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RADIO STANDARD EN 301 893 V2.2.1 5 GHz WLAN

By: Radwan Jaafar
2026-06-01, Eurofins Product Service GmbH

ETSI EN 301 893: What is & What is for?

- **Regulatory Framework**: Harmonized European standard under the Radio Equipment Directive (RED, 2014/53/EU)
- **Conformity**: Compliance grants of conformity to Article 3.2 (efficient and effective use of the radio spectrum)
- **Core Scope**: Covers **5 GHz** WAS/RLAN equipment and WLAN technologies (**IEEE 802.11a/n/ac/ax/be**, including Wi Fi 7 features in the 5 GHz band)
- **Spectrum Sharing**: Defines critical mechanisms including Listen-Before-Talk (**LBT**), Dynamic Frequency Selection (**DFS**), and Transmit Power Control (**TPC**)

ETSI EN 301 893: Historical Development – Matters for Compliance

Version	Date	Regulatory Context	Status	Notes
V1.5.1 **V1.6.1** **V1.7.2**	2008 2011 2014	R&TTE Directive 1999/5/EC	Withdrawn	V1.5.1 is the first widely used harmonised standard for 5 GHz RLAN (Wi-Fi); thereafter several updates to DFS and TPC requirements
V1.8.1	Mar 2015	R&TTE Directive 1999/5/EC	Withdrawn	Final major version under R&TTE directive; Basic DFS/TPC, radar protection
V2.0.7	2016	early RED (2014/53/EU) alignment	First RED-aligned version	Structural and compliance updates
V2.1.1	May 2017	RED	Still used in legacy approvals May 2028: End of the 3-year transition period,	Widely adopted alignment with RED; stable certification baseline
V2.2.1	Nov 2024	RED	Latest version	Officially published by ETSI as the newest harmonized standard.

ETSI EN 301 893: Key Updates

- **What's New in the latest Version V2.2.1 compared to V2.1.1:**
  - ✓ **Band extension**: Sub-Band 4 (5.725–5.875 GHz) transitions from EN 300 440 to EN 301 893 for certification testing
  - ✓ **Multi-Channel Operation**: Introduces official test requirements for MLO & Puncturing
  - ✓ **Higher Power Limits**: Increases the Band 4 RF output power limit to 200 mW (23 dBm) – well above the the 25 mW (14 dBm) limit in EN 300 440
  - ✓ **Enhanced Test Suite**: Introduces new test requirements to accommodate advanced Wi-Fi 7 features and stricter adaptivity thresholds.

🧠 **Upgrading from V2.1.1 → V2.2.1 is not a minor update !**

Regulatory notes for Wi-Fi 5 GHz

5 GHz RLAN in Europe (ETSI EN 301 893)

5150–5250	5250–5350	5470–5725	5725–5850*

Main ETSI EN 301 893 scope covers 5150–5250 MHz, 5250–5350 MHz, and 5470–5725 MHz for WAS/RLAN equipment.

Annex B contains provisions for 5725–5850 MHz, but use is subject to national frequency conditions.

Practical engineering implication / deployment notes

- ETSI EN 301 893 is fundamentally a system-level constraint, not just RF compliance
  - Design trade-offs: DFS / sharing behavior, TPC + PSD, Medium Access, and strict emission masks limits
  - Certification complexity: Firmware intelligence and the exact allowed sub-bands matter for regulatory compliance and channel-planning assumptions
  - Spectrum availability: Separate PHY capability from regional spectrum reality. A platform may support 320 MHz and MLO, but channel availability is regulation-dependent (case Wi-Fi 7).

Sources: ETSI EN 301 893 V2.2.1; EU Implementing Decision (EU) 2022/2307, Wi-Fi Alliance 5 GHz regulation.

