Combat counterfeiting through the use of RF, SAR and EMC laboratories

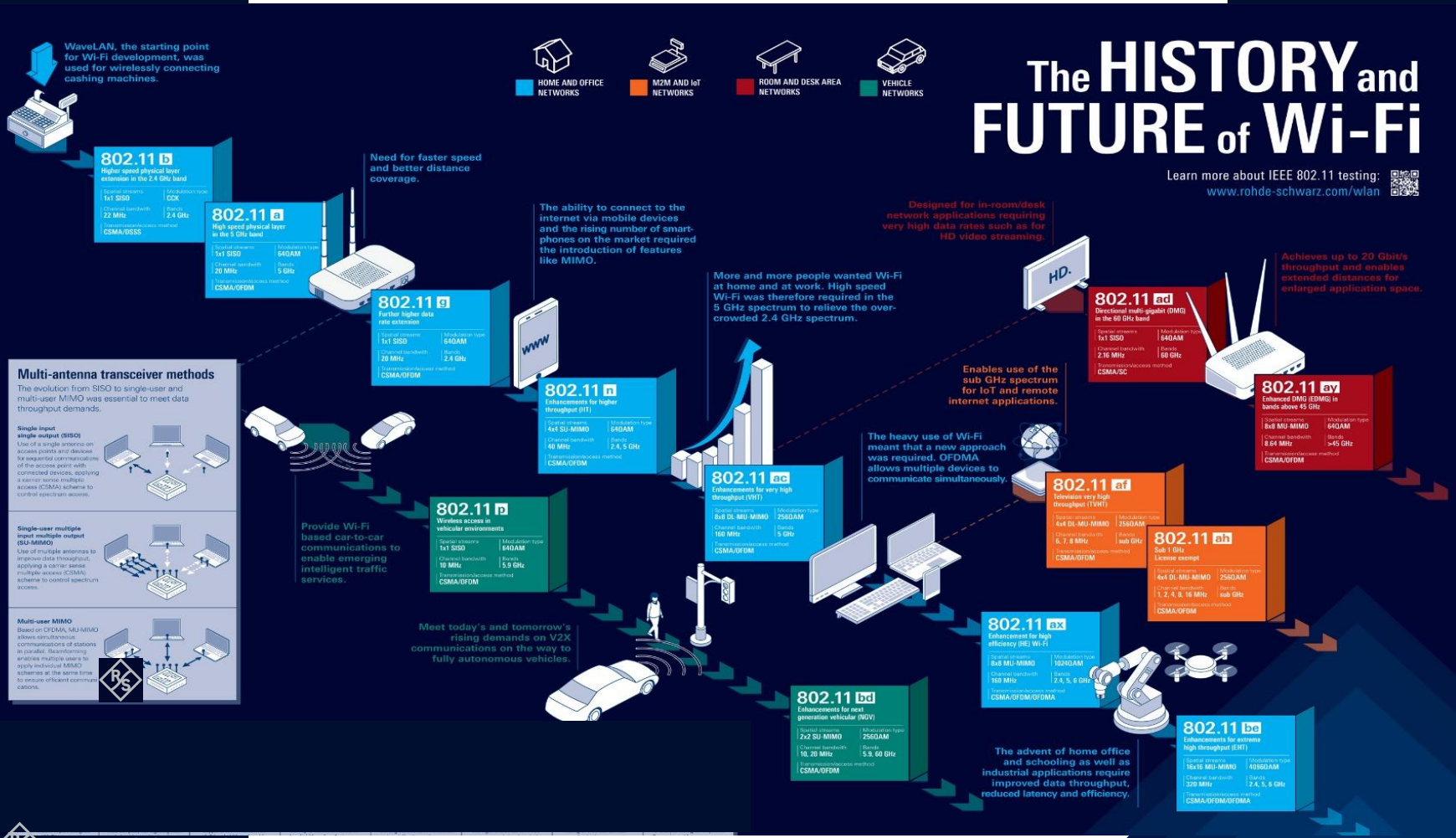
Lets talk about test standards & solutions

