Conformance Test User Meeting 2024

# EMC, OTA & REGULATORY TEST FOR WIRELESS DEVICES

**Market Segment Management**
**Wireless Communication**

ROHDE&SCHWARZ

Make ideas real

# Wireless technologies shaping the future of communication

Wi-Fi will stay the wireless power horse at home & offices

5G Advanced will pave the way for the mobile network success at verticals

UWB will become the benchmark for integrated (secure) ranging & sensing

Bluetooth gets ready for the future by mid-band operation, high-data throughput and accurate ranging

# Validation Tests secure market access of wireless products

## Diverse compliance or certification are required

***Wireless Products***

**Network Operator Acceptance Test**

Demonstrate interoperability for specific features in network

- AT&T
- T-mobile
- …
- VzW
- CMCC

**Telecom Industry Certification Test**

Enable the high quality, reliable, and secure wireless communication according to technology standards

- GCF/Cellular
- FiRa/UWB
- …
- SIG/Bluetooth
- WiFi Aliance/WiFi

**Regulatory Compliance Test**

Grant market access under legal aspect in regions

- CE RED
- FCC
- …

***Market Access***

# Wireless products need CE marking/FCC ID
## No regulatory compliance means NO market access!


Testing according to regulatory standards is a mandatory step in the demonstration of compliance.

**Test results are part of 'technical documentation':**

- be prepared before placing product on the market
- be made available to surveillance authorities
- be kept for 10years from placed on the market

Link

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

Link

# CE RED test standards and test solution overview
# ETSI is the major standard development organization for CE

## Art3.1a Health & Safety Art

Directive 2014/35/EU
CENELEC - EN 50360
Specific Absorption Rate

CMW500

CMX500

## Art 3.1b EMC

EN 301 489-1 Common
EN 301 489-17 WLAN
EN 301 489-19 GNSS
EN 301 489-33 UWB
EN 301 489-50 Cellular BS
EN 301 489-52 Cellular UE

TS9982EMS/TS9975
EMI incl. ABT

## Art 3.2 Radio Spectrum

EN 300 328 WLAN2.4GHz
EN 301 893 WLAN5GHz
EN 303 687 WLAN6GHz
EN 301 908-1 Cellular Common
EN 301 908-2 WCDMA UE
EN 301 908-13 LTE UE
EN 301 908-25 5G NR UE

TS8991

TS8980

CMsequencer

TS8996

TS8997

## Art 3.3 Specific topics

Guideline 2019/320 (E112)
Emergency service

TS-LBS

Standards list is not exhausted.

# FCC compliance requirements are defined in 47CFR
# C63 standards and KDBs give additional guidance for testing

| Cellular in licensed bands | Satellite/NTN In licensed bands | WiFi&Co In unlicensed | Ultra Wideband |
|---|---|---|---|
| 47CFR §2/22/24/27/… | 47CFR §25 SATELLITE COMMUNICATIONS | 47CFR§15C/E<br>**2.4GHz** ISM band - §15.247& KDB558074<br>**5GHz** UNII(1-4)bands - §15.407/247&KDB789033/905462(DFS)<br>**6GHz** UNII(5-8)bands - §15.407& KDB987594 | 47CFR §15F<br>Ultra-Wideband Operation |

ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in the Licensed Radio Service

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

- IEEE Std 1528™-2013 IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- C63.19 American National Standard Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids


Rohde & Schwarz

CMsequencer

Regulatory test for wireless

TS8996

TS8997

FSW43

FSV3044

# SAR is the most important test for Art3.1a Health & Safety

## Many SAR test system need upgrade to 5G NR and beyond

Art3.1a
Health & Safety

**Specific Absorption Rate**

Directive 2014/35/EU
CENELEC - EN 50360

SAR
47CFR§2.1093/IEEE1528™

HAC
47CRF§68.4/
C63.19 Hearing Aid Compatibility

### Test Challenge with SAR test

- 5G NR Network emulator is required to drive the EUT to extreme transmission condition.
- Multi-Radio UE with advanced ‘average-SAR’ feature needs flexible signaling functions, incl. all cellular standards, Wi-Fi and Bluetooth.
- ‘Easy use’ and ‘extreme stable’ signaling solution helps the time-consuming SAR test.

### CMW/CMX is perfect solution

- Improved stability& receiver dynamic range enhance stabile radio link
- In-box Data Application Unit with VoNR/VoLTE features simplify the HAC test needs

CMW500

CMX500

VNA and VSG help the calibration of SAR test system.

# Traditional EMC Art3.1b tests

## Audio breakthrough test is required for mobile phones

| Art 3.1b EMC | |
|---|---|
| EN 301 489-1 | Common |
| EN 301 489-17 | WLAN |
| EN 301 489-19 | GNSS |
| EN 301 489-33 | UWB |
| EN 301 489-50 | Cellular BS |
| **EN 301 489-52** | **Cellular UE** |
| EN 301 489-?? | … |

**Traditional EMC incl. Audio Breakthrough (ABT) test challenges**

- Art.3.1b EMC test requirements are not changed by 5G NR.
- EMC tests need both enable radio and disable radio conditions, which means signaling solution for 5G NR.
- Audio Breakthrough test is required for mobile phones, from GSM to VoLTE and VoNR by 5G.

**R&S EMC Systems cover 5G NR functionality, powered by latest CMX500.**

TS9982 EMS&TS9975 EMI systems

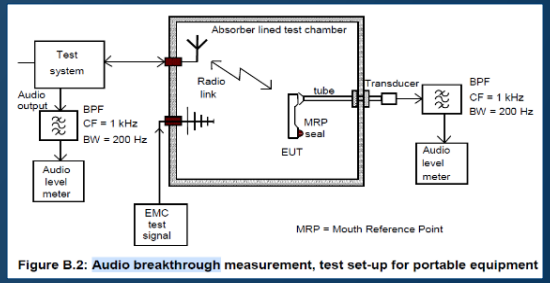



Figure B.2: Audio breakthrough measurement, test set-up for portable equipment

Application Note about ABT(link)

# Cellular technology RF test for radio spectrum Art3.2
## 5G NR specification incl. FR1 and FR2

Art 3.2
Radio Spectrum

EN 301 908-1 Cellular Common
EN 301 908-2 WCDMA UE
EN 301 908-3 WCDMA BS
EN 301 908-13 LTE UE
EN 301 908-14 LTE BS
EN 301 908-24 5G NR BS
EN 301 908-25 5G NR UE (draft)