Deltas that matter (Wi-Fi 4 → Wi-Fi 7)

Wi-Fi 4 / 802.11n (yr 2009)
2.4/5 GHz
20/40 MHz
64-QAM
Up to 4x4 MIMO
600 Mb/s

Wi-Fi 5 / 802.11ac (yr 2013)
5 GHz
80/160 MHz
256-QAM
Up to 8x8 + DL MU-MIMO
≈6.9 Gb/s

Wi-Fi 6/6E/802.11ax (yr 2018/21)
2.4/5/6 GHz
Up to 160 MHz
1024-QAM
UL/DL MU-MIMO + OFDMA
9.6 Gb/s

Wi-Fi 7 / 802.11be (yr 2024/25)
2.4/5/6 GHz
Up to 320 MHz
4096-QAM
MLO + M-RU + advanced MU
≈46 Gb/s

Channel width progression

20/40 MHz — 80/160 MHz — Up to 160 MHz + 6 GHz — Up to 320 MHz

Modulation progression

64-QAM — 256-QAM — 1024-QAM — 4096-QAM

MAC efficiency progression

SU-MIMO baseline — DL MU-MIMO + beamforming — OFDMA + UL/DL MU-MIMO + TWT — MLO + M-RU + 512 Block Ack

Why Wi-Fi 6 changed design practice

802.11ax added OFDMA, denser modulation, and better MAC signaling so engineering value moved from peak single-link rate to aggregate capacity in dense networks.

Why Wi-Fi 7 matters

802.11be combines 320 MHz channels, Multi-Link Operation, and 4K QAM to improve throughput, latency, and reliability—especially where 6 GHz is available.

Sources: Wi-Fi Alliance Wi-Fi (MAC/PHY), Wi-Fi CERTIFIED 6 paper, Wi-Fi 6E paper, Wi-Fi CERTIFIED 7 overview.

Wi-Fi 7 Innovations

Core Innovations

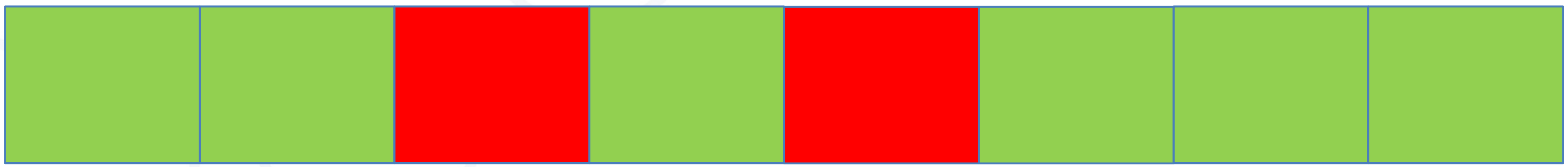
- **Multi-Link Operation (MLO)**
- 320 MHz ultra-wide channels
- **4096-QAM** for higher data rates
- Detects interference precisely
- **Preamble Puncturing**: Skips only affected parts
- Uses remaining bandwidth efficiently

Advantages

- ✓ Higher real-world **throughput**
- ✓ Better spectrum **efficiency**
- ✓ Improved **reliability** in dense networks
- ✓ Up to 4 times **lower latency** than Wi-Fi 6 and 6E

Disadvantages

- High Cost (More complex radios and processing)
- Band Limitations Shorter Range at High Speeds
- Infrastructure Upgrade Required
- Higher Power Consumption



Wi-Fi 7 (IEEE 802.11be) – Key Findings

Category	Wi-Fi 7 Feature	Technical Details / Values	Benefit
Standard	IEEE 802.11be (EHT – Extremely High Throughput)	Successor to 802.11ax	Higher performance WLAN
Frequency Bands	Multi-band operation	2.4 GHz, 5 GHz, 6 GHz	Flexibility, reduced congestion
Channel Bandwidth	Up to 320 MHz	Double Wi-Fi 6 (160 MHz)	Much higher throughput
Modulation	4096-QAM (4K-QAM)	12 bits per symbol	~20% higher data rate vs 1024-QAM
Peak Data Rate	>30 Gbps (theoretical)	Depends on MIMO streams & bandwidth	Ultra-high speed connectivity
MIMO	Up to 16 spatial streams (DL/UL)	Improvement over Wi-Fi 6 (8 streams typical)	Increased capacity & throughput
Multi-Link Operation (MLO)	Simultaneous multi-band links	Aggregation or switching between links	Lower latency, higher reliability
OFDMA Enhancements (MRU)	Multi-RU	Flexible resource unit allocation	Improved spectral efficiency
Preamble Puncturing	Enhanced	Allows use of partial channel if interference present	Better spectrum utilization
Latency	Deterministic low latency	Improved scheduling & MLO	Suitable for real-time apps
Power Efficiency	Enhanced power-saving modes	Coordinated scheduling	Better battery performance
Backward Compatibility	Yes	Supports legacy Wi-Fi 6/5/4 devices	Smooth migration
Target Use Cases	AR/VR, 8K streaming, cloud gaming, industrial automation	High bandwidth + low latency	Enables next-gen applications
Key Innovation	Multi-Link Operation + 320 MHz	Core differentiators of Wi-Fi 7	Major performance leap
Regulatory Framework	Article 3.2: • EN 300 328 (2.4 GHz) • **EN 301 893 (5 GHz)** • EN 303 687 (6 GHz) Article 3.1(a): • EN 50566 / EN 50665 (SAR / RF exposure) Article 3.1(b): • EN 301 489-1 • EN 301 489-17 (specific to Wi-Fi)		

