Wi-Fi 7 is now!
WHAT YOU NEED TO KNOW ABOUT GLOBAL REGULATORY COMPLIANCE

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ROHDE&SCHWARZ

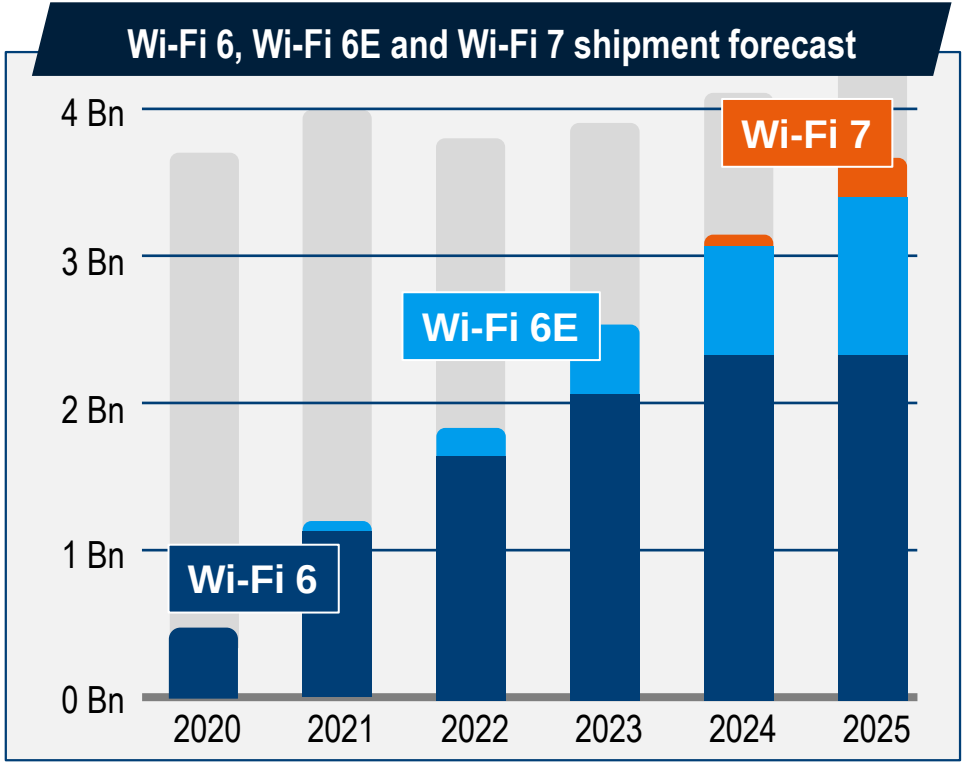
Make ideas real

What you need to know about global regulatory compliance

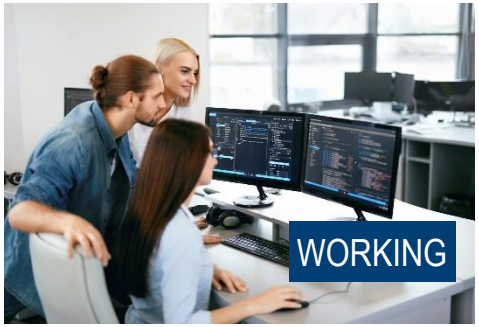
- Wi-Fi 7 is now!
- What does it mean for regulatory compliance?
- What do we need to know about?
- What is next in Wi-Fi?

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



The 7th generation of Wi-Fi for Extreme High Throughput (EHT) at home, offices and factories

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

modulated bits

4096QAM

Code rate

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

Symbol time

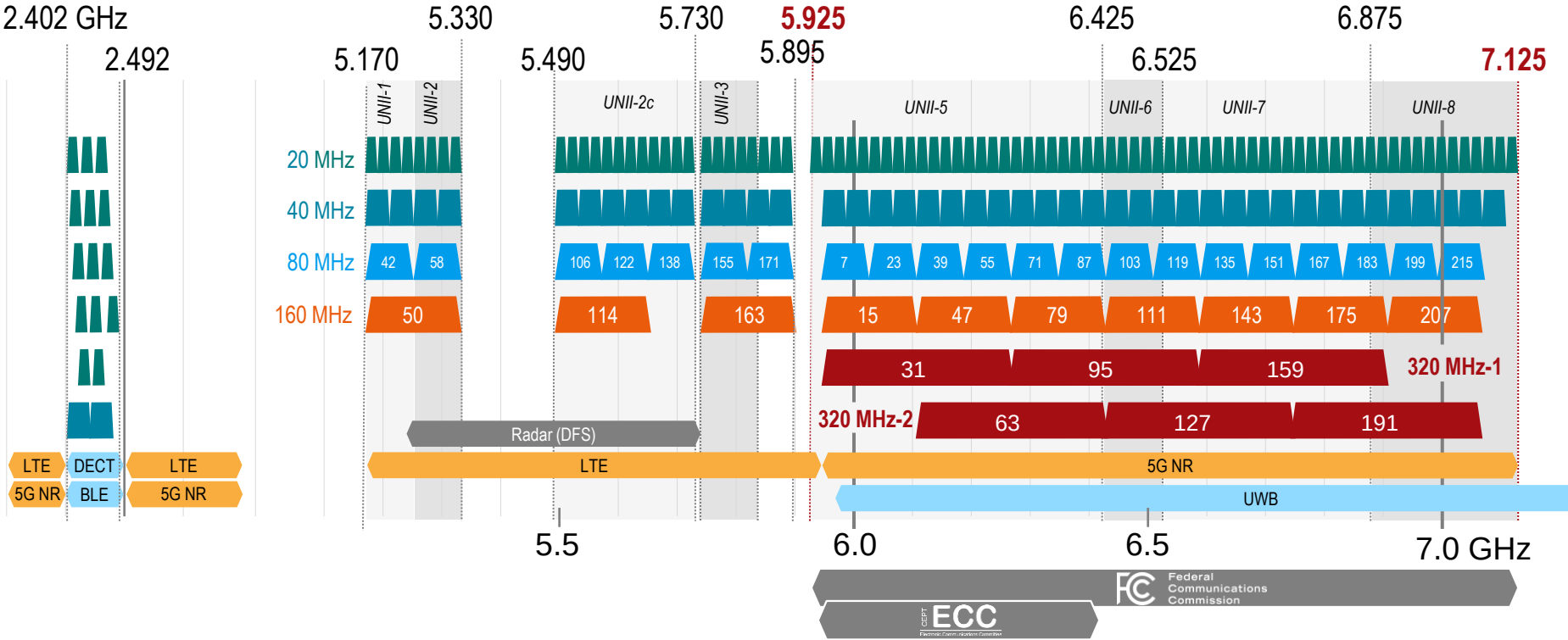
# of data carriers

spatial streams

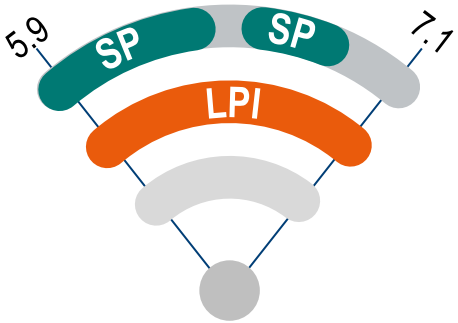
Over two generations a six-fold increase of max. throughput

	Wi-Fi 5 (802.11ac) *Very High Throughput (VHT)*	Wi-Fi 6E (802.11ax) *High Efficiency (HE)*	Wi-Fi 7 (802.11be) *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)**