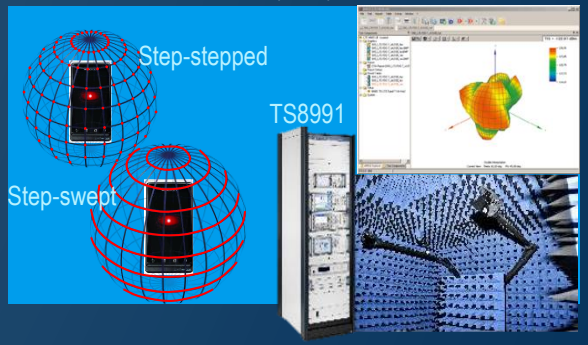
### "3GPP" test cases

- Transmitter maximum output power
- Transmitter minimum output power
- Transmitter spectrum emission mask
- Transmitter Adjacent Channel Leakage Power Ratio
- Transmitter spurious emissions
- Receiver Reference Sensitivity Level
- Receiver adjacent channel selectivity (ACS)
- Receiver blocking characteristics
- Receiver spurious response
- Receiver intermodulation characteristics
- Receiver spurious emissions
- Transmit OFF power

- Almost the same RF conformance test cases in 3GPP
- 5G NR specification needs support of FR1/FR2/FR1+FR2
- FR1 test setup stays conducted; FR2 test setup become radiated


### "CTIA-OTA" test cases

- Receiver Total Radiated Sensitivity (TRS)
- Total Radiated Power (TRP)




### "RSE" test case

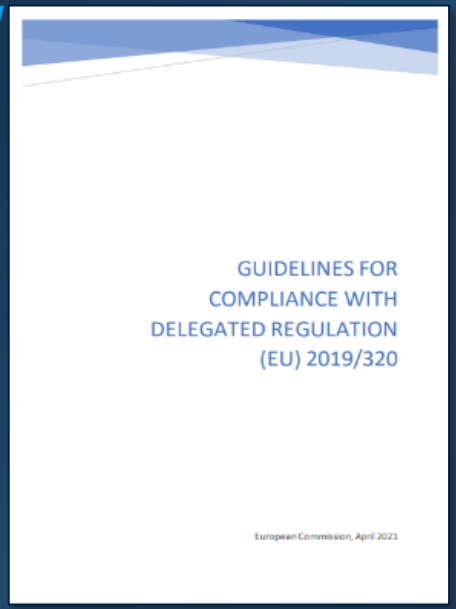
- Radiated Spurious Emissions

- Measurement up to 200 GHz(FCC) for 5G FR2 with high sensitivity of -40 dBm/MHz
- Special signaling Conditioning for carrier
- All standards support

# Special smart phone RED requirement for Art3.3g
## A regulatory compliance requirement without ETSI standard

Art 3.3g
Specific topics

**E112**
**Guideline 2019/320**
**Emergency service**




All smartphones sold in the European Union have to be compliant as of March 17, 2022, with the Delegated Regulation (EU) 2019/320. It defines that 112 emergency calls provide caller location information to emergency services in a fast and accurate way, to make sure first responders can arrive at the site of an accident quickly.

Notified body has to be involved, when there is no EN standard available. R&S TS-LBS location-based services test system is the first test solution available to perform the necessary LBS compliance tests.

# FCC compliance requirements are defined in 47CFR

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| 47CFR §2/22/24/27/… | 47CFR §25 Satellite Communications | 47CFR §15C/E<br>▪ 2.4GHz ISM band §15.247 & KDB558074<br>▪ 5GHz UNII(1-4) bands §15.407/.247 & KDB789033/905462(DFS)<br>▪ 6GHz U-NII(5-8) §15.407 & KDB987594 | 47CFR §15F Ultra-Wideband Operation |

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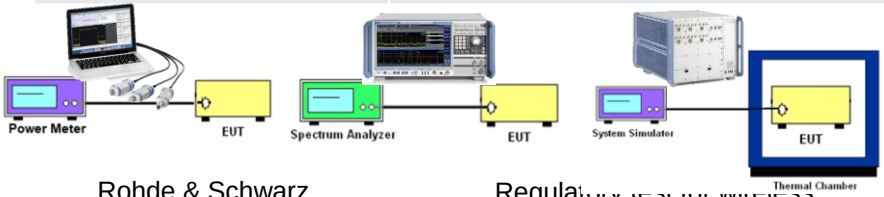
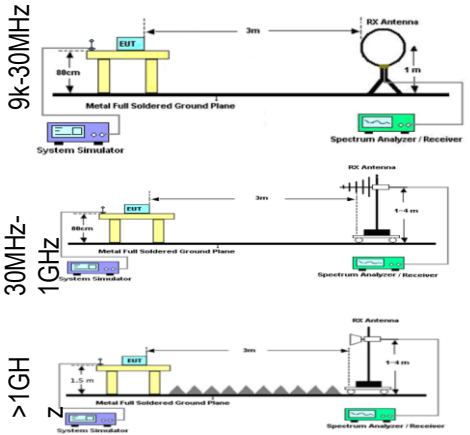
# Code of Federal Regulation CFR47 Test specifications
## licensed cellular (2G/3G/4G/5G) technology

| Test items | CFR47 |
|---|---|
| RF power output | §2.1046/§22.913/§24.232/§27.50 |
| Modulation characteristics | §2.1047 |
| Occupied bandwidth | §2.1049 |
| Band Edge | §2.1051/§22.917/§24.238/§27.53 |
| Spurious emissions at antenna terminals | §2.1051/§22.917/24.238/§27.53 |
| Frequency stability | §2.1055/22.355/24.235/§27.54 |
| Peak to average ratio | §27.50 |
| Field Strength of Spurious Radiation | §2.1053/§22.917/§24.238/27.53 |