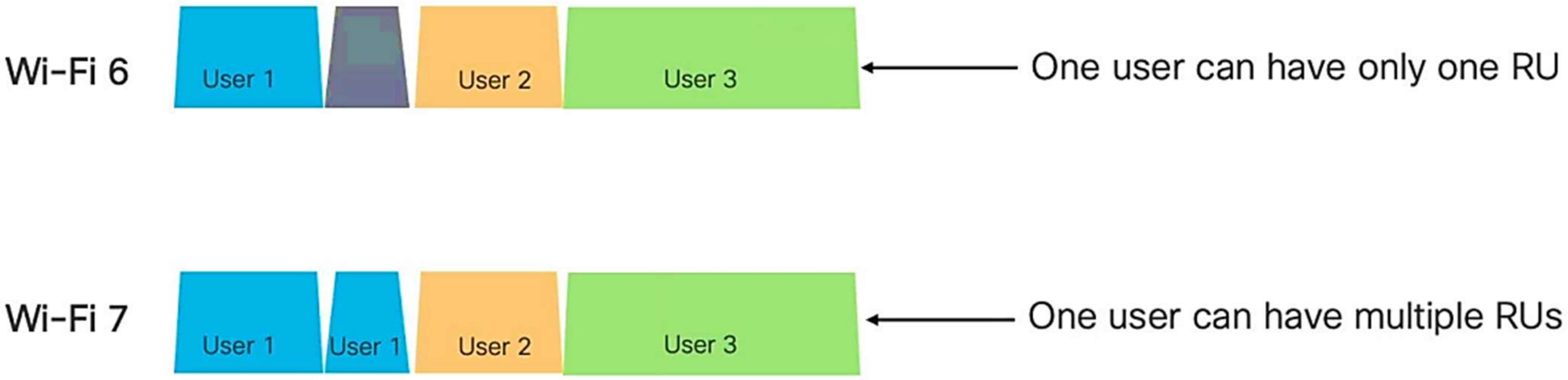
Multi–Resource Units

- In OFDMA-based Wi-Fi (802.11ax):

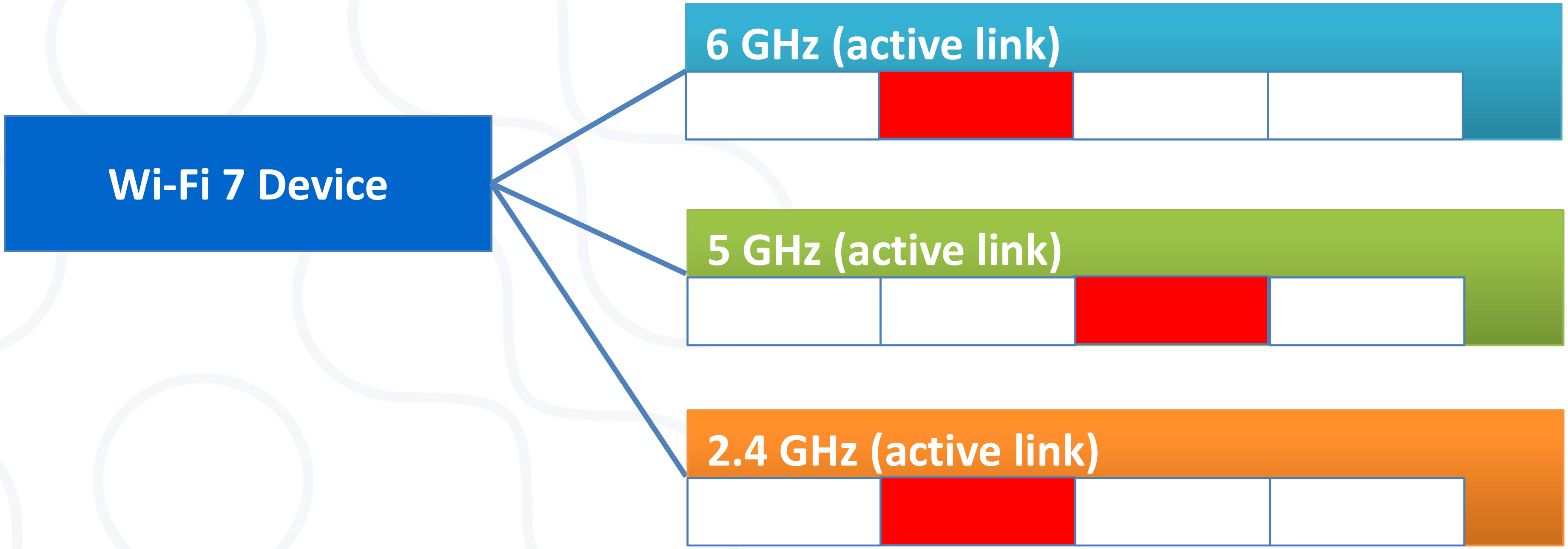
  The access point (AP) assigns **one RU per user per transmission**.