Mourad Belmrissi

Mourad.Belmrissi@rohde-schwarz.com

ROHDE&SCHWARZ

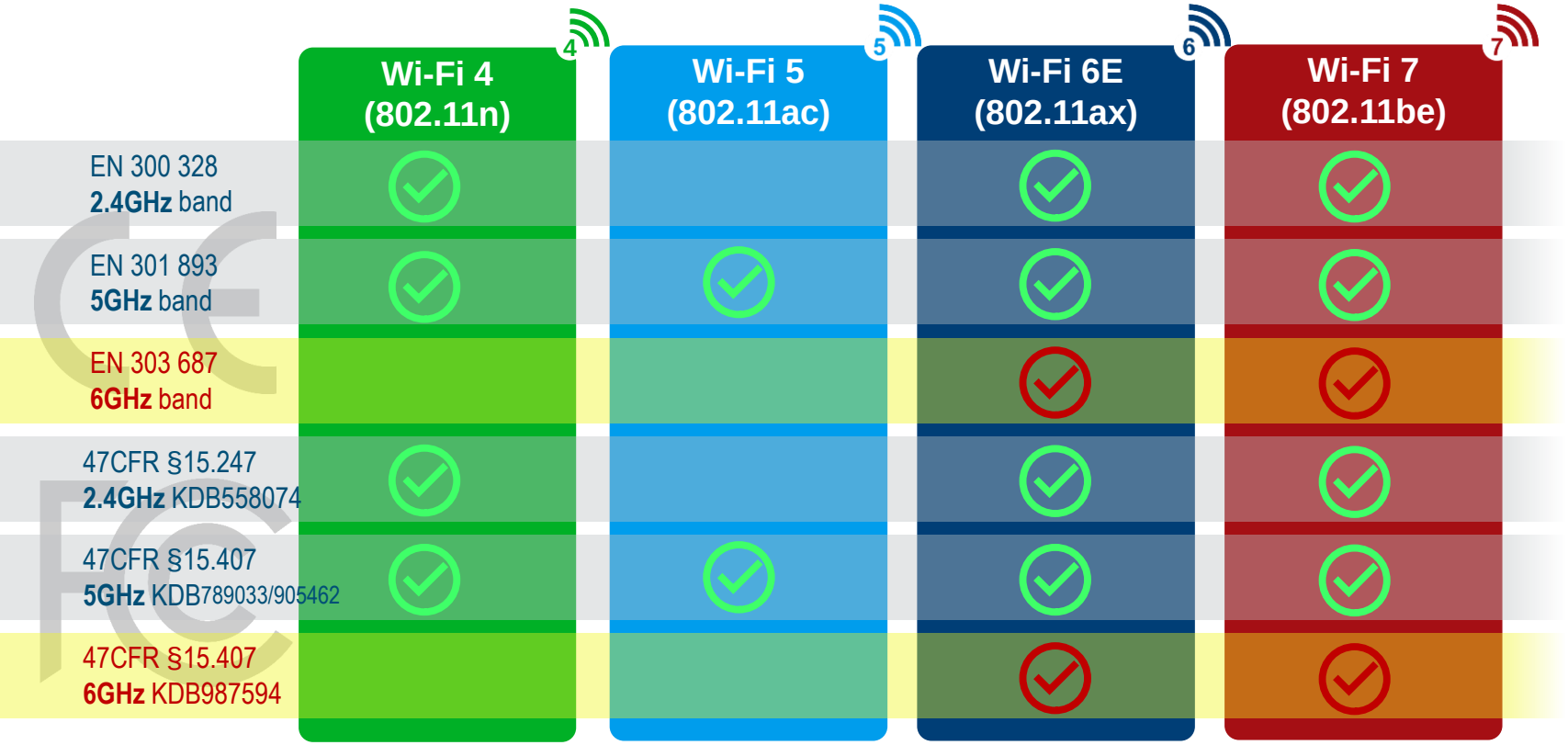
Make ideas real


The HISTORY and FUTURE of Wi-Fi
Learn more about IEEE 802.11 testing:
www.rohde-schwarz.com/wlan
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 bandwith: 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 bandwith: 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 bandwith: 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 smart-phones 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 bandwith: 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 bandwith: 160 MHz
Bands: 5 GHz
Transmission/access method: CSMA/OFDM
Designed for in-room/desk network applications requiring very high data rates such as for HD video streaming.
802.11 ad
Directional multi-gigabit (DMG) in the 60 GHz band
Spatial streams: 1x1 SISO
Modulation type: 64QAM
Channel bandwith: 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 bandwith: 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 bandwith: 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 bandwith: 1, 2, 4, 8, 16 MHz
Bands: sub 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 bandwith: 160 MHz
Bands: 2.4, 5, 6 GHz
Transmission/access method: CSMA/OFDM/OFDMA
802.11 be
Enhancements for extreme high throughput (EHT)
Spatial streams: 16x16 MU-MIMO
Modulation type: 4096QAM
Channel bandwith: 320 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 p
Wireless access in vehicular environments
Spatial streams: 1x1 SISO
Modulation type: 64QAM
Channel bandwith: 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.
802.11 bd
Enhancements for next generation vehicular (NGV)
Spatial streams: 2x2 SU-MIMO
Modulation type: 256QAM
Channel bandwith: 10, 20 MHz
Bands: 5.9, 60 GHz
Transmission/access method: CSMA/OFDM
Meet today's and tomorrow's rising demands on V2X communications on the way to fully autonomous vehicles.
Multi-antenna transceiver methods
The evolution from SISO to single-user and multi-user MIMO was essential to meet data throughput demands.
Single input single output (SISO)
Use of a single antenna on access points and devices for sequential communications of the access point with connected devices, applying a carrier sense multiple access (CSMA) scheme to control spectrum access.
Single-user multiple input multiple output (SU-MIMO)
Use of multiple antennas to improve data throughput, applying a carrier sense multiple access (CSMA) scheme to control spectrum access.
Multi-user MIMO
Based on OFDMA, MU-MIMO allows simultaneous communications of stations in parallel. Beamforming enables multiple users to apply individual MIMO schemes at the same time to ensure efficient communications.