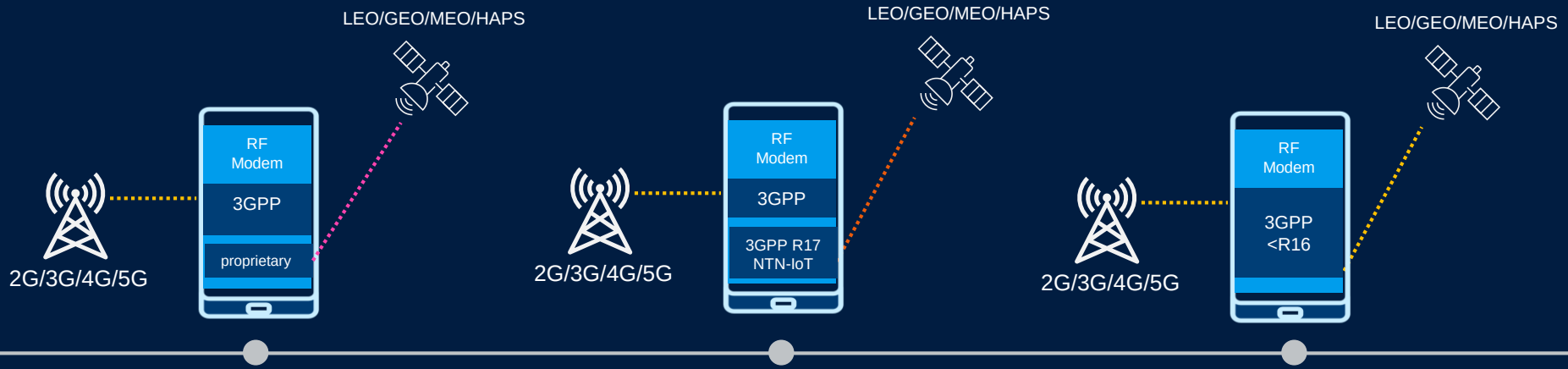



| Operating frequency | § 2.1057 Frequency spectrum to be investigated | |
|---|---|---|
| | Lower limit | Upper limit |
| <10GHz | Min {lowest radio frequency signal generated in the equipment; **9kHz**} | Min {10th harmonic of the highest fundamental frequency;**40 GHz**} |
| 10-30GHz | | Min {5th harmonic of the highest fundamental frequency;**100 GHz**} |
| >30GHz | | Min {5th harmonic of the highest fundamental frequency;**200 GHz**} |




- R&S®TS8996

# The Different Implementations of NTN for SOS Messaging – Device Aspects 3gpp Vs. Proprietary




## PROPRIETARY UE

e.g. iPhone 14/Globalstar, Qualcomm/Iridium etc.

## 3GPP R17 NTN-IoT UE

e.g. MTK/Bullitt/Skylo

## Reuse spectrum assets /3GPP UNMODIFIED UE

e.g. AT&T/AST Space Mobile, T-Mobile/Starlink, Optus/Lynk

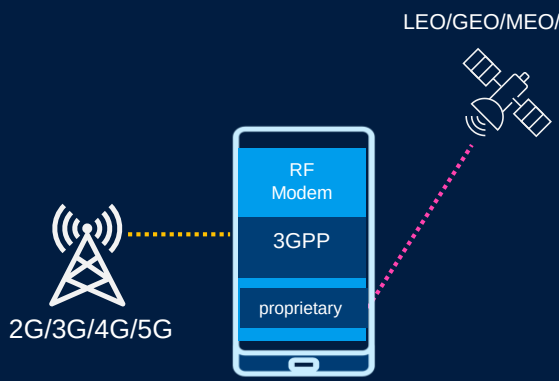
- A group of EN standards and FCC CFR47§25 for Mobile Satellite Service are valid as regulations for current market access.
- CE RED/ETSI and FCC are working on regulation adaptation for coming mobile satellite communication services.

# Satellite communication has history in ETSI EN standards

## Further standard development for 3GPP NTN is under progress

| CE RED Art3.2 | Earth-to-space in MHz | Space-to-earth in MHz | Product examples on the markets (Declaration of Conformity) | Note |
|---|---|---|---|---|
| EN 301 441 | 1610-1626.5 | 1613.8-1626.4<br>2483.5-2500 | iPhone14 | S-PCN (Satellite-Personal Communications Network) |
| EN 301 442 | 1980-2010 | 2170-2200 | | NGSO (Non-geostationary satellite systems); S-PCN |
| EN 301 444 | 1626.5-1660.5<br>1668-1675 | 1525-1559<br>1518-1525 | | LMES(Land Mobile Earth Stations);<br>MMES(Maritime Mobile Earth Stations) |
| EN 301 681 | 1626.5-1660.5<br>1668-1675 | 1525-1559<br>1518-1525 | Bullitt defy satellite link | GSO(Geostationary satellite systems);S-PCN;<br><15dBW(45dBm) |
| EN 302 574 | 1980-2010 | 2170-2200 | | GSO |
| EN 303 981 | 14000-14500 | 10700-12750 | StarLink Dish | NEST (Non-geostationary satellite systems)<br>WBES (Wide Band Earth Station) |

