



Let's talk

# EMC & Regulatory test for 5G, NTN/LEO & Connectivity

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market segment manager

Wireless Communication

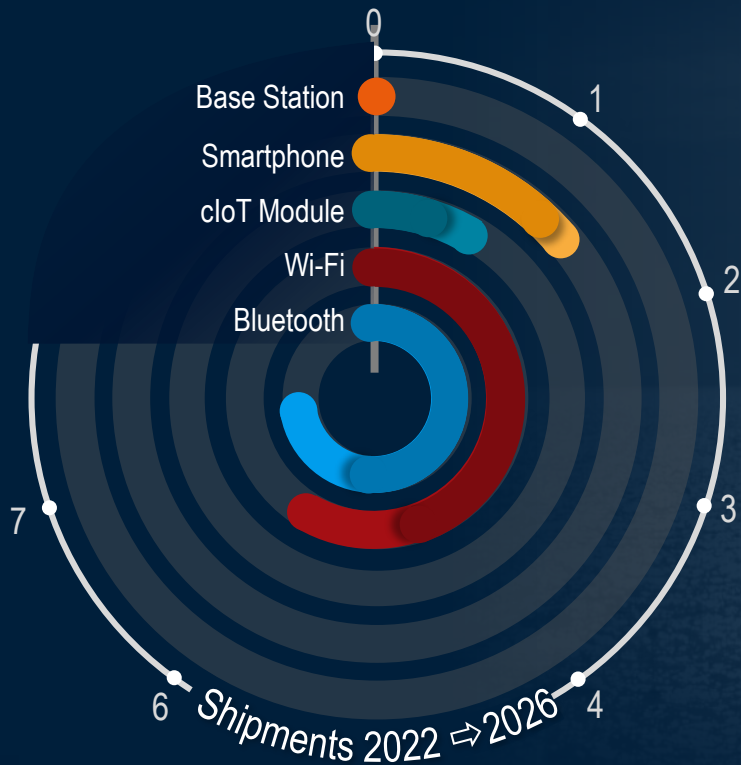
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**ROHDE & SCHWARZ**

Make ideas real



# Shipment of wireless communication equipment projected to grow in all areas driven by emerging use cases



● **0.01 Bn** (CAGR<sub>4</sub>: +5%)  
Base Station RUs in 2022

● **1.2 Bn** (CAGR<sub>4</sub>: +4%)  
Smartphones in 2022

● **0.4 Bn** (CAGR<sub>4</sub>: +19%)  
Cellular IoT modules in 2022

● **4.4 Bn** (CAGR<sub>4</sub>: +8%)  
Wi-Fi devices in 2022

● **5.1 Bn** (CAGR<sub>4</sub>: +8%)  
Bluetooth devices in 2022

*Figures based on forecasts from IDC, Berg Insight, Murata*



# Wireless technology evolution is paving the way for future

## Diverse standards enable fragmented applications and devices

### 5G NR eMBB



**8.5 Bn**

mobile subscriptions (E2022)

**1100+** 5G device types (E2022)



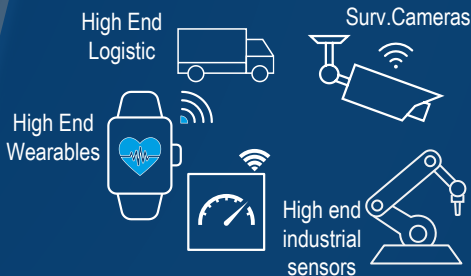
**250** 5G FWA

fixed wireless access  
device types (E2022)

2021

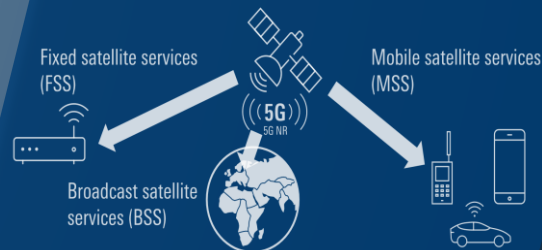
2022

### RedCap 5G NR IoT



2023

### 5G Non-Terrestrial Network



2024

2025

### Wi-Fi 5

802.11ac  
5GHz  
20,40,80,80+80,160MHz

### Wi-Fi 6/6E

802.11ax  
2.4GHz 5GHz **6GHz**  
20,40,80,80+80,160MHz

### Wi-Fi 7

802.11be  
2.4GHz 5GHz **6GHz**  
20,40,80,160,320MHz

Other connectivity technologies: Ultra-wideband (UWB), Bluetooth, ....