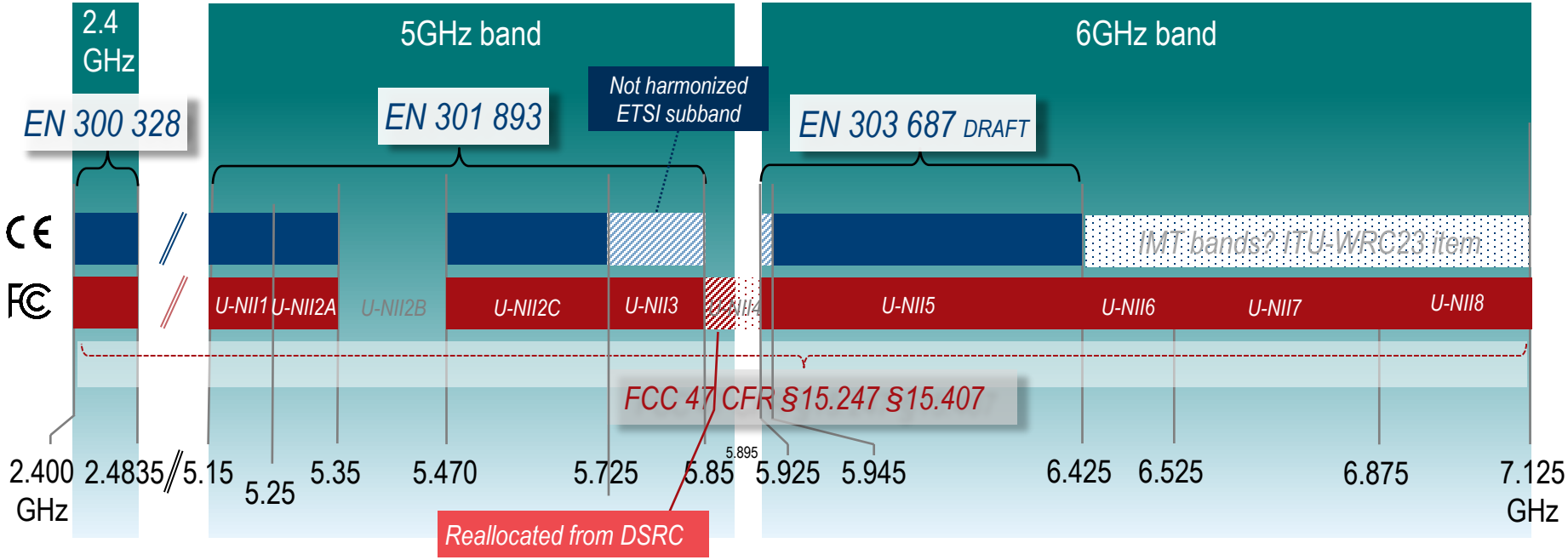
Wi-Fi technology evolution

	Wi-Fi 4 (802.11n) *High Throughput (HT)*	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	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)

Wi-Fi technology evolution and regulatory requirements



Unlicensed frequency bands in ETSI and FCC standards
Regulatory requirements depend on the bands



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

IMT: International Mobile Telecommunication
ITU-WRC: International Telecommunication Union-World Radiocommunication Conference

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

Test cases for demonstration of compliance of CE RED

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	
	Power spectral density	X	X	X
	Occupied channel bandwidth	X	X	X
	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	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

Cellular technologies

publishes requirements	“anybody” can develop specifications	“marketing”
IMT - 2000	3GPP: UMTS	3G
IMT - Advanced	3GPP: LTE-Advanced (R10) IEEE: Advanced Mobile WiMAX, 802.16m	4G
IMT - 2020	3GPP: “5G-RAN + 5GC + LTE”	5G