# In case signaling solution is required for RX test or others…



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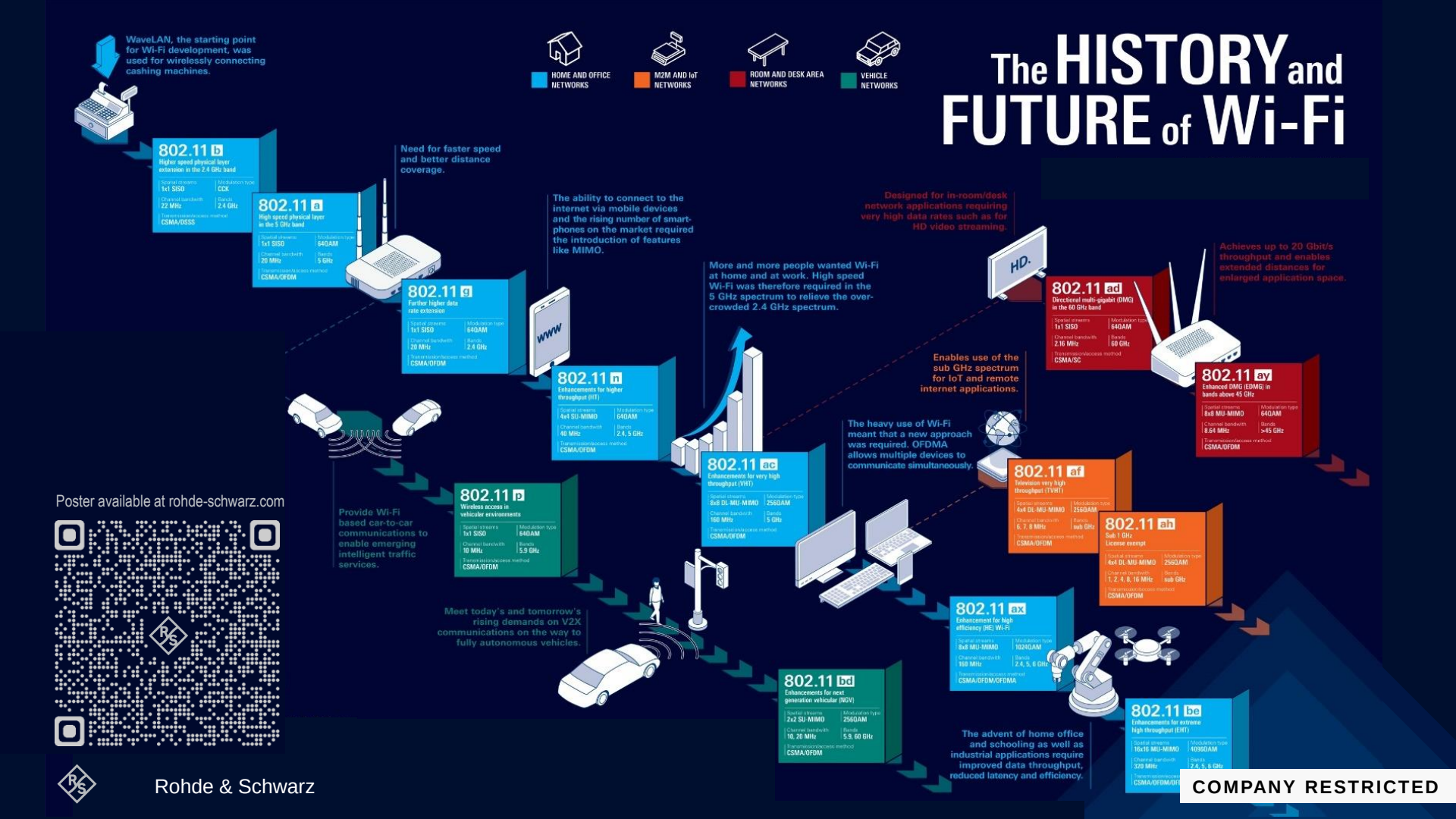

The HISTORY and FUTURE of Wi-Fi
HOME AND OFFICE NETWORKS
M2M AND IoT NETWORKS
ROOM AND DESK AREA NETWORKS
VEHICLE NETWORKS
WaveLAN, the starting point for Wi-Fi development, was used for wirelessly connecting cashing machines.
802.11 b
Higher speed physical layer extension in the 2.4 GHz band
Spatial streams: 1x1 SISO
Modulation type: CCK
Channel bandwidth: 22 MHz
Bands: 2.4 GHz
Transmission/access method: CSMA/DSSS
802.11 a
High speed physical layer in the 5 GHz band
Spatial streams: 1x1 SISO
Modulation type: 64QAM
Channel bandwidth: 20 MHz
Bands: 5 GHz
Transmission/access method: CSMA/OFDM
Need for faster speed and better distance coverage.
802.11 g
Further higher data rate extension
Spatial streams: 1x1 SISO
Modulation type: 64QAM
Channel bandwidth: 20 MHz
Bands: 2.4 GHz
Transmission/access method: CSMA/OFDM
The ability to connect to the internet via mobile devices and the rising number of smartphones on the market required the introduction of features like MIMO.
802.11 n
Enhancements for higher throughput (HT)
Spatial streams: 4x4 SU-MIMO
Modulation type: 64QAM
Channel bandwidth: 40 MHz
Bands: 2.4, 5 GHz
Transmission/access method: CSMA/OFDM
More and more people wanted Wi-Fi at home and at work. High speed Wi-Fi was therefore required in the 5 GHz spectrum to relieve the over-crowded 2.4 GHz spectrum.
802.11 ac
Enhancements for very high throughput (VHT)
Spatial streams: 8x8 DL-MU-MIMO
Modulation type: 256QAM
Channel bandwidth: 160 MHz
Bands: 5 GHz
Transmission/access method: CSMA/OFDM
The heavy use of Wi-Fi meant that a new approach was required. OFDMA allows multiple devices to communicate simultaneously.
802.11 ax
Enhancement for high efficiency (HE) Wi-Fi
Spatial streams: 8x8 MU-MIMO
Modulation type: 1024QAM
Channel bandwidth: 160 MHz
Bands: 2.4, 5, 6 GHz
Transmission/access method: CSMA/OFDM/OFDMA
The advent of home office and schooling as well as industrial applications require improved data throughput, reduced latency and efficiency.
802.11 be
Enhancements for extreme high throughput (EHT)
Spatial streams: 16x16 MU-MIMO
Modulation type: 4096QAM
Channel bandwidth: 320 MHz
Bands: 2.4, 5, 6 GHz
Transmission/access method: CSMA/OFDM/OFDMA
Designed for in-room/desk network applications requiring very high data rates such as for HD video streaming.
HD
802.11 ad
Directional multi-gigabit (DMG) in the 60 GHz band
Spatial streams: 1x1 SISO
Modulation type: 64QAM
Channel bandwidth: 2.16 MHz
Bands: 60 GHz
Transmission/access method: CSMA/SC
Achieves up to 20 Gbit/s throughput and enables extended distances for enlarged application space.
802.11 ay
Enhanced DMG (EDMG) in bands above 45 GHz
Spatial streams: 8x8 MU-MIMO
Modulation type: 64QAM
Channel bandwidth: 8.64 MHz
Bands: >45 GHz
Transmission/access method: CSMA/OFDM
Enables use of the sub GHz spectrum for IoT and remote internet applications.
802.11 af
Television very high throughput (TVHT)
Spatial streams: 4x4 DL-MU-MIMO
Modulation type: 256QAM
Channel bandwidth: 6, 7, 8 MHz
Bands: sub GHz
Transmission/access method: CSMA/OFDM
802.11 ah
Sub 1 GHz License exempt
Spatial streams: 4x4 DL-MU-MIMO
Modulation type: 256QAM
Channel bandwidth: 1, 2, 4, 8, 16 MHz
Bands: sub GHz
Transmission/access method: CSMA/OFDM
802.11 p
Wireless access in vehicular environments
Spatial streams: 1x1 SISO
Modulation type: 64QAM
Channel bandwidth: 10 MHz
Bands: 5.9 GHz
Transmission/access method: CSMA/OFDM
Provide Wi-Fi based car-to-car communications to enable emerging intelligent traffic services.
Meet today's and tomorrow's rising demands on V2X communications on the way to fully autonomous vehicles.
802.11 bd
Enhancements for next generation vehicular (NGV)
Spatial streams: 2x2 SU-MIMO
Modulation type: 256QAM
Channel bandwidth: 10, 20 MHz
Bands: 5.9, 60 GHz
Transmission/access method: CSMA/OFDM
Poster available at rohde-schwarz.com
Rohde & Schwarz
COMPANY RESTRICTED