# Wireless technology is enabling a connected world

## Tests are critical tasks for successful market access



Wireless products become more complex than ever.

((5G)) Wireless technology innovations are chasing higher frequency & bandwidth.



Wireless test scopes and methods are developed for 'next-level' of challenges.

### Regulatory Compliance Test

To grant market access under legal aspect

- CE RED
- FCC
- ...

### Telecom Industry Certification Test

To enable the high quality, reliability, and secure wireless communication

- GCF/Cellular
- SIG/Bluetooth
- FiRa/UWB
- WiFi Alliance/WiFi

### Cellular Network Operator Acceptance Test

To demonstrate interoperability for specific features

- AT&T
- VzW
- T-mobile
- CMCC

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# CE RED focuses on 4 essential requirements

## Tons of EN standards for wireless devices

### 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  
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-?? ...



### Radio Spectrum Art 3.2

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 301 908-3 WCDMA BS  
EN 301 908-13 LTE UE  
EN 301 908-14 LTE BS  
EN 301 908-24 5G NR BS  
EN301 908-25 5G NR UE



### Specific topics Art 3.3

Guideline 2019/320 (E112)  
Emergency service



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

## The test system needs upgrade, more than 5G ready

Health & Safety Art  
Art3.1a

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

### SAR test

- 5G NR network emulator is required to drive the EUT to extreme transmission condition.
- Be prepared: FR2 power density measurement or 5G NR RedCap wearable devices could come soon.
- Multi-Radio UE with advanced 'time-average-SAR' feature needs flexible signaling functions, incl. cellular, Wi-Fi and Bluetooth.
- 'Easy use' and 'extreme stable' signaling solution helps the time-consuming SAR test.



Beside SAR, FCC requires HAC test for all audio functions in mobile phones. CMX500 with in-box DAU/IMS support is useful for HAC test.



# Traditional EMC Art3.1b tests

## Audio breakthrough test is required for mobile phones

### EMC Art 3.1b

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-?? ...

### EMC & ABT

- Art.3.1b EMC test requirements are not changed by 5G NR or WiFi6E/7.
- 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.

[https://scdn.rohde-schwarz.com/ur/pws/dl\\_downloads/dl\\_application/application\\_notes/1sl391/AppNote\\_Audio\\_Break\\_Through.pdf](https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_application/application_notes/1sl391/AppNote_Audio_Break_Through.pdf)