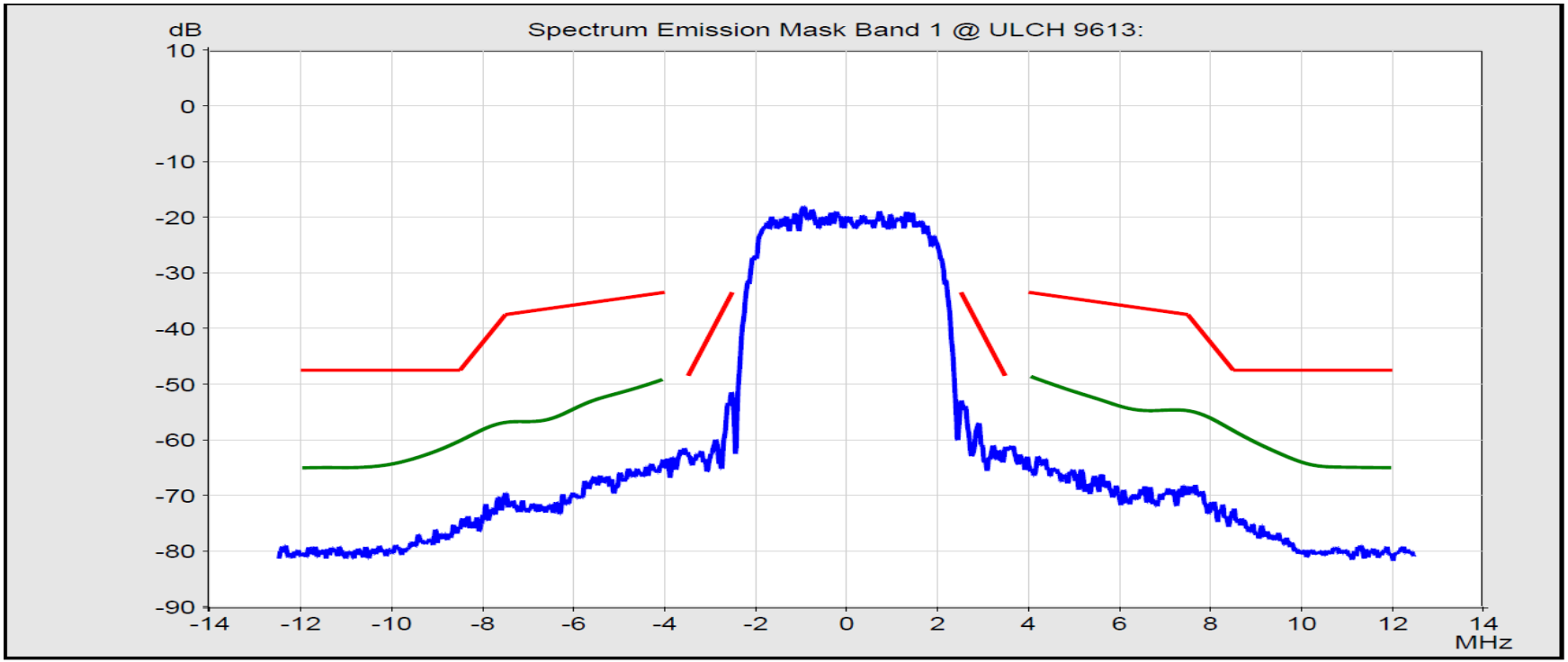
Specs…

- The specs are good harmonized over all instances . ETSI/EN/3GPP