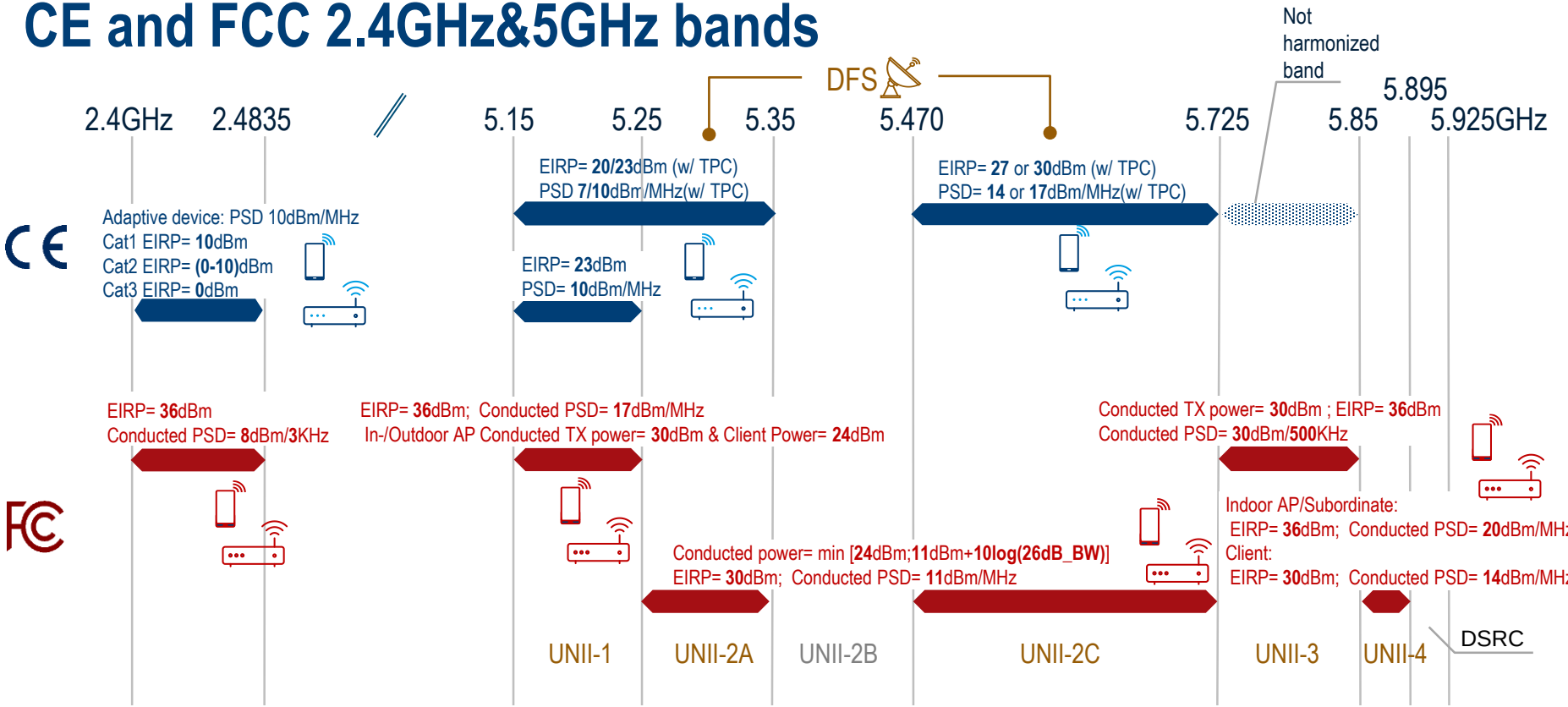
# Wi-Fi technology evolution

## physical layer enhancement is powered by more spectrum

| | Wi-Fi 4 (802.11n) | Wi-Fi 5 (802.11ac) | Wi-Fi 6E (802.11ax) | Wi-Fi 7 (802.11be) |
|---|---|---|---|---|
| | *High Throughput (HT)* | *Very High Throughput (VHT)* | *High Efficiency (HE)* | *Extreme High Throughput (EHT)* |
| **Supported bands** | 2.4 GHz, 5 GHz | 5 GHz | 2.4 GHz, 5 GHz, **6 GHz** | 2.4 GHz, 5 GHz, 6 GHz |
| **Channel bandwidth (MHz)** | 20, 40 | 20, 40, 80, 80+80, 160 | 20, 40, 80, 80+80, 160 | 20, 40, 80, 160, **320** |
| **Transmission scheme** | OFDM | OFDM | OFDM, OFDMA | OFDM, OFDMA |
| **Subcarrier spacing** | 312.5 kHz | 312.5 kHz | 78.125 kHz | 78.125 kHz |
| **Guard interval** | 0.4 µs, 0.8 µs | 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** | 4x4 (SU-MIMO only) | 8x8 (incl. DL-MU-MIMO) | 8x8 (incl. MU-MIMO) | **16x16** (incl. MU-MIMO) |
| **Modulation (highest)** | 64QAM (6 bit) | 256QAM (8 bit) | 1024QAM (10 bit) | **4096QAM (12** bit) |