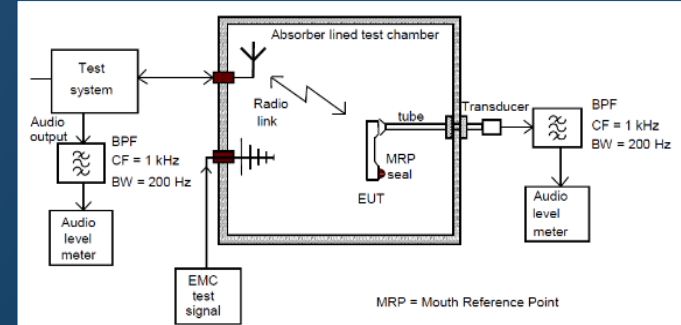


Figure B.2: Audio breakthrough measurement, test set-up for portable equipment



# Wi-Fi RF test for radio spectrum Art3.2

## The RED specifications are frequency bands depended

Radio Spectrum Art 3.2		Wi-Fi 4 (802.11n) <i>High Throughput (HT)</i>	Wi-Fi 5 (802.11ac) <i>Very High Throughput (VHT)</i>	Wi-Fi 6E (802.11ax) <i>High Efficiency (HE)</i>	Wi-Fi 7 (802.11be) <i>Extreme High Throughput (EHT)</i>
EN 300 328	WLAN2.4GHz				
EN 301 893	WLAN5GHz				
EN 303 687	WLAN6GHz				
	<b>Supported bands</b>	2.4 GHz, 5 GHz	5 GHz	2.4 GHz, 5 GHz, 6 GHz	2.4 GHz, 5 GHz, 6 GHz
	<b>Channel bandwidth (MHz)</b>	20, 40	20, 40, 80, 80+80, 160	20, 40, 80, 80+80, 160	20, 40, 80, 160, 320
	<b>Transmission scheme</b>	OFDM	OFDM	OFDM, OFDMA	OFDM, OFDMA
	<b>Subcarrier spacing</b>	312.5 kHz	312.5 kHz	78.125 kHz	78.125 kHz
	<b>Guard interval</b>	0.4 $\mu$ s, 0.8 $\mu$ s	0.4 $\mu$ s, 0.8 $\mu$ s	0.8 $\mu$ s, 1.6 $\mu$ s, 3.2 $\mu$ s	0.8 $\mu$ s, 1.6 $\mu$ s, 3.2 $\mu$ s
	<b>Spatial streams</b>	4x4 (SU-MIMO only)	8x8 (incl. DL-MU-MIMO)	8x8 (incl. MU-MIMO)	16x16 (incl. MU-MIMO)
	<b>Modulation (highest)</b>	64QAM (6 bit)	256QAM (8 bit)	1024QAM (10 bit)	4096QAM (12 bit)



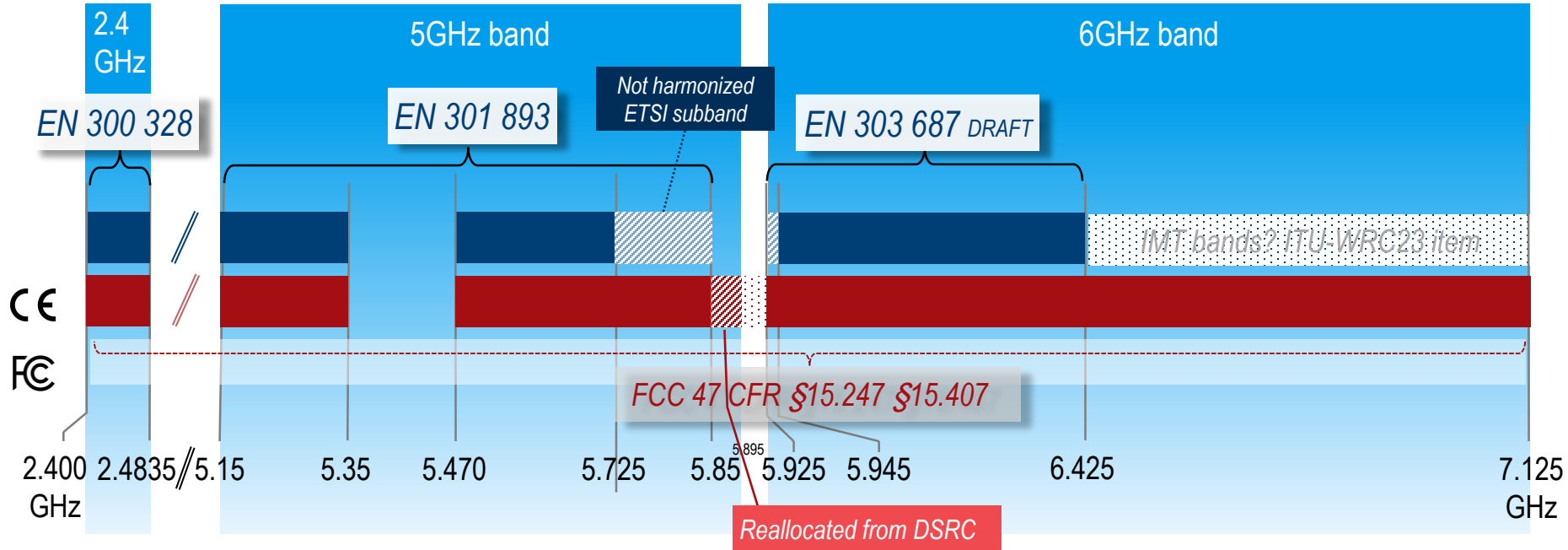
# Wi-Fi technology evolution

## Wi-Fi 6E/7 enable the test requirements at 6GHz band

	Wi-Fi 4 (802.11n)	Wi-Fi 5 (802.11ac)	Wi-Fi 6E (802.11ax)	Wi-Fi 7 (802.11be)
EN 300 328 2.4GHz band	✓		✓	✓
EN 301 893 5GHz band	✓	✓	✓	✓
EN 303 687 6GHz band			✓	✓
47CFR §15.247 2.4GHz KDB558074	✓		✓	✓
47CFR §15.407 5GHz KDB789033/905462	✓	✓	✓	✓
47CFR §15.407 6GHz KDB987594			✓	✓