- Wi-Fi 7 removes that limitation:

  A single user can be assigned ***multiple RUs simultaneously*** **within the same transmission.**



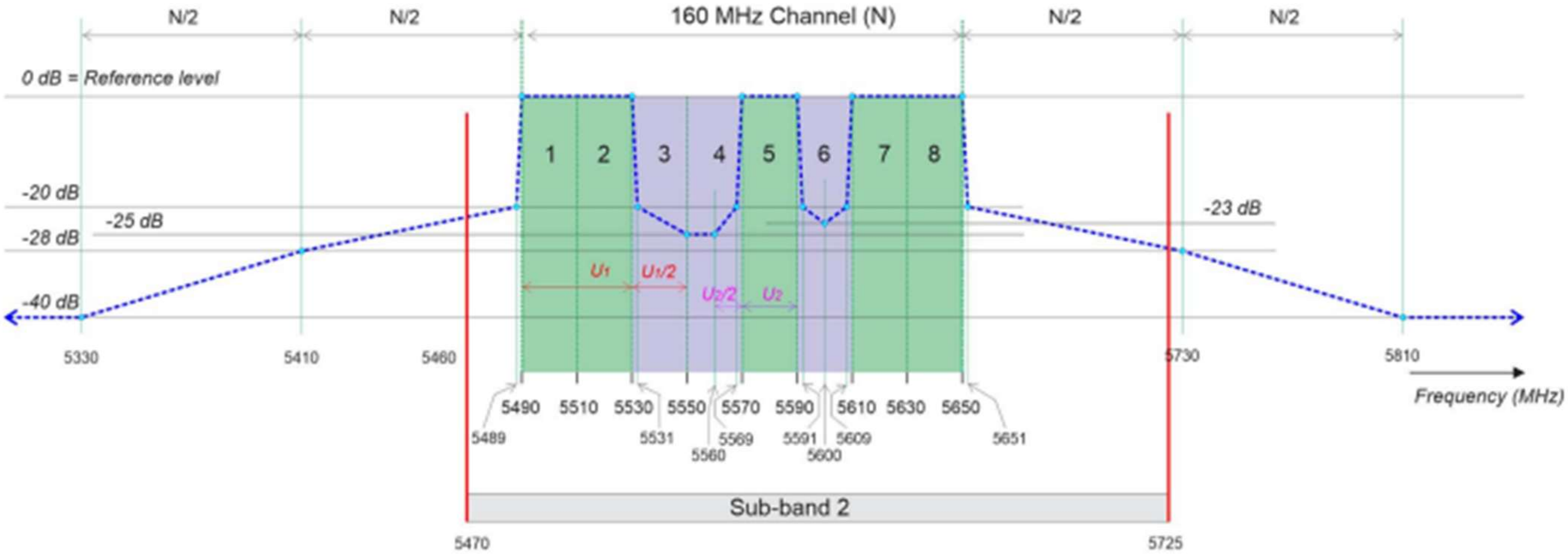
MLO & Puncturing – Entirely New



MLO: Multiple bands used simultaneously | Puncturing: Red blocks are skipped