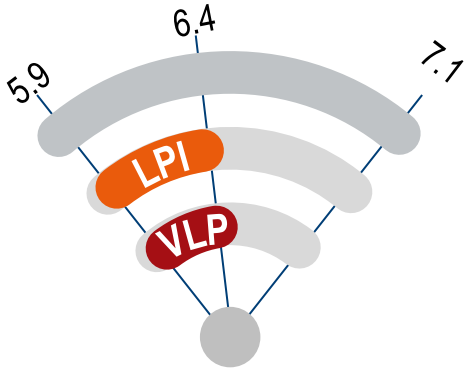
New spectrum allocation allows more wide channels in a (still) less congested 6 GHz band



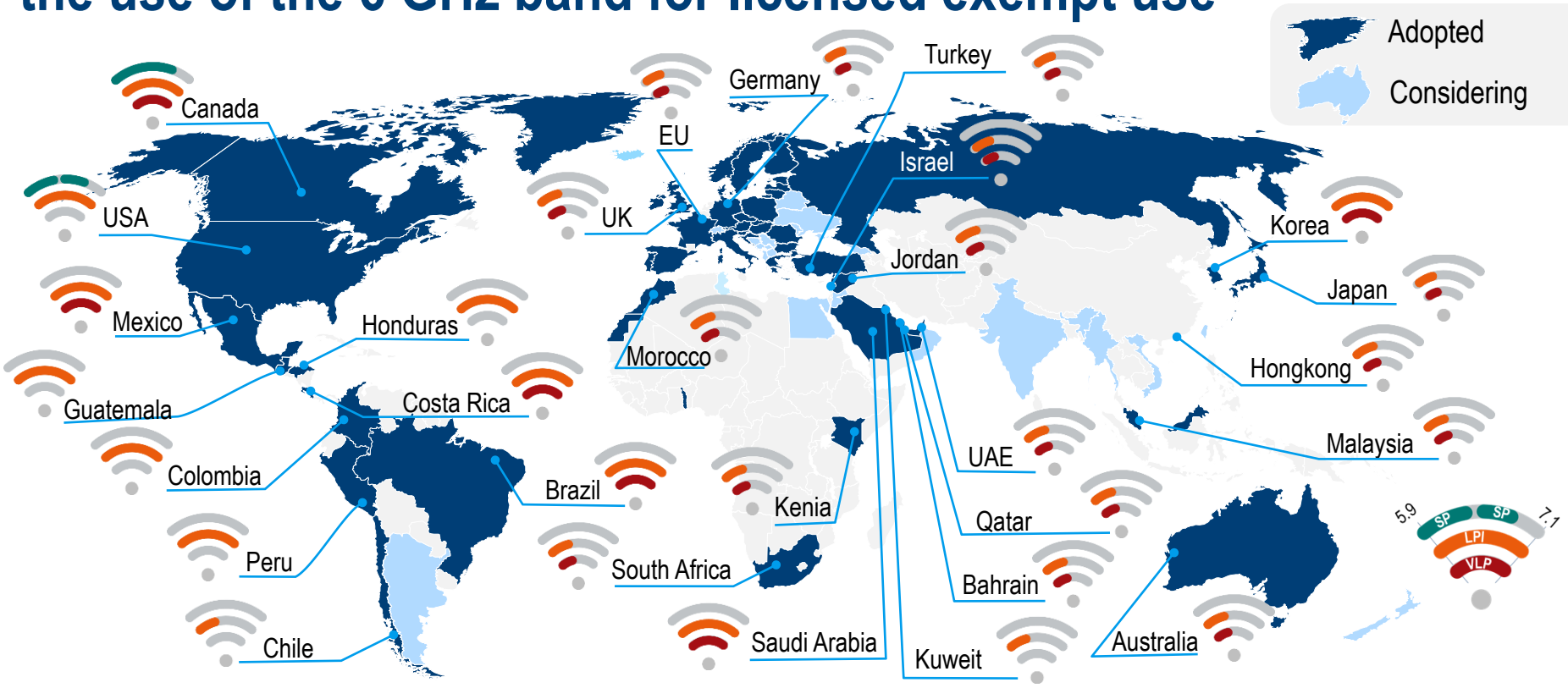
A common approach for 6 GHz band indoor operation with lower power, but …



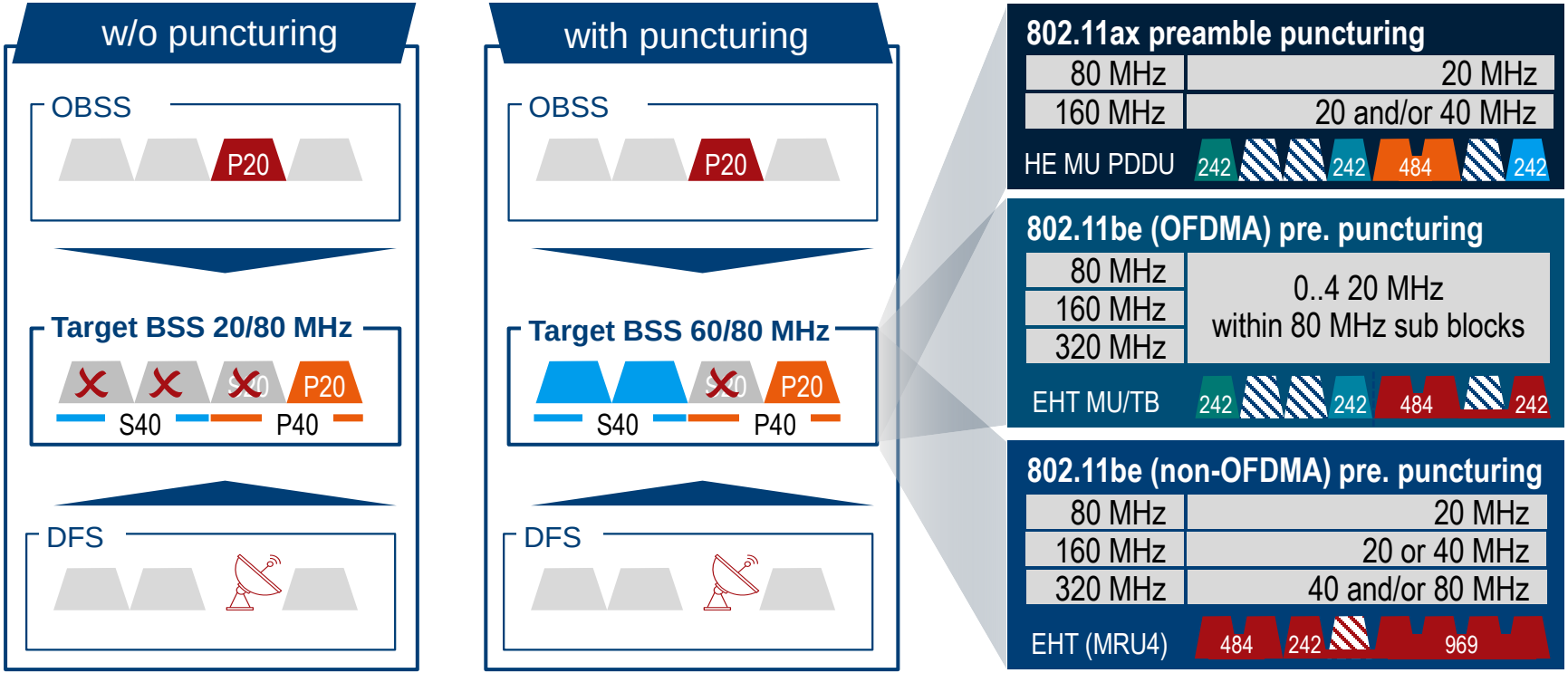
Federal Communications Commission	CEPT ECC Electronic Communications Committee
Standard Power AP: EIRP: 36 dBm (AFC) UE: EIRP: 30 dBm	
Low Power Indoor AP: EIRP: 30 dBm UE: EIRP: 24 dBm	**Low Power Indoor** AP: EIRP: 23 dBm UE: EIRP: 23 dBm
	Very Low Power AP: EIRP: 14 dBm UE: EIRP: 14 dBm