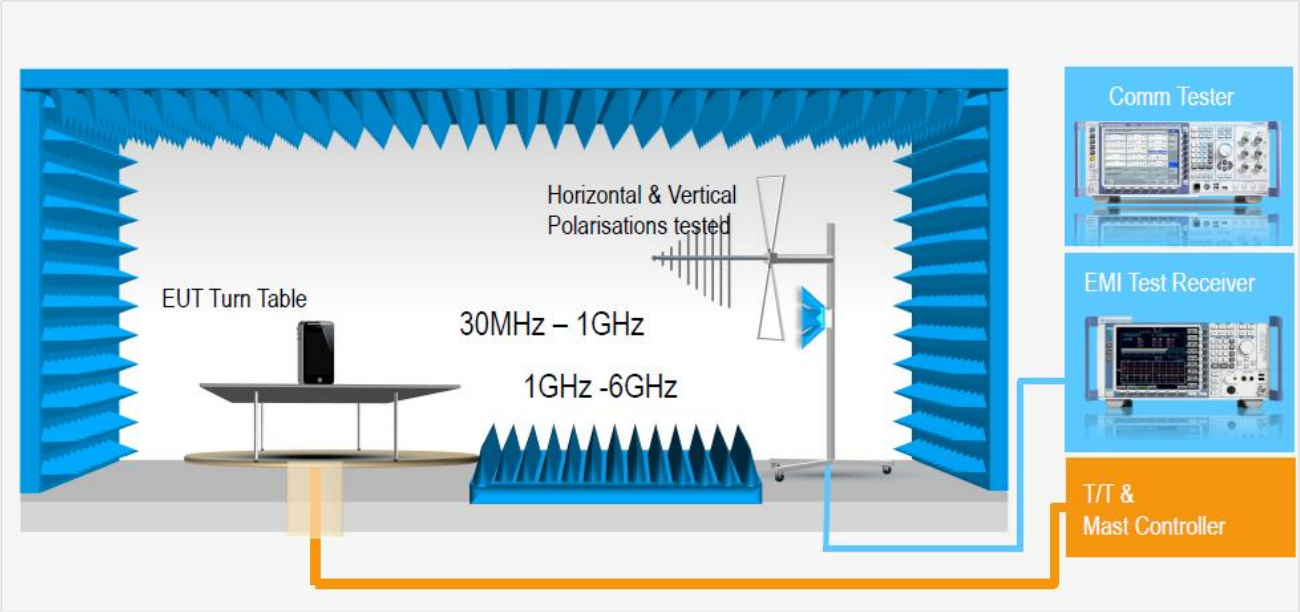
- 2G: TS51-010 chapter 12/13

- 3G: TS34-121 Chapter 6,7
- 4G: TS36-521 Chapter 5,6,7
- 5G: TS38-521 Chapter 6,7