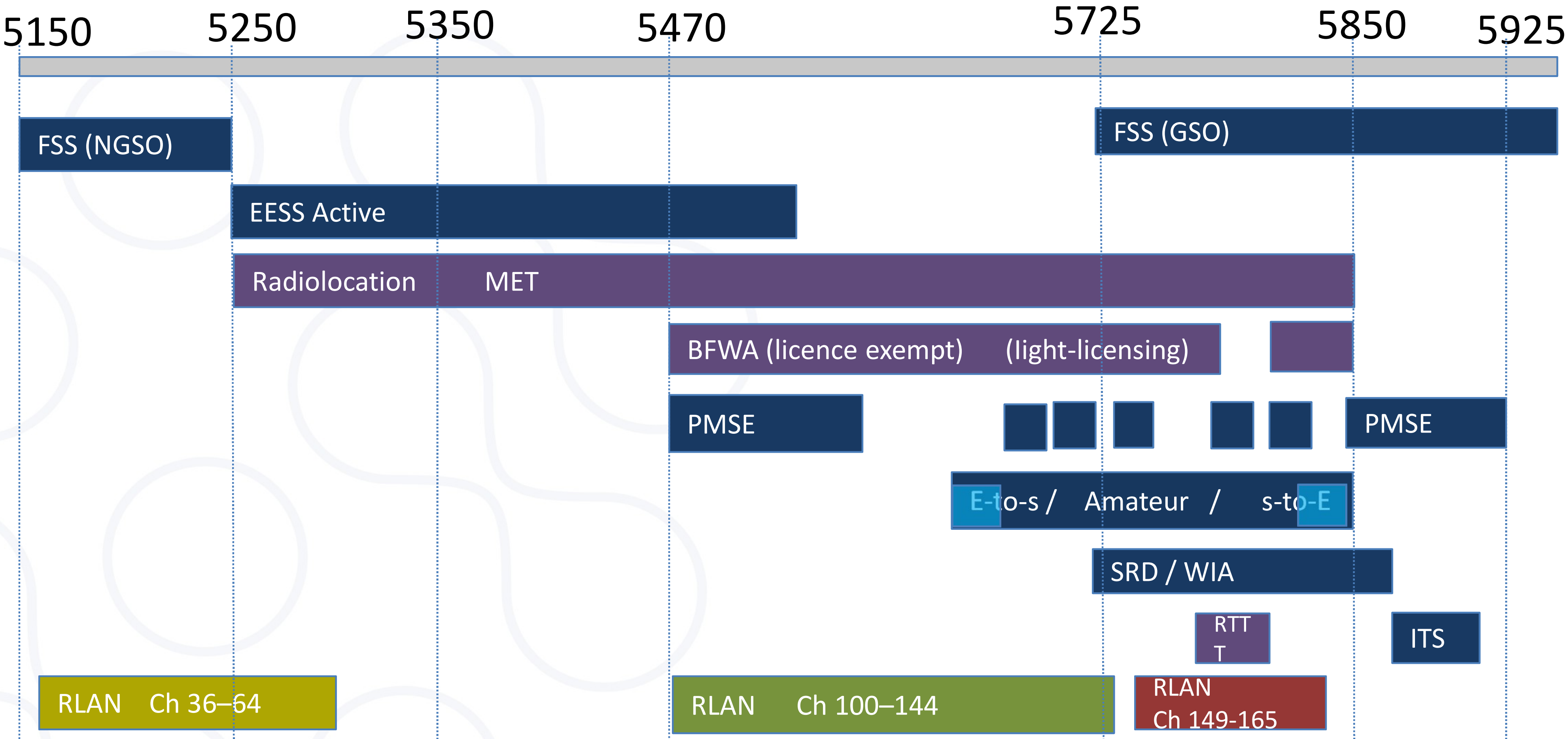
Multi-Channel Operation / Puncturing Emission Mask

- Wi-Fi 7 introduces punctured transmissions
- EN 301 893 **V2.2.1** is the first version explicitly testing this behavior