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



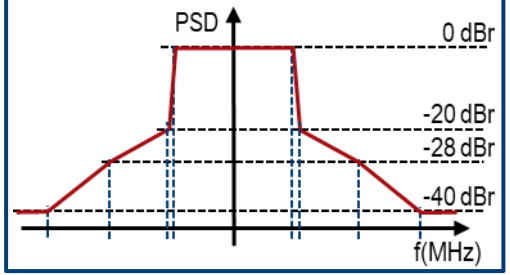
Use of wider channels (80/160/320 MHz) decrease the probability of experiencing interferences



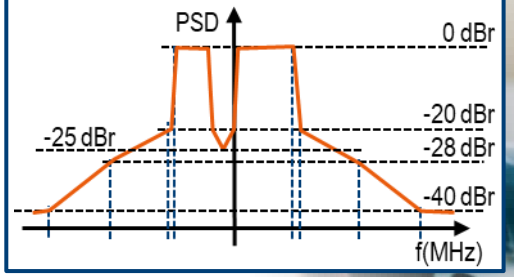
Receiver and transmitter requirement based on IEEE 802.11be

- Spectral flatness
- Center frequ. leakage
- Min. input sensitivity
- Channel rejection
- Maximum input level

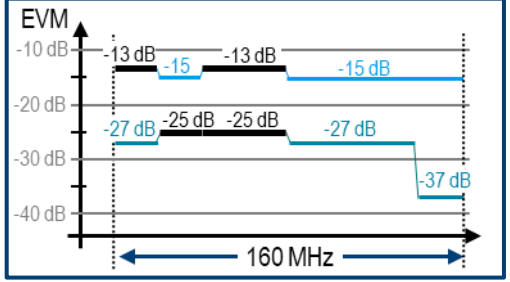
320 MHz spectrum mask



Punctured spectrum mask



MRU unused tone error



Transmitter constellation error

MCS	Mod.	Coding	Error Vector Magnitude of		
			EHT MU PDDU	EHT TB PDDU	
				P > MCS7	P ≤ MCS7
12	4096-QAM	3/4	-38 dB	-38 dB	- 38 dB
13		5/6	-38 dB	-38 dB	-38 dB

- Absolut power accuracy
- Relative power accuracy
- RSSI meas. accuracy
- Carrier frequency offset
- Timing drift

Conformance, compliance and acceptance
Diverse test requirements for Wi-Fi STAs and APs

Standard conformance

Based on requirements defined in IEEE 802.11 like:

- Spectrum mask
- Spectral flatness
- Transmitter modulation accuracy (EVM)
- Receiver minimum input sensitivity
- …..

Wi-Fi interoperability

Validate interoperability with other Wi-Fi CERTIFIED equipment operating in the same frequency band. Examples are Wi-Fi certified 6 (incl. 6E) or Wi-Fi EasyMesh

Wi Fi CERTIFIED

Wi-Fi mobile converged devices

RF perform. evaluation of Wi-Fi mobile converged devices. The scope of testing includes handheld, self-contained Wi-Fi/ mobile modules, access point, notebook and tablet devices that support Wi-Fi as well as cellular technologies.

CTIA Certification

Wi-Fi AP operator acceptance

Test cases for RF performance, coverage, capacity & bandwidth, and stability / robustness.

broadband forum

BBF.398 Grade Wi-Fi Products

Regulatory compliance

Based on national laws covering:

- Interference
- Efficient use of RF resource
- Coexistence

ETSI EN 300 328, EN 301 893, EN 303 687
FCC 15.407 & FCC 15.247

Wi-Fi device related regulatory test requirements for CE RED & FCC compliance

Test results are part of 'technical documentation':

- Prepared before placing product on the market
- Made available to surveillance authorities
- Kept for 10 years from placed on the market

Health & Safety Art 3.1a

Directive 2014/35/EU
CENELEC - EN 50360
Specific absorption rate

EMC Art 3.1b

EN 301 489-1 Common
EN 301 489-17 WLAN

Specific Topics Art 3.3

Guideline 2019/320 (E112)
Emergency service

Radio Spectrum Art 3.2

EN 300 328 WLAN 2.4 GHz
EN 301 893 WLAN 5 GHz
EN 303 687 WLAN 6 GHz

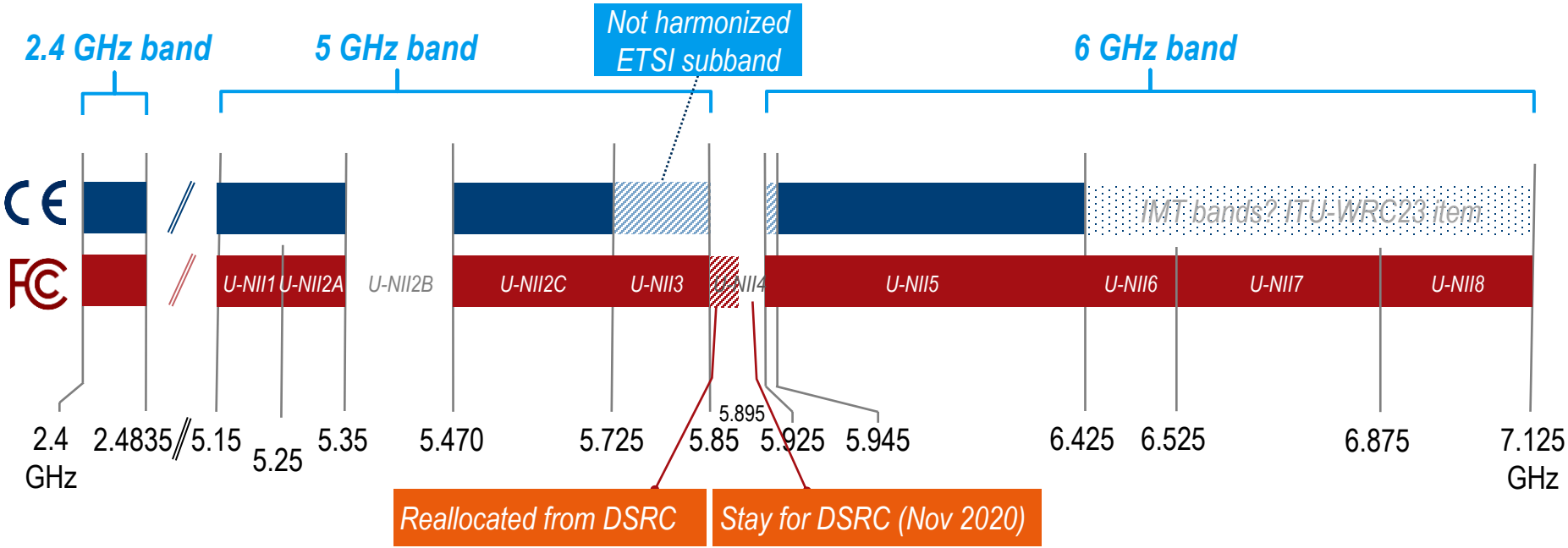
Testing is performed by an FCC-recognized accredited testing laboratory.