EN 300 328
EN 301 893
47CFR 15.407

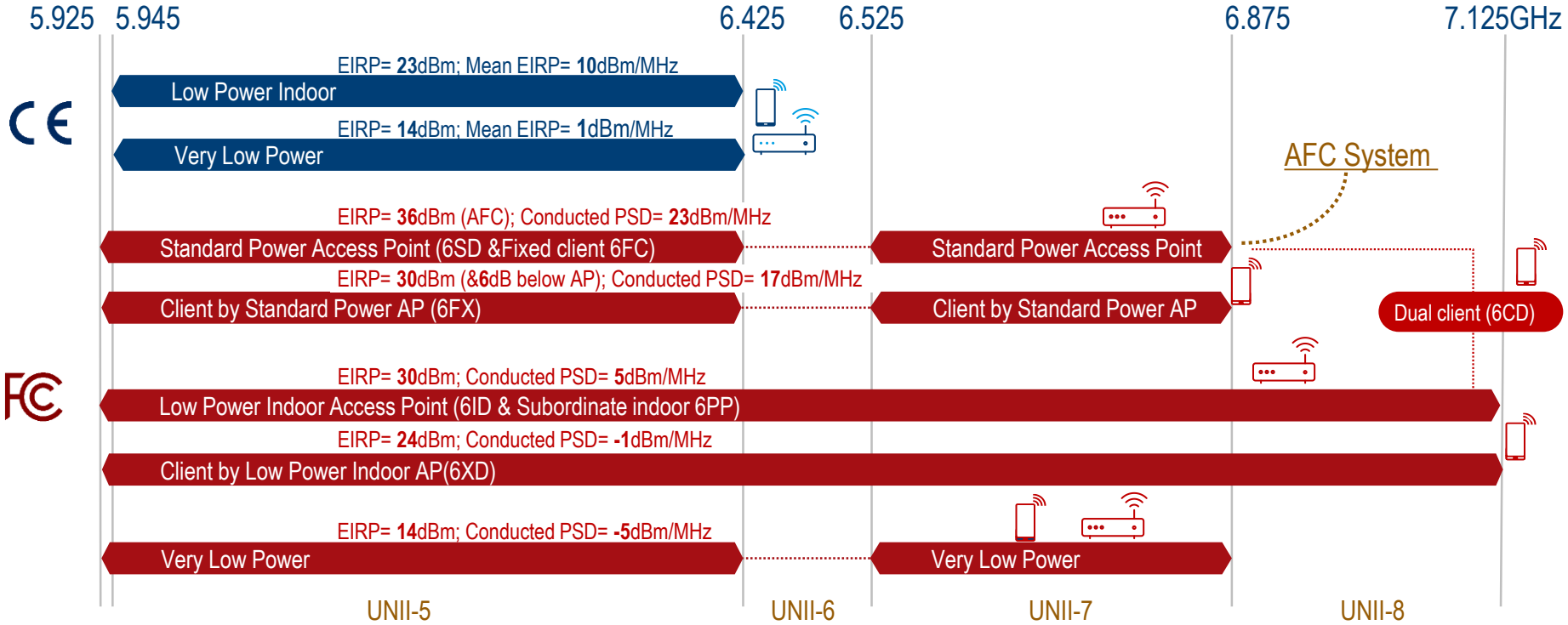
# Wi-Fi device spectrum allocations and power limits
# CE and FCC 2.4GHz&5GHz bands




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

EN 300 328
EN 301 893
EN 303 687
47CFR 15.407

# Wi-Fi device spectrum allocations and power limits CE and FCC 6GHz bands



# Tons RED EN standards under the 4 essential requirements

## Wi-Fi devices have specific Radio Spectrum standards

### *Art 3.1a Health & Safety*

Directive 2014/35/EU
CENELEC - EN 50360
Specific Absorption Rate

### *Art 3.1b EMC*

EN 301 489-1 Common
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EN 301 489-?? …

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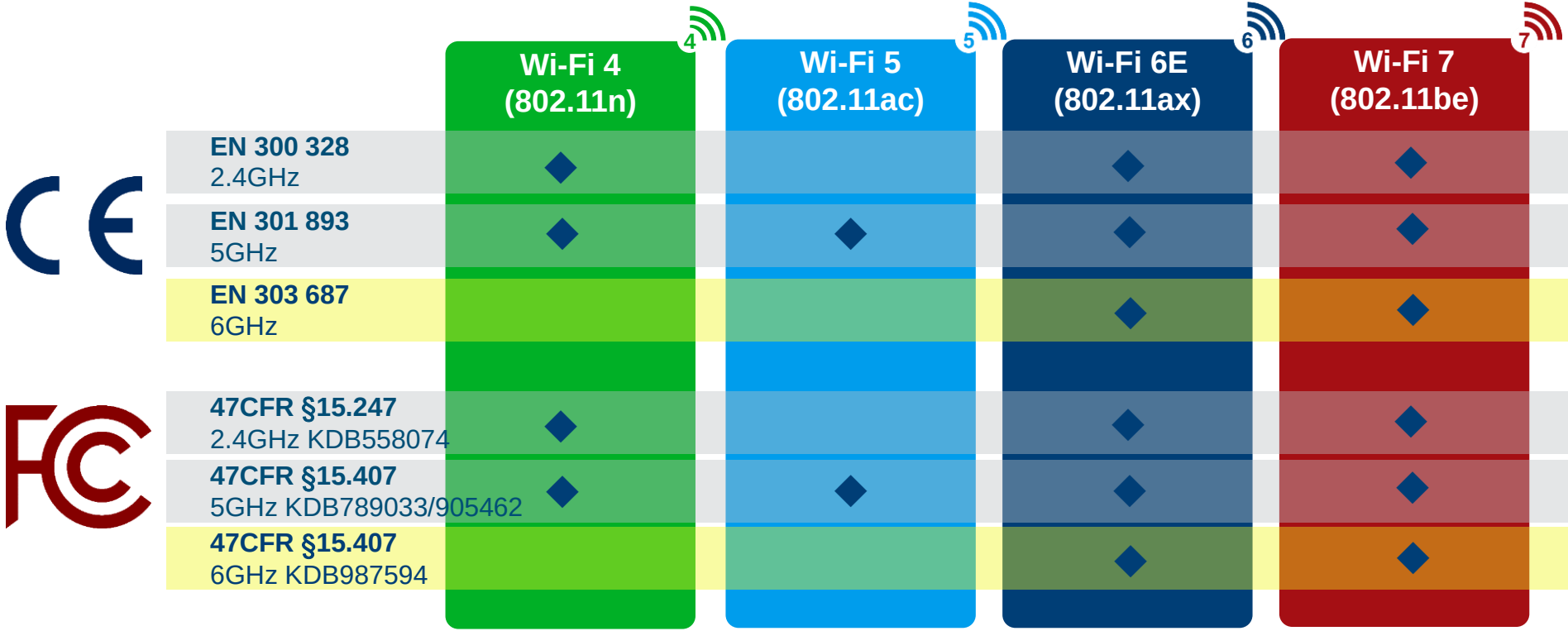
# Wi-Fi 6E/7 enable the test requirements at 6GHz band
# Both CE & FCC give new test standards for 6GHz devices