Sources: ETSI EN 301 893 V2.2.1

5 GHz Spectrum Allocation – Coexistence of Various Applications



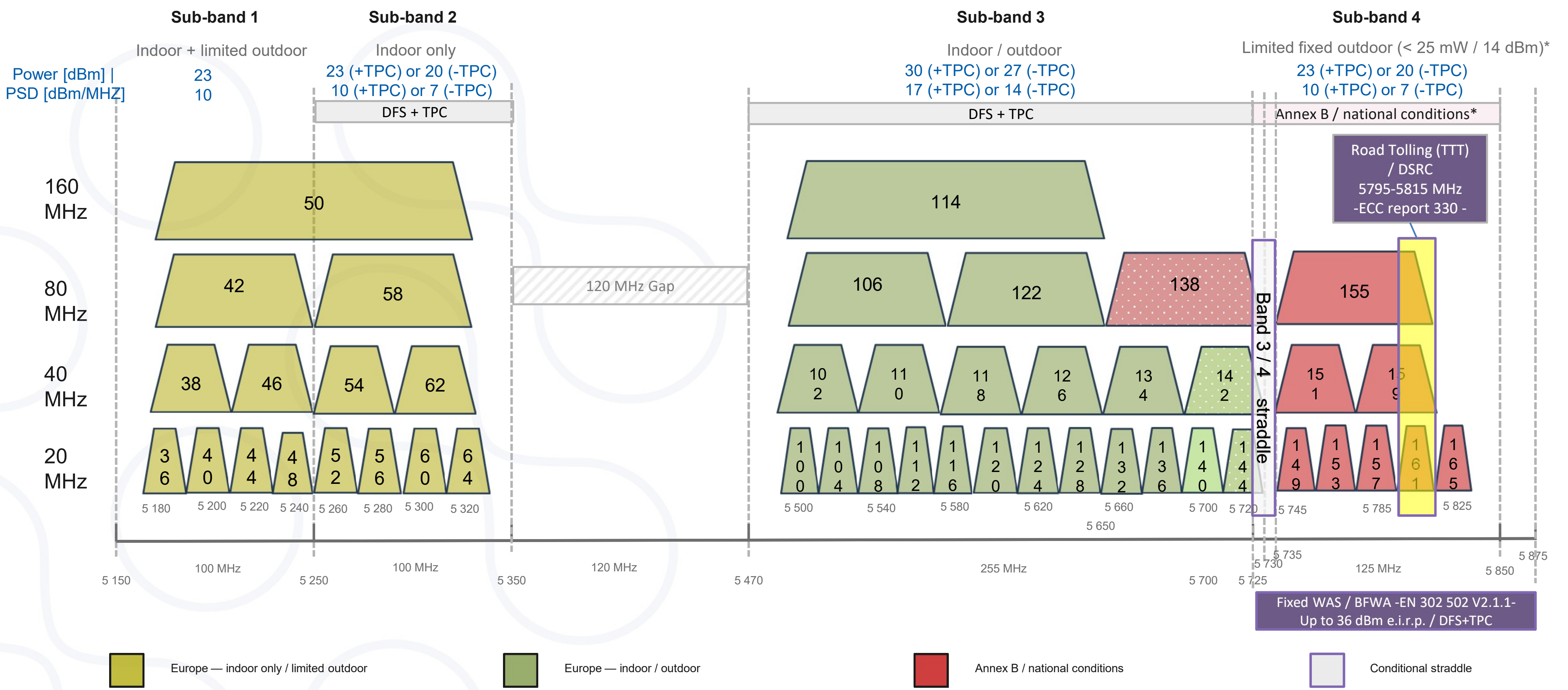
FSS: Fixed-Satellite Service (Earth to space) **GSO:** Geostationary Orbit **EESS**: Earth Exploration-Satellite Service **MET:** use of radiolocation (radar) technology to acquire meteorological (MET) data **BFWA**: Broadband Fixed Wireless Access **TTT**: Transport and Traffic Telematic **WIA**: Wireless Infrastructure Association **RLAN**: Radio Local Network **ISM**: Industrial, Scientific, and Medical **PMSE:** Programme Making and Special Events **ITS:** Intelligent Transport Systems **RTTT:** Road Transport and Traffic Telematics (Tachograph and radar)