47CFR §15.247/15.407

C63.10 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

2.4 GHz:	KDB 558074
5 GHz:	KDB 789033/KDB 905462
6 GHz:	KDB 987594

Unlicensed frequency bands landscape: e.g. ETSI & FCC
Significant difference on details



U-NII: Unlicensed National Information Infrastructure
DSRC: Dedicated Short-Range Communication

ETSI EN standards test cases for CE RED

	Test case	EN 300 328 2.4 GHz band	EN 301 893 5 GHz band	EN 303 687 6 GHz band
Transmitter	Carrier frequency accuracy		◆	◆
	RF output power	◆	◆	◆
	Transmit power control (TPC)		◆	
	Power spectral density	◆	◆	◆
	Occupied channel bandwidth	◆	◆	◆
	Transmitter unwanted emissions	*In out-of-band domain* *Spurious domain*	*Within 5 GHz bands* *Outside 5 GHz bands*	*Within 6 GHz bands* *Outside 6 GHz band*
Coexistence	Duty cycle, TX sequence, TX gap	◆		
	Dwell time, min. freq. occupation, hopping sequence (only for freq. hopping DUTs)	◆		
	Hopping frequency separation	◆		
	Medium utilization (MU) factor	◆		
	Adaptivity	◆	◆	◆
	Dynamic frequency selection (DFS)		◆	
Rec.	Receiver spurious emissions	◆	◆	◆
	Receiver blocking	◆	◆	◆
	Receiver adjacent channel selectivity			◆

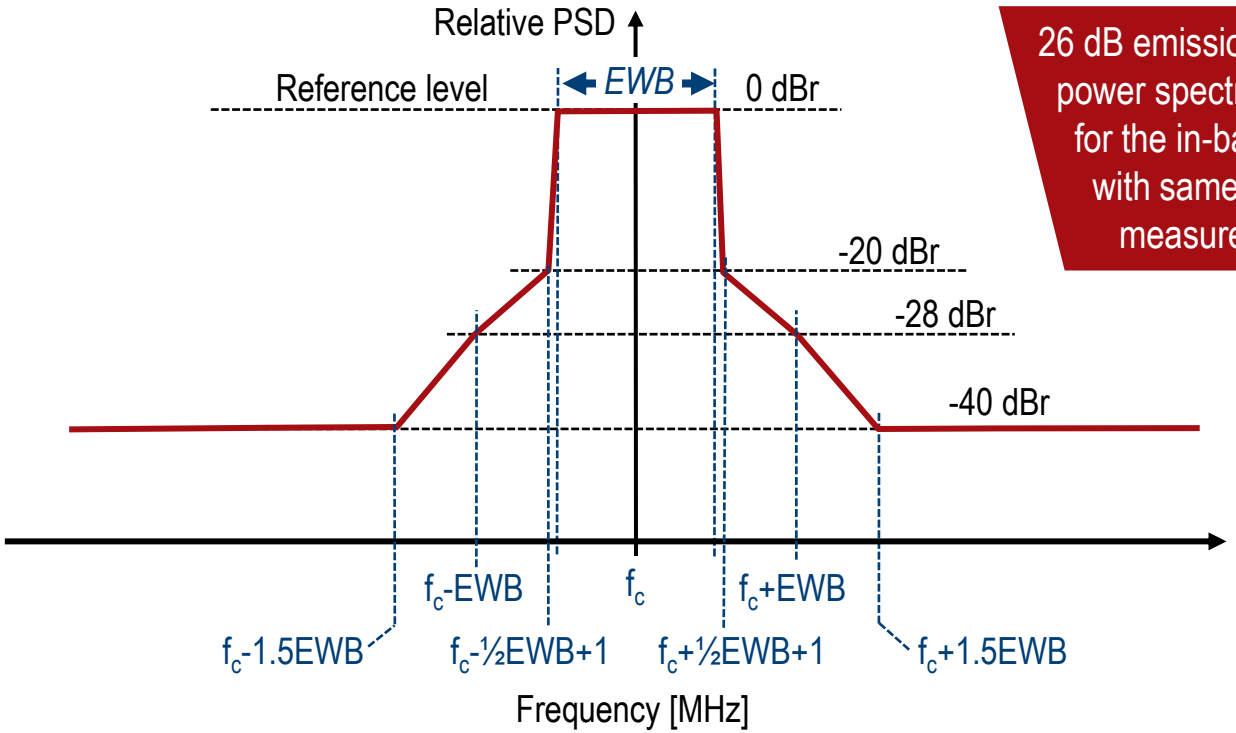
47CFR test cases for FCC

	Test case	47CFR §15.247 2.4 GHz* (KDB558074)	47CFR §15.407(/.247) 5 GHz (KDB 789033/905462)	47CFR §15.407 6 GHz (KDB 789033/987594)
Transmitter	Peak output power	◆	◆	◆
	Max. conducted output power	◆	◆	◆
	Power spectral density	◆	◆	◆
	Emission bandwidth (6dB / 20dB / 26dB)	◆	◆	◆
	99% occupied bandwidth	◆	◆	◆
	Spurious emission	◆	◆	◆
	Frequency stability		◆	◆
Coe	Dynamic frequency selection (DFS)		◆	
	Contention-based protocol (CBP)			◆
	Dual client test			◆
Rec.				

WASHINGTON, March 29, 2023 — FCC Chairwoman Jessica Rosenworcel today proposed that she and her colleagues establish high-level principles to guide the FCC's work on promoting efficient and effective use of advanced wireless technologies. …**Improved receiver performance** can promote more efficient spectrum use and enable valuable new services to be introduced ….