# Unlicensed frequency bands in ETSI and FCC regulations

## Regulatory requirements depend on the bands



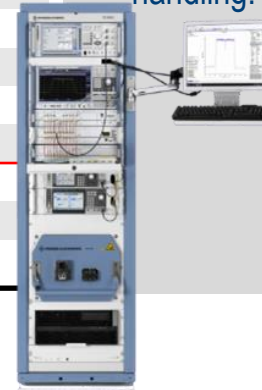
# Test cases for CE RED 3.2 with unlicensed bands

## Different bands need different test cases

	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		X	X
	RF output power	X	X	X
	Transmit power control (TPC)		X	
	Spectrum power density	X	X	X
	Occupied channel bandwidth	X	X	X
	Transmitter unwanted emissions	<i>In out-of-band domain Spurious domain</i>	<i>within 5 GHz bands Outside 5 GHz bands</i>	<i>within 6 GHz bands Outside 6 GHz band</i>
Coexistence	Duty cycle, TX sequence, TX gap	X		
	Dwell time, min. freq. occupation, hopping sequence (only for freq. hopping DUTs)	X		
	Hopping frequency separation	X		
	Medium utilization (MU) factor	X		
	Adaptivity	X	X	X
	Dynamic frequency selection (DFS)		X	
Rec.	Receiver spurious emissions	X	X	X
	Receiver blocking	X	X	X
	Receiver adjacent channel selectivity			X

### Be ready for Wi-Fi 6E/7

- 6GHz band support is a must for Wi-Fi 6E/7.
- 320MHz BW (WiFi7) is not required yet. (Be prepared for future?)
- 'Golden' device or easy-use wireless communication tester simplifies DUT handling.



# Cellular technology RF test for radio spectrum Art3.2

## 5G NR specification incl. FR1 and FR2

### Radio Spectrum Art 3.2

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-like"

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

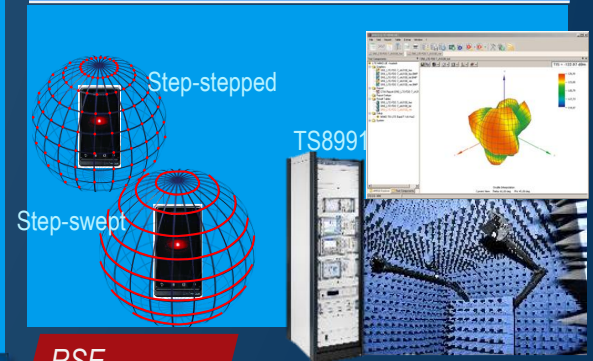
- Almost the same RF conformance test cases in 3GPP
- 5G NR specification needs support of FR1/FR2/FR1+FR2
- FR1 test setup stays conducted; FR2 test setup become radiated

FR1 SA	FR1 LTE NSA	FR2 SA	FR2 LTE NSA
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### "CTIA-like"

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



### RSE

#### 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

### Specific topics Art 3.3

Guideline 2019/320 (E112)  
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 defines test requirements under CFR47

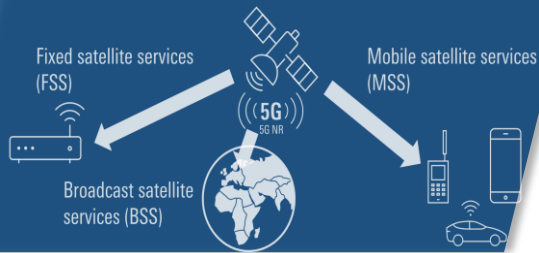
## Many fragmented test solutions are required

	5G NR	NTN	Wi-Fi6E/7	UWB
Technology	Cellular	Satellite/MSS	Unlicensed bands WiFi&Co	Ultra Wideband
CFR47	§2/22/24/27/...	§25	§15 (c/e)	§15 (f)
Conducted RF Test			 R&S®TS8997	
Radiated EMC Test	 R&S®TS8996 RSE			
EMF Test/ Human exposure &Co.				