5.8 GHz Spectrum Allocation – Applications summary

Application	Frequency Range	ECC/ERC harmonisation measure	Standard	Notes
Amateur	5650-5850 MHz		EN 301 783	
Amateur Satellite	5830-5850 MHz			
BFWA	5725-5875 MHz	ECC/REC/(06) 04	EN 302 502	
Direct Air-to-Ground Communications (DA2GC)	5855-5875 MHz	ECC/DEC/(15) 03	EN 303 316 , EN 303 339	
FSS Earth Stations	5850-5925 MHz		EN 301 443	Priority for civil networks
ITS	5855-5875 MHz, 5875-5935 MHz	ECC/DEC/(08) 01, ECC/REC/(08) 01, ERC/REC 70-03	EN 302 571	Only the part non- safety 5855-5875 MHz is considered here.
Maritime Broadband Radio (MBR)	5852-5872 MHz, 5880-5900 MHz	ECC/REC/(17) 03	EN 303 276	
Non-specific SRD	5725-5875 MHz	ERC/REC 70-03	EN 300 440	< 25 mW e.i.r.p.
Radiodetermination applications	4500-7000 MHz	ERC/REC 70-03	EN 302 372	Within the band 4500-7000 MHz for TLPR application
Radiolocation (military)	5250-5850 MHz			
TTT	5795-5815 MHz	ERC/REC 70-03	EN 300 674, part 1-3	In the band 5805-5815 MHz on a national basis
Weather Radar	5250-5850 MHz			Ground based and airborne
WIA	5725-5875 MHz	ERC/REC 70-03	EN 303 258	Not considered to be used outside factories

Sources: based on ECC report 330

5 GHz WLAN Channel Plan — EU / ETSI



* Band 4 (5725–5850 MHz) is covered by **ETSI EN 301 893 V2.2.1** Annex B and remains subject to national frequency-usage conditions. Fixed outdoor/ or in vehicles installations for devices with an EIRP >25 mW are excluded - (ECC report 330 describes the national implementation and conditions for WAS/RLAN within the 5.8 GHz band above the SRD limit of 25 mW up to 200 mW e.i.r.p. EN 302 502 V2.1.1 covers 5.8 GHz BFWA / WAS Systems WAS-).

Sources: based on ETSI EN 301 893 V2.2.1 + EU Decision 2022/2307 + EN 302 502 + ECC report 330

EN 301 893: Gap Analysis Matrix (V2.1.1 vs V2.2.1) - critical

Clause Area	V2.1.1 (2017)	V2.2.1 (2024)	Impact
Operating Bands	Band 1–2 defined	Updated bands (**1-3**) + **Band 4 introduced / Straddle channels**	🔴 Mandatory redesign for devices using 5.8 GHz
Adaptivity (LBT / ED)	Basic ED threshold rules	**Revised ED threshold calculation** (bandwidth-dependent), **antenna gain** removed	🔴 Major change, impacts all Wi-Fi 6 80/160 MHz / Punctured transmissions - High implementation risk
Receiver Requirements	Minimal receiver tests	**New requirements added:** - Adjacent Channel Selectivity (**ACS**); Blocking – updated interference profile	🔴 New mandatory tests; Test plan update required
Multi-channel Operation	Limited guidance	Explicit handling for **wideband / punctured transmission**	🔴 Critical for Wi-Fi 6E / 7 chipsets
Country Determination Capability	-	**New requirement:** Mandatory for Band 4 operation > 25 mW EIRP; requires OTA verification and adaptive power control	🔴 Test plan update required

EN 301 893: Gap Analysis Matrix (V2.1.1 vs V2.2.1) – strict

Clause Area	V2.1.1 (2017)	V2.2.1 (2024)	Impact
DFS – General	Mandatory DFS (radar bands)	DFS retained + clarified test behavior	🟡 Mostly alignment, but stricter validation
DFS – Radar Detection	Defined radar test waveforms	Updated radar test handling & detection criteria, More detailed radar & operational scenarios	⚠️ Lower margins → risk of fail
DFS – Timing	CAC, Channel Move Time defined	More **strict or clarified timing interpretation**	⚠️ risk of fail if firmware borderline
DFS – Channel Use	Uniform spreading requirement	Improved wording + stricter behavior checks	🟡 Implementation verification needed
Transmitter Unwanted Emissions	Standard emission limits	New masks for modern PHY modes (MLO, Puncturing)	🟡 Test update required
Medium Access	Basic fairness requirements	More detailed **coexistence and channel access rules**	⚠️ Impacts MAC algorithm compliance