In-Band Emission

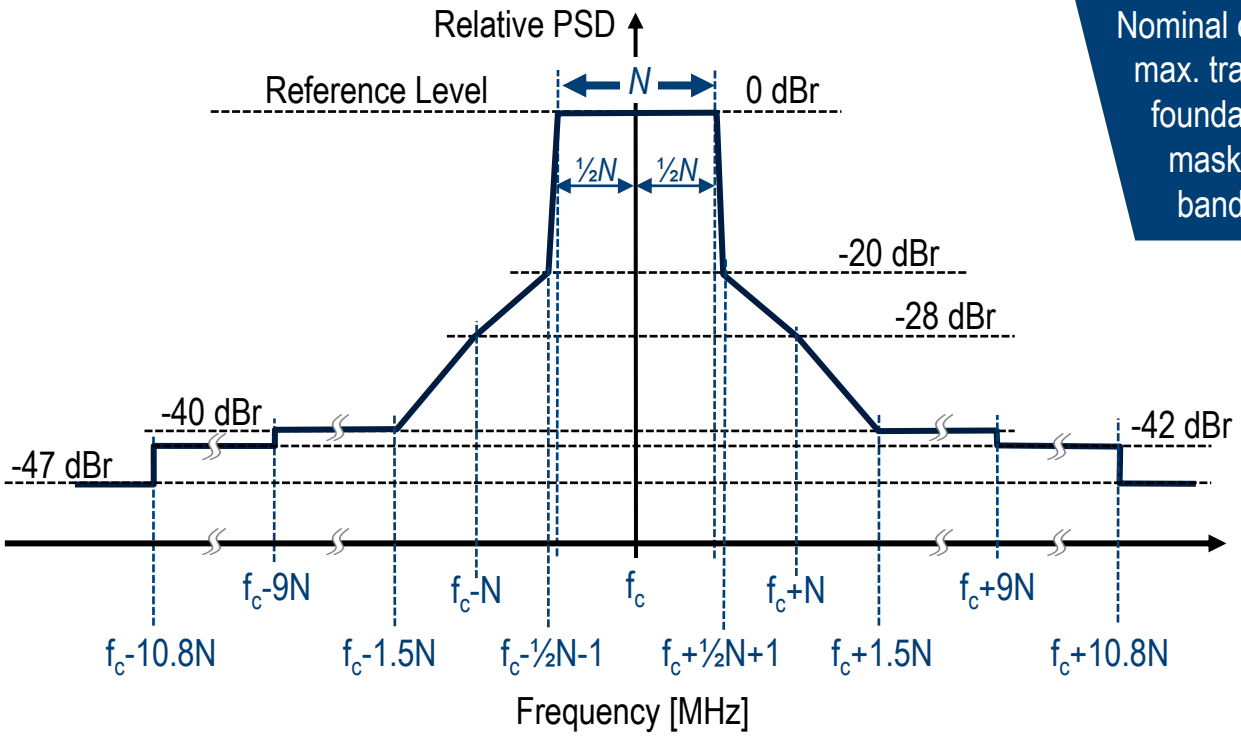
In-band emissions as defined in *FCC KDB 987594 and FCC KDB 789033*



26 dB emission bandwidth (EWB) and peak power spectral density build the foundation for the in-band emission mask, measured with same RBW used for 26 dB EBW measurement (≈1% of EMB).

In case of channel puncturing the remaining emissions do not bleed into the notched ch., i.e., 26 dB or 99% bandwidth is contained outside of the notched band.

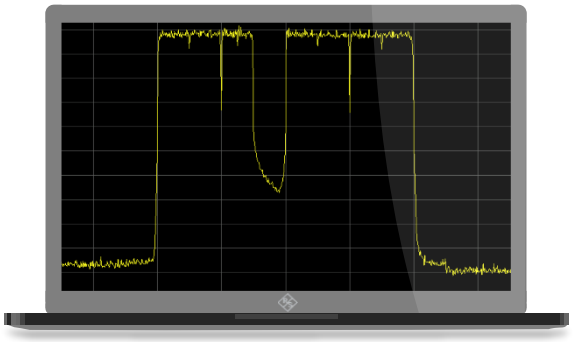
Transmitter unwanted emissions within the transmitter's operating bands (EN 301 893/EN 303 687)



Nominal channel bandwidth ***N*** and the max. transmitted **PSD** build the foundation for transmit spectral power mask, measured with a resolution bandwidth of 1 MHz.

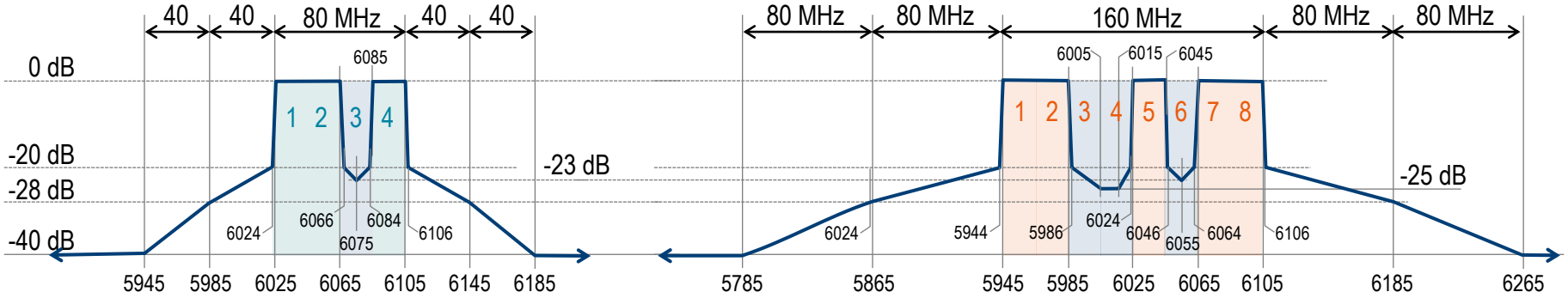
The mean PSD of the transmitter unwanted emissions within the transmitter's operating bands shall not exceed the limits of the mask or an **absolute level of -30 dBm/MHz.**

Transmitter unwanted emissions in case of multi-channel operation in adjacent or non-adjacent channels



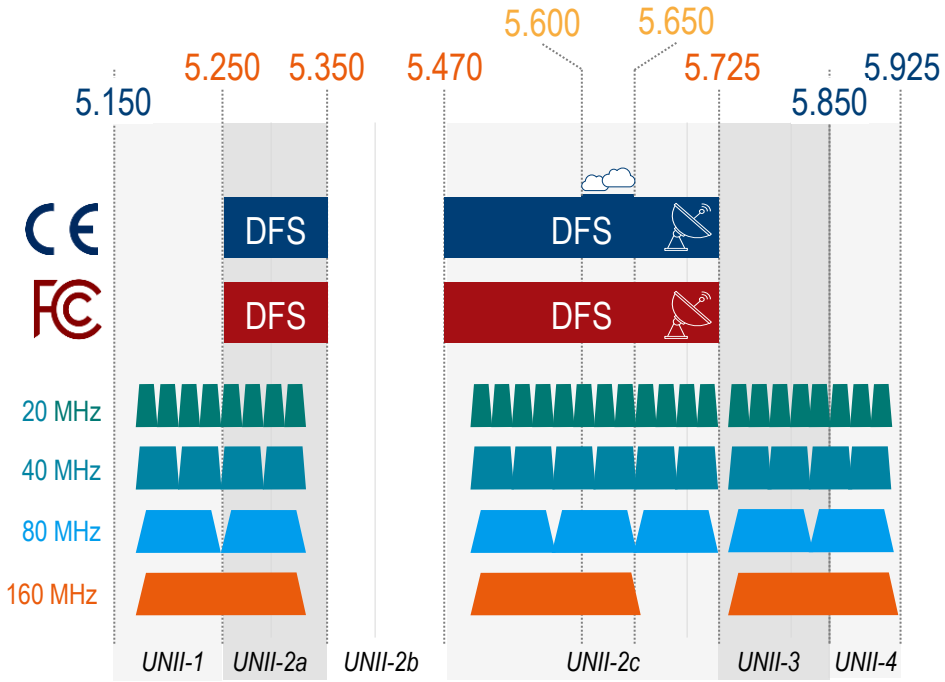
In case of a multi-channel configuration (e.g. Wi-Fi preamble puncturing) on a group of adjacent channels where not all the adjacent channels are used for transmissions, the overall transmit spectral power mask is constructed from specific channel edge masks:

- When there is only one 20 MHz channel not used for transmission
- When there are two or more channels not used for transmission
- When the lowest channel(s) and/or the highest channel(s) are not used



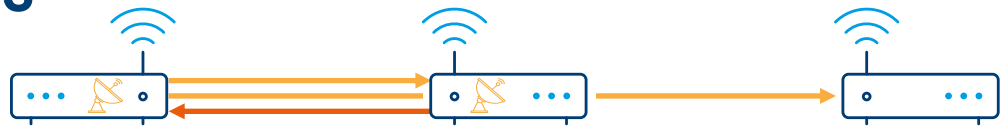
Dynamic Frequency Selection

Dynamic Frequency Selection (DFS) grants priority to different radar applications operating in the 5 GHz band