# Satellite communication is not new for ETSI EN standards

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

### 5G Non-Terrestrial Network



CE RED Art3.2	Earth-to-space in MHz	Space-to-earth in MHz	Note
EN 301 441	1610-1626.5	1613.8-1626.4 2483.5-2500	S-PCN
EN 301 442	1980-2010	2170-2200	NGSO; S-PCN
EN 301 444	1626.5-1660.5 1668-1675	1525-1559 1518-1525	LMES;MMES (15-33dBW/45-63dBm)
EN 301 681	1626.5-1660.5 1668-1675	1525-1559 1518-1525	GSO;S-PCN; <15dBW(45dBm)
EN 302 574	1980-2010	2170-2200	GSO
EN 303 980	14000-14500	10700-12750	NEST

- **MES**  
Mobile Earth Station
- **S-PCN**  
Satellite-Personal Communications Network
- **LMES**  
Land Mobile Earth Stations
- **MMES**  
Maritime Mobile Earth Stations
- **NEST**  
Non-geostationary satellite systems
- **NGSO**  
Non-geostationary satellite systems
- **GSO**  
Geostationary satellite systems

- ETSI MSG group is working on review/update for 3GPP NTN devices.
- FCC rules Mobile Satellite Service (MSS) by CFR47 §25 - SATELLITE COMMUNICATIONS.

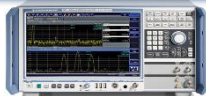
Federal Communications Commission

Home / EDOCS / Commission Documents /

### Proposing a New Regulatory Framework for a Single Network Future



R&S@SMM100A



R&S@FSW

# Ultra Wideband communication is the 're-invented' pulse radio

## The signal should be kind of low power white noise to others

Ultra Wideband

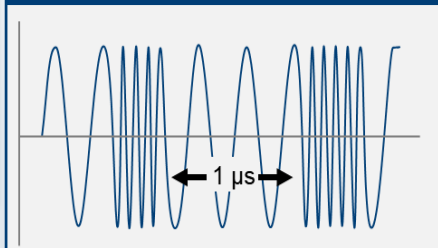
# 1901

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

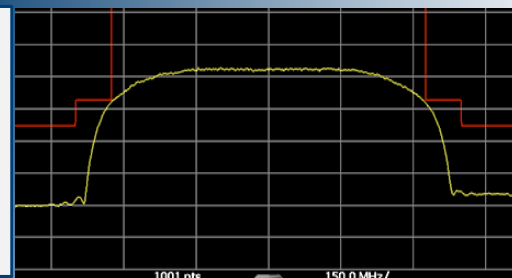
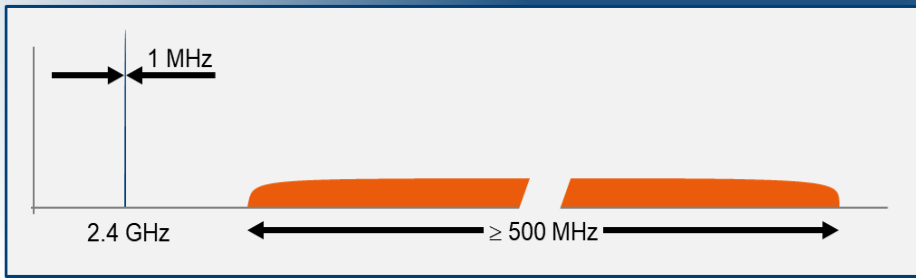
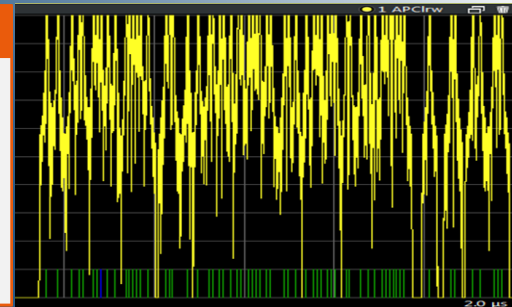
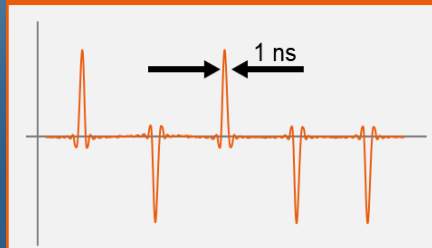