EN 301 893: Gap Analysis Matrix (V2.1.1 vs V2.2.1) – formal

Clause Area	V2.1.1 (2017)	V2.2.1 (2024)	Impact
Scope	5 GHz RLAN (5150–5725 MHz)	Extended scope (split to **3 sub-bands**, incl. **5725–5850 MHz),** removes dependence on **EN 300 440** for Band 4	⚠️ New band → additional testing, regulatory constraints, extra certification scope
Normative references	Legacy references	References updated to support new RX tests, emission masks and DFS clarifications	⚠️ Impacts test interpretation and documentation
Definitions	Basic RLAN definitions	Adds **new technology terms (Wi-Fi 6E / 7, puncturing, MRU, enhanced DFS terminology)**	⚠️ Impacts test interpretation and documentation
Output Power (EIRP) / PSD / TPC	Static limits per band	Similar limits but **clarified aggregation rules (MIMO, multi-radio); TPC mandatory for higher powers.**	⚠️ Common failure in Wi-Fi 6/7 devices

EN 301 893 V2.2.1: Measurement Requirements

Clause	Requirement	Test Parameter	Measurement Method	Test Setup / Equipment	Wi-Fi 7 (802.11be) Considerations
4.2.1	Frequency Range	Operating frequency	Conducted measurement using spectrum analyzer	SA + RF cables	Verify operation within 5 GHz bands; multiple MLO links must remain within allowed sub-bands
4.2.2	Channel Bandwidth	Occupied bandwidth	OBW measurement (99% power)	Wideband SA	Include 20–320 MHz; ensure analyzer BW supports.
4.2.3	Transmit Power	Mean EIRP / conducted power	Average power measurement	Power meter / SA	Power scaling may apply for wide channels (160/320 MHz), Uniform distribution required
4.2.3	Power Spectral Density	PSD (dBm/MHz)	PSD calculation with RBW normalization	SA with appropriate RBW	Uniform distribution required
4.2.3	Transmit Power Control (TPC)	Power reduction range	Controlled attenuation	Power meter	Required in DFS bands
4.2.4	Transmit Unwanted Emissions	Mask compliance	Spectrum mask measurement	SA with mask function	Due to high-order modulation (4096-QAM) – demands significantly tighter mask controls and steeper roll-off shoulders
4.2.4	In-band Emissions	Leakage within band	Spectrum analysis	SA	Important with preamble puncturing (Wi-Fi 7)
4.2.4	Spurious Emissions (Tx)	Conducted / Radiated spurious	Swept measurement outside channel	SA with high dynamic range	Include harmonics and wideband effects
4.2.5	Spurious Emissions (Rx)	Receiver spurious emissions	Passive measurement	SA + termination	Independent of modulation; same for Wi-Fi 7

EN 301 893 V2.2.1: Measurement Requirements – continued

Clause	Requirement	Test Parameter	Measurement Method	Test Setup / Equipment	Wi-Fi 7 (802.11be) Considerations
4.2.6	DFS – Detection Probability	Radar detection	Radar waveform injection	DFS test system	Must detect radar even with wideband (up to 320 MHz) signals
4.2.6	DFS – Channel Shutdown	Channel Move Time	Time-domain measurement	DFS setup + SA	Ensure MLO does not delay the shutdown
4.2.6	DFS – Channel Availability Check (CAC)	Channel availability time	Timing measurement	DFS setup	Typically 60 s; unaffected by Wi-Fi 7 but must be verified
4.2.6	DFS – Non-Occupancy Period	Channel re-use restriction	Time monitoring	DFS system	Must respect 30 min non-occupancy
4.2.7	Adaptivity (channel access mechanism)	CCA threshold	Energy detect threshold	Signal generator + SA	Critical coexistence requirement; applies also to Wi-Fi 7
4.2.7	Channel Occupancy Time	Maximum TX duration	Time-domain analysis	Oscilloscope / SA	Verify duty cycle constraints
4.2.7	Short Control Signalling (SCS) transmissions	Channel selection behavior	Functional testing	Traffic generator	Must coexist fairly in shared bands
4.2.8	Receiver Blocking	Blocking performance	PER vs interferer	Signal generator + PER tester	Higher modulation (4K-QAM) → more sensitive to interference
4.2.9	Adjacent Channel Selectivity	Interference rejection	PER degradation	Signal generator	Validate under dense deployments
4.x.x	Multi-Antenna Systems	Antenna gain / EIRP compliance	Conducted + radiated	MIMO test setup	Up to 16 multiple spatial streams; verify worst-case EIRP

Open discussion

- Questions?
- Suggestions?
- Open points?

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