- DFS is required for operation in UNII-2A (5250 MHz – 5350 MHz) and in UNII-2C (5470 MHz – 5725 MHz)
- EN 301 893 requires stricter limits (e.g. longer channel access check) to grant priority to weather radars in frequency range from 5600 MHz to 5650 MHz
- In FCC, the radar signal detection threshold is -64 dBm or -62 dBm dependent on EIRP and power spectral density.
- In EN 301 893, the threshold is a function of PSD, between -64 dBm and -62 dBm

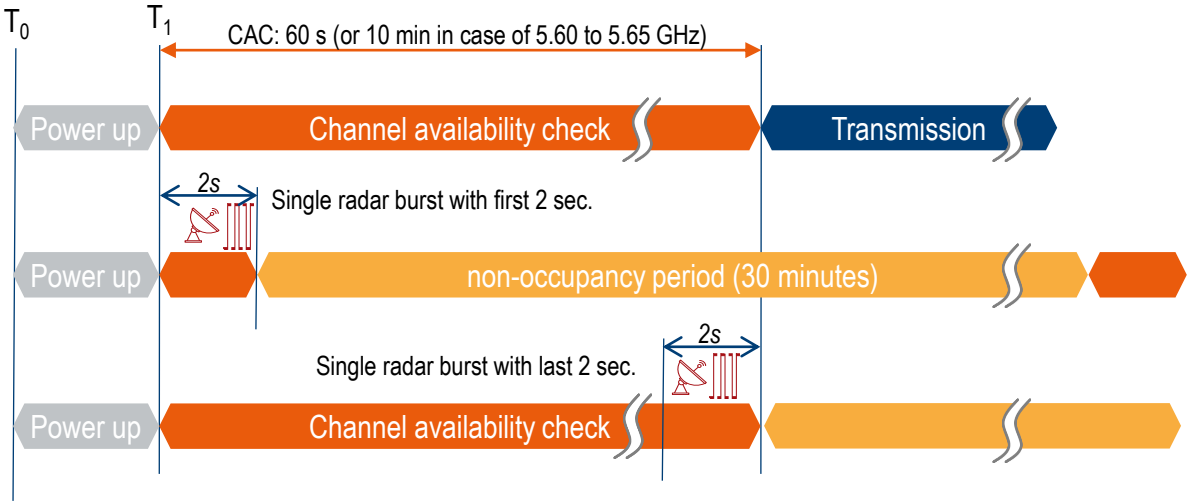
CE RED: DFS test requirements are different for primary and secondary devices



	Primary device w/ radar detection	Secondary device w/ radar detection	Secondary device w/o radar detection
Channel availability check	◆		
Radar detection threshold	◆		
In service monitoring	◆	◆	
Channel shutdown	◆	◆	◆
Non-occupancy time	◆	◆	

CE RED: DFS test item details and test challenges (1 of 3)

- **Channel availability check**
- Radar detection threshold
- In service monitoring
- Channel shutdown
- **Non-occupancy time**



- All antenna ports of the DUT must be connected simultaneously.
- Test setup must manage time synchronization and RF calibration.
- A couple of hundreds waveforms must be selected randomly to cover seral combinations of radar signal and pulse types

CE RED: DFS test item details and test challenges (2 of 3)

- Channel availability check
- **Radar detection threshold**
- In service monitoring
- Channel shutdown
- Non-occupancy time

- Radar level = DFS detection threshold
- At least 12 detected in 20 repetitions
- At least **20** detected in 20 repetitions in case of 5.60 to 5.65 GHz

- As a function of DUT's transmitted power spectral density, the DFS detection threshold should be adapted during the test.
- The required number of repetitions to get statistical relevant results and diverse channel/bandwidth combinations leads to long test time of several hours.

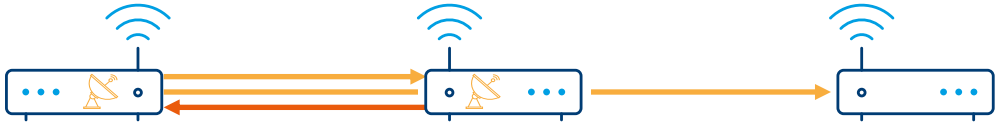
CE RED: DFS test item details and test challenges (3 of 3)

- Channel availability check
- Radar detection threshold
- **In service monitoring**
- **Channel shutdown**
- Non-occupancy time

- Can DUT detect radar during transmission?
- Is channel move time <10s?
- Is channel closing transmit time <1s?

- Accurate system synchronization for timing measurement is very important.
- Requires extensive post processing of measurement data

FCC DFS test requirements are similar to RED

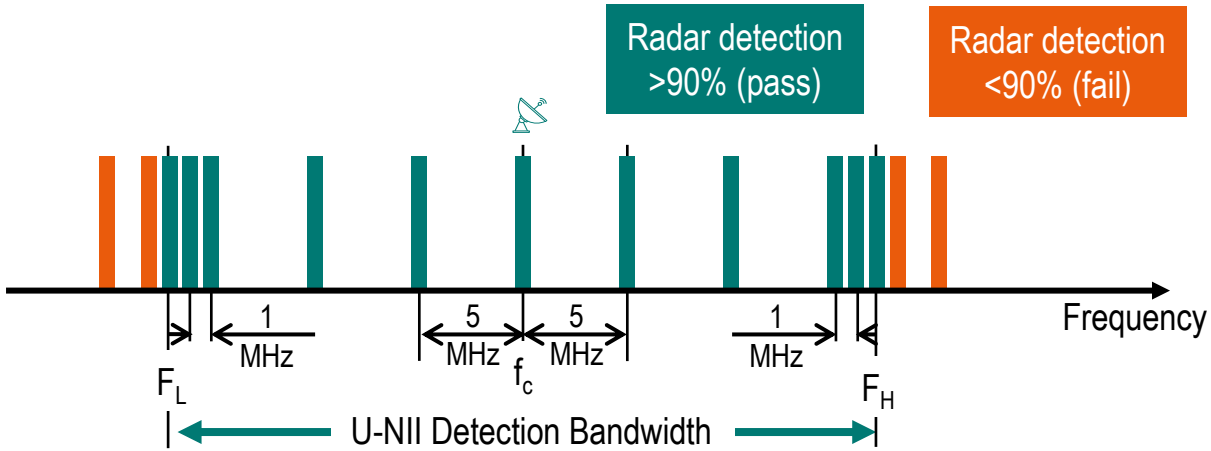


	Primary device w/ radar detection	Client device w/ radar detection	Client device w/o radar detection
Channel availability check	◆		
Radar detection threshold	◆		
U-NII detection bandwidth	◆	◆	
Closing trans. time	◆	◆	◆
Channel move time	◆	◆	◆
Non-occupancy time	◆	◆	

FCC: U-NII detection bandwidth test case is required

- Channel availability check
- Radar detection threshold
- **U-NII detection bandwidth**
- Closing trans. time
- Channel move time
- Non-occupancy time

Check: U-NII Detection BW ≥ Occupied Channel BW (99% power)



- In order to get statistically relevant results many repetitions of radar detection test procedure are required
- All bandwidth modes for multichannel device should be tested.