# R&S®TS8997 regulatory test system supports CE/FCC test cases for all Wi-Fi 4/5/6/6E/7 devices

| Wi-Fi 4 (802.11n) | Wi-Fi 5 (802.11ac) | Wi-Fi 6E (802.11ax) | Wi-Fi 7 (802.11be) |
|---|---|---|---|

CE

- **EN 300 328** 2.4GHz
- **EN 301 893** 5GHz
- **EN 303 687** 6GHz

FCC

- **47CFR §15.247** 2.4GHz KDB558074
- **47CFR §15.407** 5GHz KDB789033/9
- **47CFR §15.407** 6GHz KDB987594

## R&S®TS8997

- Supports latest CE RED and FCC test requirements for all Wi-Fi 4/5/6/6E/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

# Ultra Wideband communication is the ‘re-invented’ pulse radio
## The signal should be kind of low power white noise to others

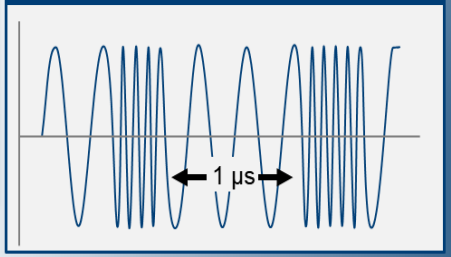
*Ultra Wideband*

**1901**

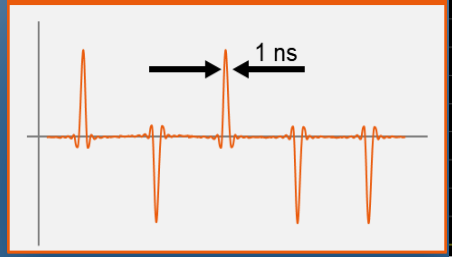
The Italian electrical engineer **Guglielmo Marconi** sent the letter S (•••) more than 2,100 miles across the Atlantic

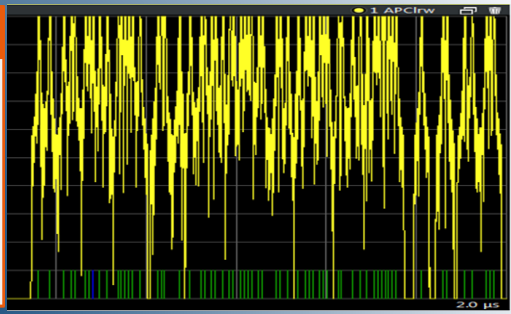
**100 years later…**

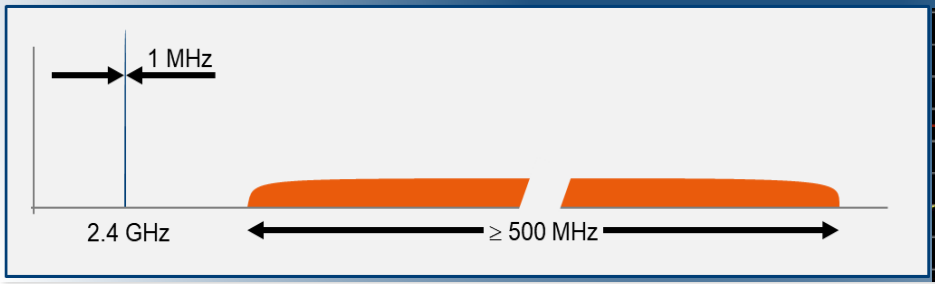
NB/WB e.g. Bluetooth GFSK

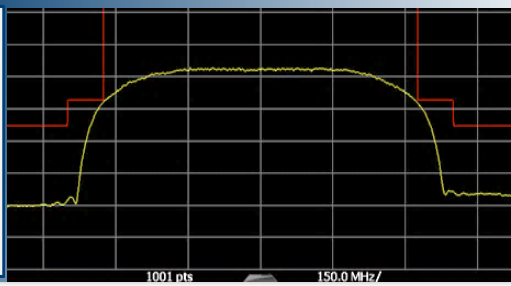



UWB pulse – Phase shift keying



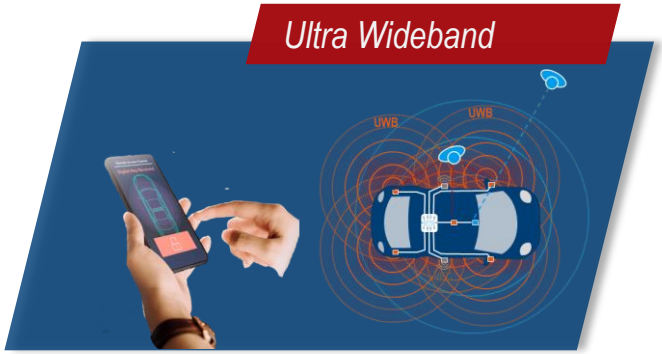



# Regulations for UWB are earlier than present applications

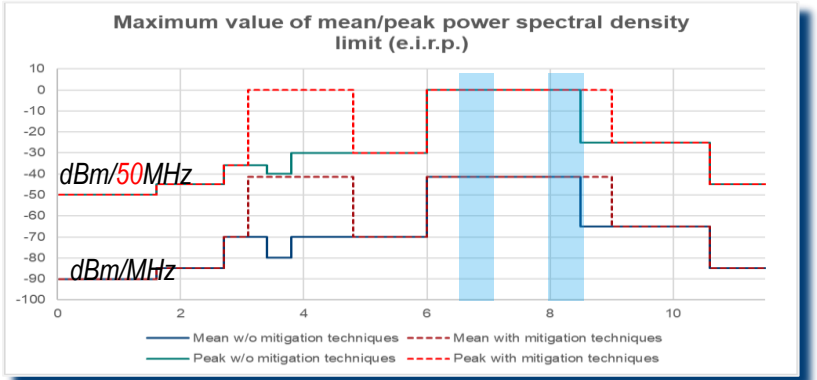
## The minimum bandwidth and highest power are key parameters