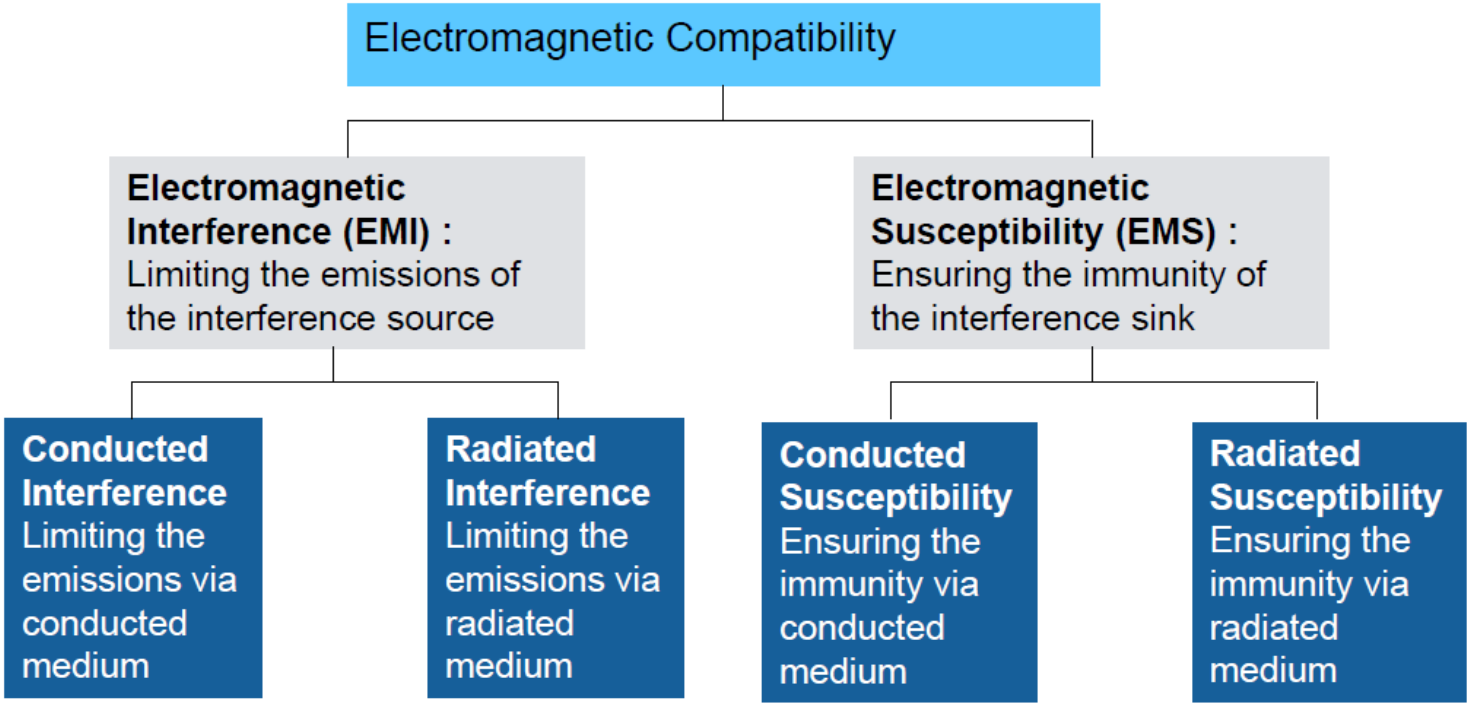
Typical conformity tests



EMC Electromagnetic Compatipility



EMI and EMS


Electromagnetic Compatibility
Electromagnetic Interference (EMI) : Limiting the emissions of the interference source
Electromagnetic Susceptibility (EMS) : Ensuring the immunity of the interference sink
Conducted Interference Limiting the emissions via conducted medium
Radiated Interference Limiting the emissions via radiated medium
Conducted Susceptibility Ensuring the immunity via conducted medium
Radiated Susceptibility Ensuring the immunity via radiated medium

Which standard shall we go for?

