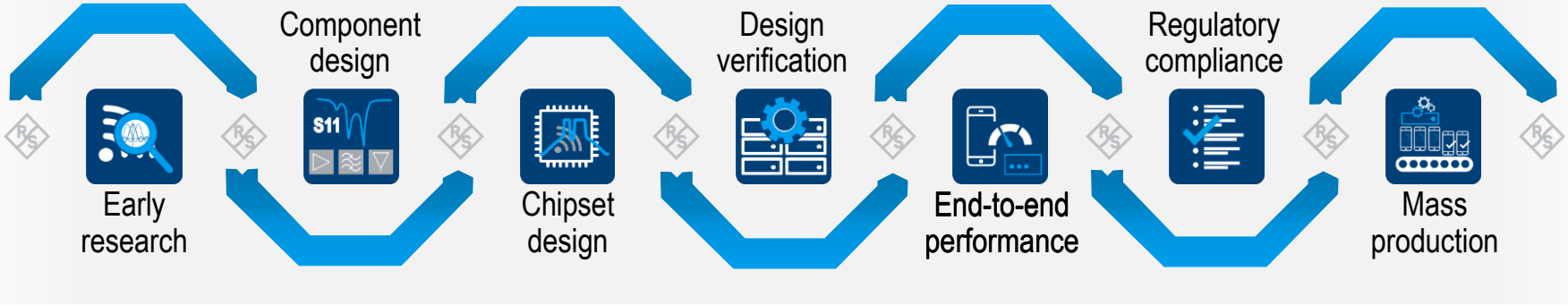


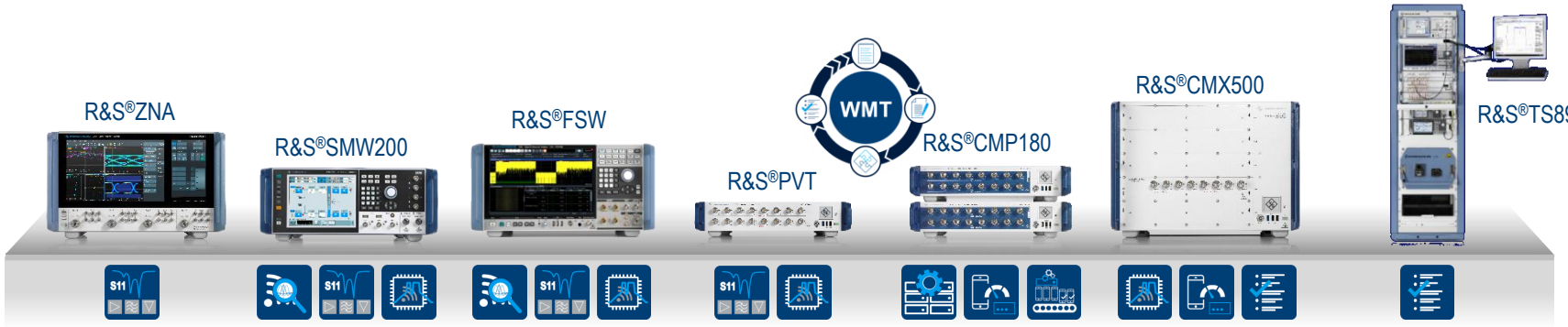
Only in MLO operation with at least on sub 7 GHz link



- Non-overlapping channels 42 to 71 GHz using single-user OFDM
- Leverages or reuses existing PHY and MAC (11be) specifications defined for the operation in sub-7 and MLO
- Single-user (SU) OFDM, single stream, 2.5 MHz SCS, up to 256QAM

Committed to enhancing our wireless testing portfolio to empower the ecosystem at the forefront of technology





Wi-Fi

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