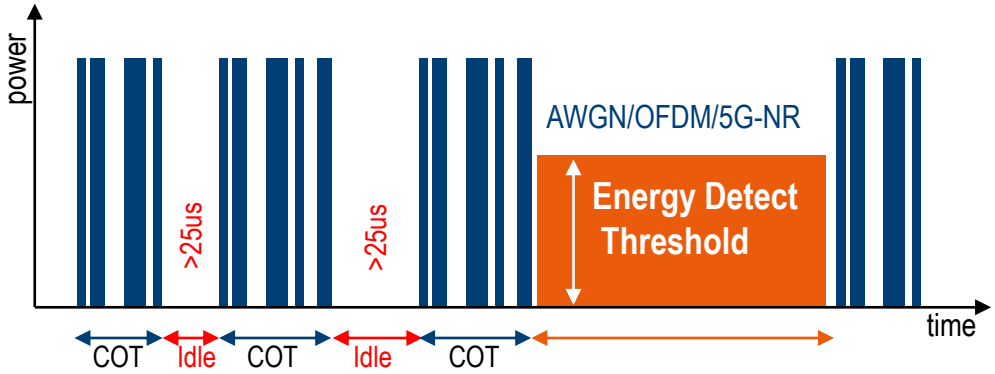
Listen Before Talk

RED adaptivity/channel access mechanism test

LBT test is required for all 2.4 GHz, 5 GHz & 6 GHz devices

Listen Before Talk (LBT) based Channel Access Mechanism for channel clearance assessment procedure

(example with EUT type: Load based, Initiating device, Surprising device)



- Is **C**hannel **O**ccupation **T**ime (COT) below limit?
- Is duration of **Idle** period **randomly** distributed (cumulative histogram limit)?
- Does EUT **stop transmission properly** on this channel when other Energy is detected?
- Does **Short Control Signalling Transmissions** behave correctly?

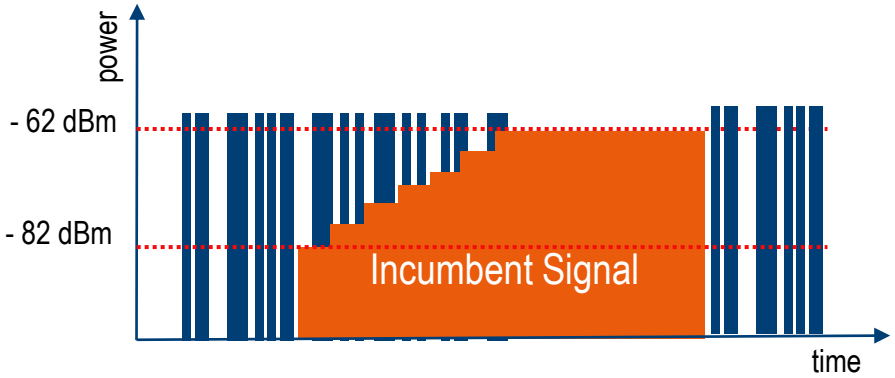
- Test procedure is complex and time consuming.
- High resolution (<1us) power measurement and long test time (>60s) generates huge test data.
- Post processing needs analyze >60,000,000 power measurements data get meaningful statistic results.

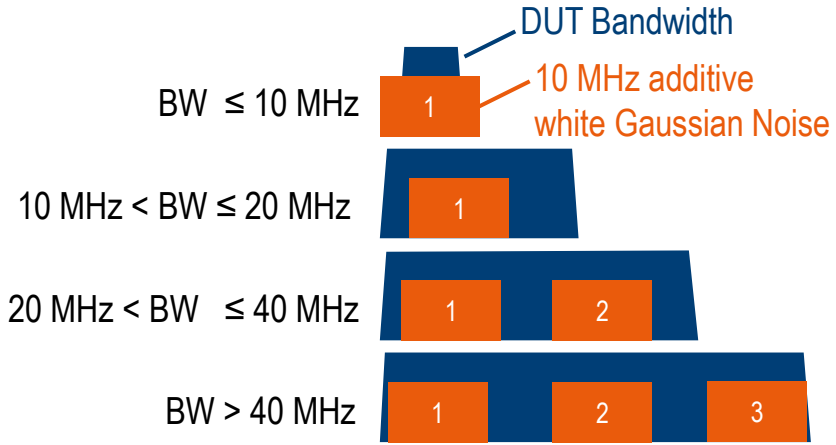
FCC contention-based protocol test for 6 GHz band

Listen before talk test for indoor access points and subordinate/clients

Expected DUT LBT behaver in time domain:

DUT should detect co-channel energy, with > 90% certainty.

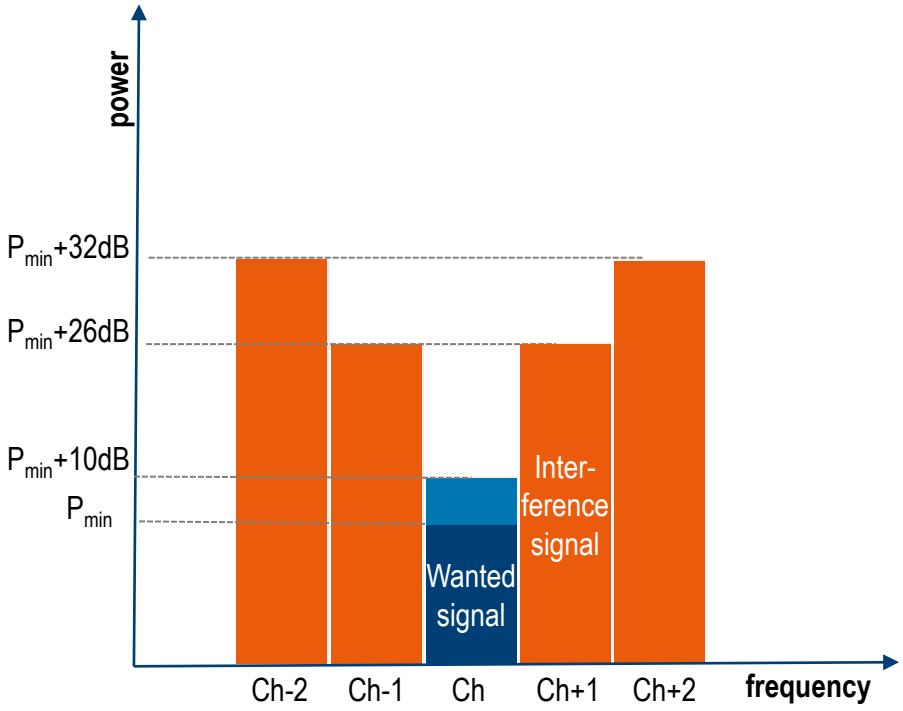




- At least 10 repetitions for each channel & bandwidth is required due to 90% certainty.
- All bandwidth modes of the multichannel DUT should be tested.
- Precise power level threshold on DUT antenna ports needs calibration on test setup.