EMC Standards

- Different Electronic Equipment require compliance to different Standards

Commercial Equipment:
- ISM Equipment
- Consumer Electronics Equipment
- IT / Household Equipment
- Lighting Equipment

Applicable Standards:
- CISPR 11 to 35
- IEC/EN61000-X-X series
- Product Specific Standards

A&D Equipment:
- Aircraft Equipment
- Ship & Submarine Equipment
- Land Based Equipment

Applicable Standards:
- Mil-Std 461
- Mil-Std 464
- RTCA DO 160

Automotive Equipment:
- Control Equipment
- Infotainment Equipment
- Communication Equipment

Applicable Standards:
- CISPR 12, 25
- ISO11451, ISO11452
- Country specific standards
- OEM Specific Standards

TAL RF Type Approval Lab RF

1

2

3

4

► Transmitter:

1. TX max Power
2. OCB
3. ACLR
4. EVM

► Reciever:

1. Sensitivity
2. ACS

► Equipments

1. Network emulator
2. Shielded Box
3. Power supply
4. Bench analyzer

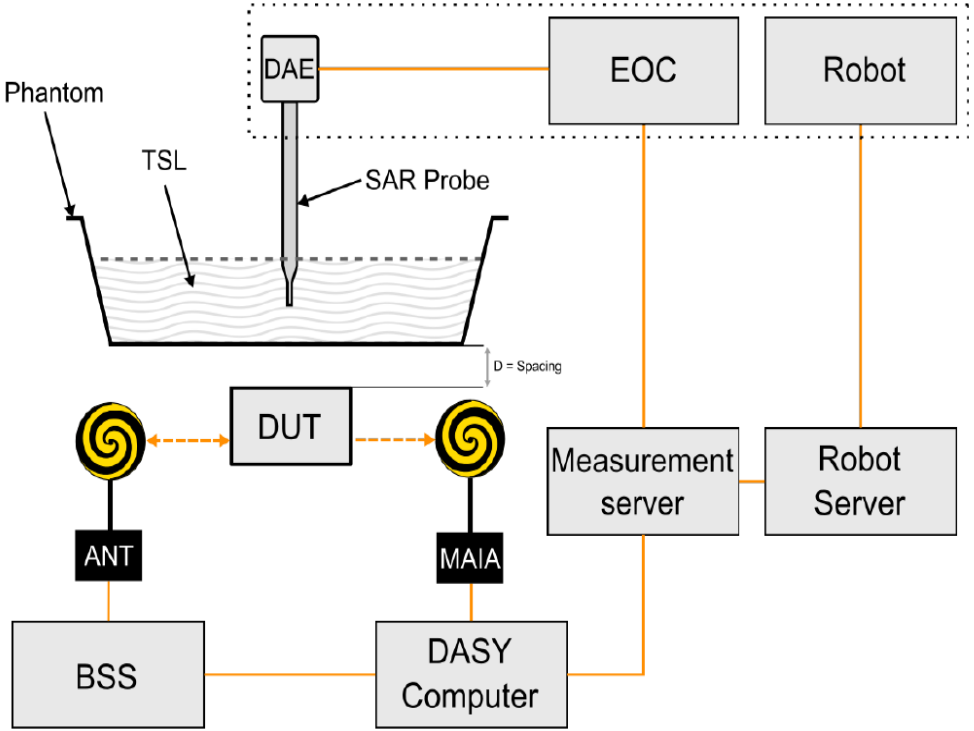
Specs…

- The specs are good harmonized over all instances . ETSI/EN/3GPP

- 2G: TS51-010 chapter 12/13

- 3G: TS34-121 Chapter 6,7
- 4G: TS36-521 Chapter 5,6,7
- 5G: TS38-521 Chapter 6,7

SAR Specific absorption rate



Some dedicated specs are:

IEC 62209
IEC 62209-2
IEEE 1528


Questions