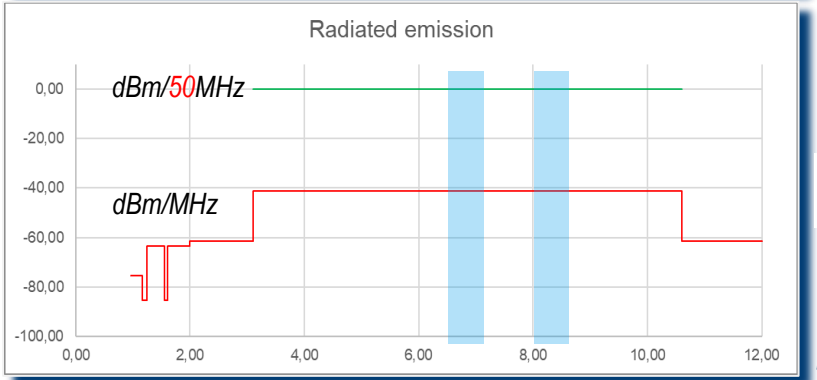



- UWB car-key and allocation trackers are popular products.
- Most chipsets support Channels 5 (6.5 GHz) and 9 (8 GHz) and 500MHz bandwidth.
- Regulators in many countries have concern of the interference by UWB devices.

R&S®SMW200A
[12.75 GHz; 2 GHz BW]

R&S® FSW43
[FSW-B8 50MHz RBW]




**EN 302 065-1/2/…**
**EN 303 883-1/2**
**EN 301 489-33**

*An issue for traditional measurement method*:*
"When using resolution bandwidths below 50MHz, this method ***overestimates*** *the* ***peak power*** result for most UWB signals due to the ***worst-case*** correction factor …"

$$Corr_{dB} = 20 \times \log_{10}\left(\frac{50\ MHz}{RBW_{used}\ [MHz]}\right)$$

**CFR47 /§15/Subpart F**

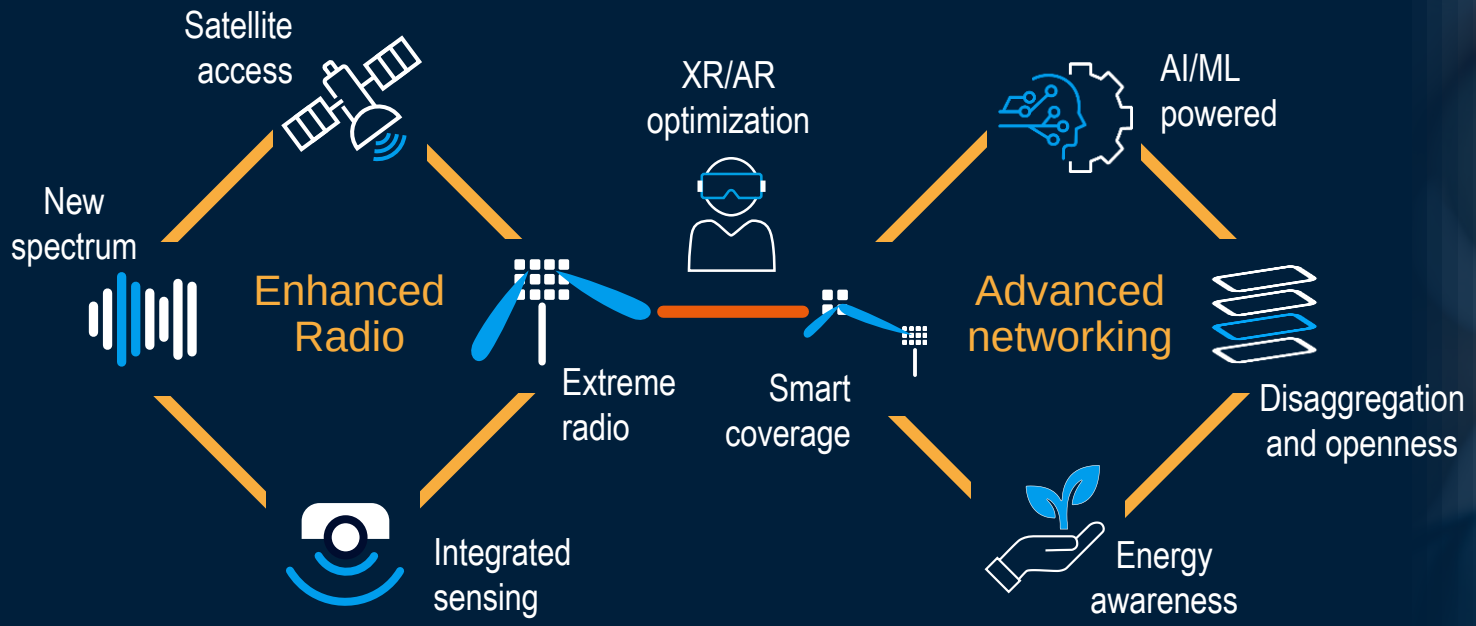
# Designing mobile phones and tablets to be sustainable
## new Energy Efficient Index from EU Eco-Design Directive

- **COMMISSION DELEGATED REGULATION (EU) 2023/1669** of 16 June 2023 supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to the **energy labelling of smartphones and slate tablets**
- …It shall apply from 20 June 2025.
- ANNEX II Energy efficiency classes & ANNEX IV: Measurement and calculation methods
- ANNEX Iva EEI test specifications: https://ec.europa.eu/docsroom/documents/50214
- ETSI TECHNICAL COMMITTEE (TC) ENVIRONMENTAL ENGINEERING (EE) got mandate to develop harmonized standard.


GSMA MWC Barcelona

Press release about joint CMX demo in MWC2024

# Heading towards the future of wireless communication – technology cornerstones




# Primary test instruments for wireless regulatory test labs
## Broad portfolio provides benefit for tailored flexible solutions

Wireless communication tester

EMI test receiver

Signal & spectrum analyzer

Vector signal generator

Broadband Amplifier

Network analyzer


Thank you
very much
ROHDE&SCHWARZ
Make ideas real
COMPANY RESTRICTED