## 100 years later...

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



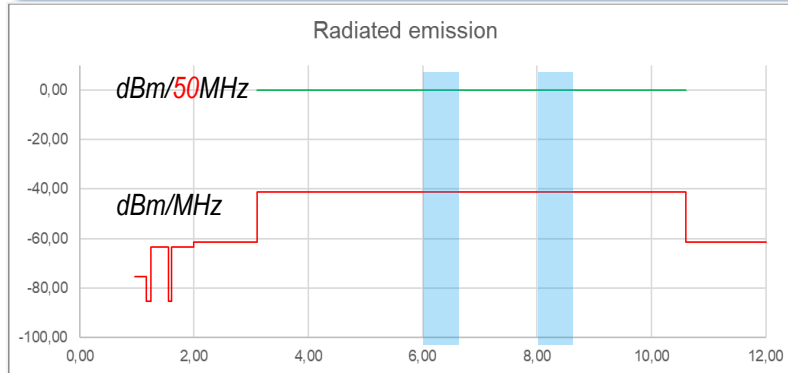
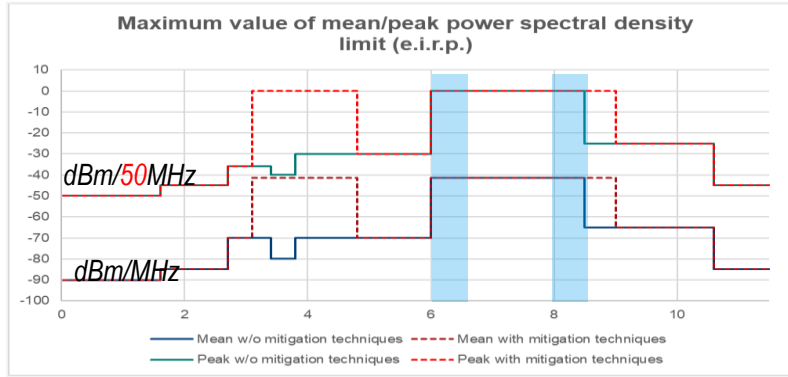
- UWB car-key and allocation trackers are popular products.
- Most chipsets support Channels 5 (6.5 GHz) and 9 (8 GHz) and 500MHz bandwidth.
- Regulators in many countries have concern of the interference by UWB devices.



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 ...”

$$\text{Corr}_{\text{dB}} = 20 \times \log_{10} \left( \frac{50 \text{ MHz}}{\text{RBW}_{\text{used}} [\text{MHz}]} \right)$$

CFR47  
/§15/Subpart F





# Telecom Industry Certification and Cellular Network Operator Approve your device quality for successful Go-To-Market

## Regulatory Compliance Test

To grant market access under legal aspect

- CE RED
- FCC
- ...

## Telecom Industry Certification Test

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## Cellular Network Operator Acceptance Test

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**firo** | The Power to Be Precise



CMP180 for FiRa UWB



R&S@ATS1800M



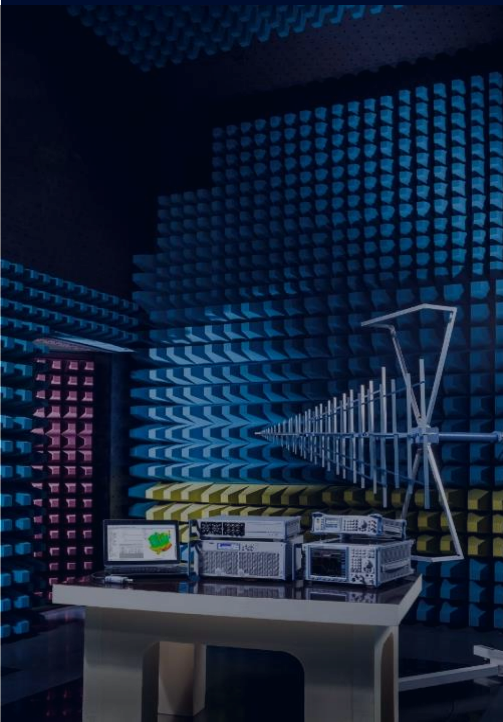
R&S@TS8980



R&S@ CMX500



R&S@ TS-LBS



## KEY Takeaways

- Beside 5G NR devices, RedCap IoT devices and NTN devices are almost available in 2023/2024.
- Wi-Fi 6E devices dominate unlicensed 6GHz band, Wi-Fi 7 devices will be commercialized soon.
- UWB devices get momentum in short time and give challenges to regulators.
- It is time to prepare EMC& regulatory test solutions to welcome a 5G era with diverse wireless devices.

Xie is   
Thankful 