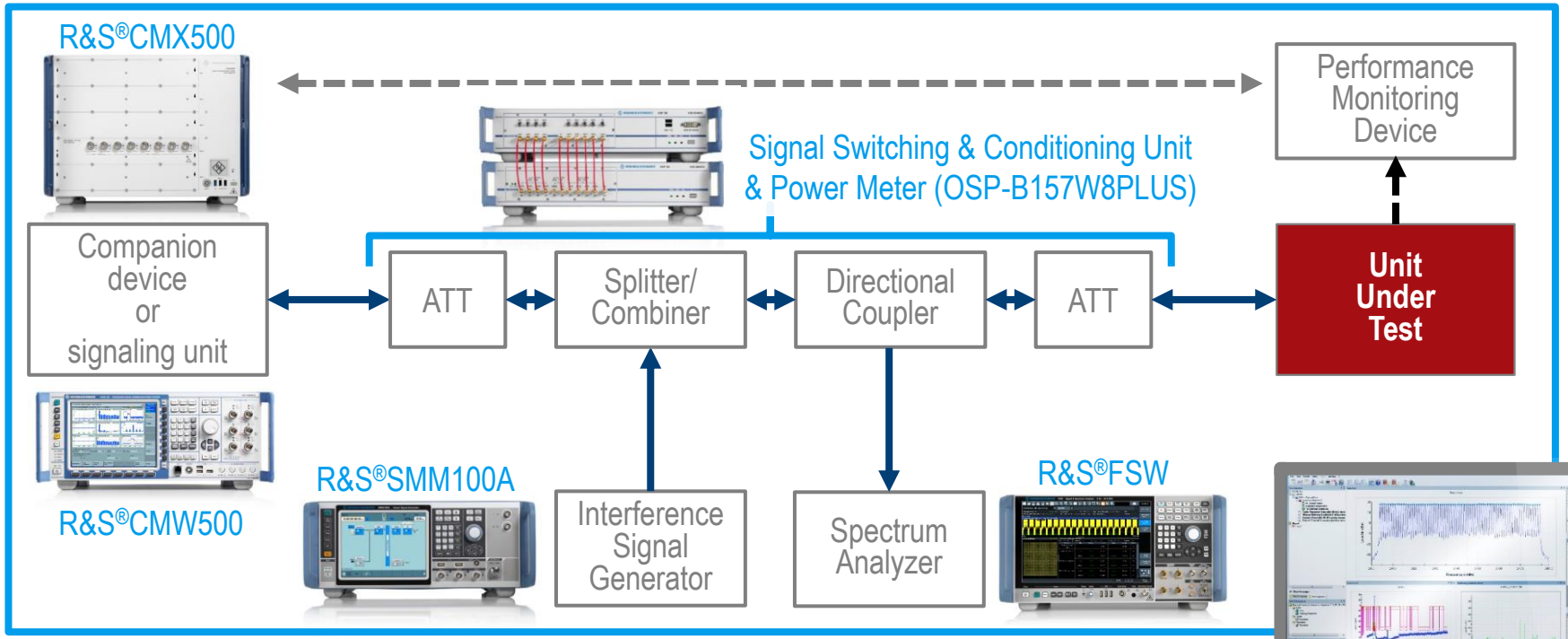
Receiver Adjacent Channel

RED Receiver Adjacent Channel Selectivity Test



1. Adapt wanted signal power (<1dB step) to find a P_{min} on DUT antenna port, which leads to 10% PER.
2. Increase wanted signal power to (P_{min}+10dB) on DUT.
3. Add interference signal on adjacent channel 20MHz offsets (ch+1) with (P_{min}+26dB). DUT should maintain PER <10%
4. Add interference signal on adjacent channel 20MHz offsets (ch-1) with P_{min}+26dB. DUT should maintain PER <10%
5. Add interference signal on adjacent channel 20MHz offsets (ch+2) with P_{min}+32dB. DUT should maintain PER <10%
6. Add interference signal on adjacent channel 20MHz offsets (ch-2) with P_{min}+32dB. DUT should maintain PER <10%

Wi-Fi DUT Receiver Test Setup
From theory to practice



R&S® TS8997 turnkey regulatory test system

R&S®TS8997

- Supports latest CE RED and FCC test requirements for all Wi-Fi standards incl. Wi-Fi 6E/7
- Turnkey automated solution covers all complex test cases
- Follows measurement requirements details chasing high precision and granularity
- Supports all test methods according to standards, incl. normalized testing
- Long term maintenance& service secure the stability and performance of test system

R&S®TS8996 supports all radiated spurious emission test items.

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

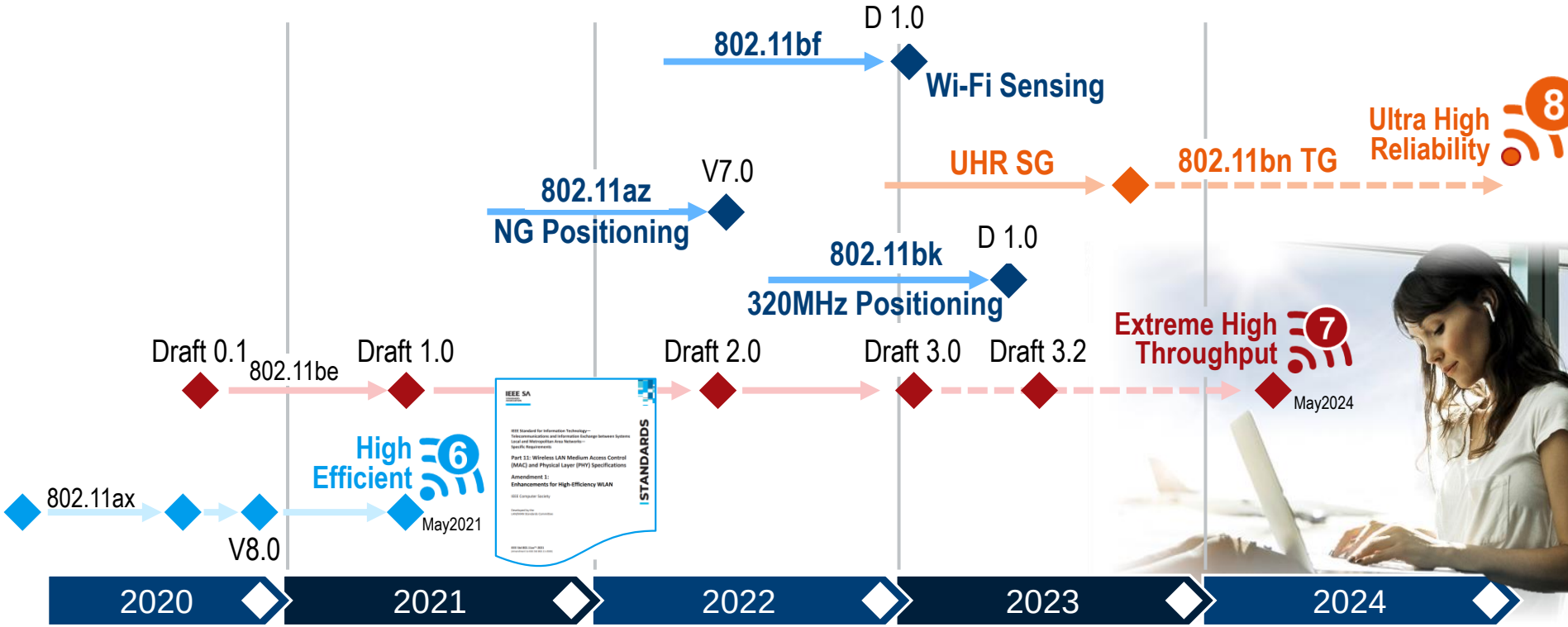
RF design and compliance

R&S®NGU

R&S®RTP

Embedded design & power

What else and what's next in Wi-Fi?



The next generation of Wi-Fi targeting ultra high reliability

Extended reality | Factory control | Internet of Things | Enterprise networks




UHR ultra high reliability

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

Find out more

www.rohde-schwarz.com/WLAN/11be

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Make ideas real