

Taiwan 2023

Wireless technologies powering the *Metaverse*

Joerg Koepp
Market Segment & Technology Manager
Rohde & Schwarz

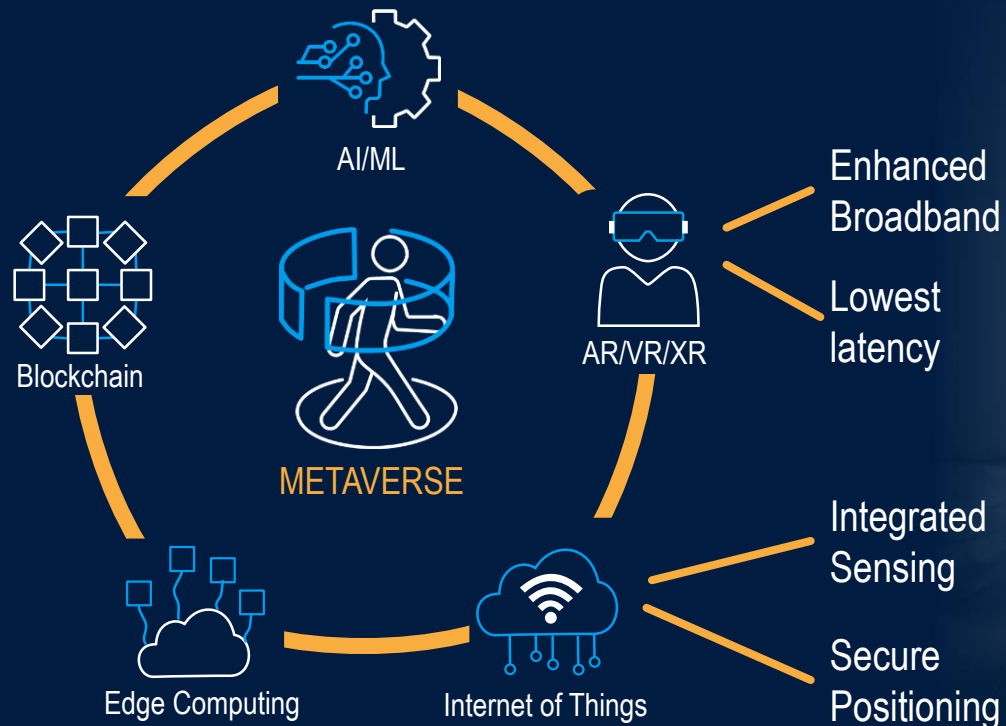
ROHDE & SCHWARZ

Make ideas real



META what? META how?

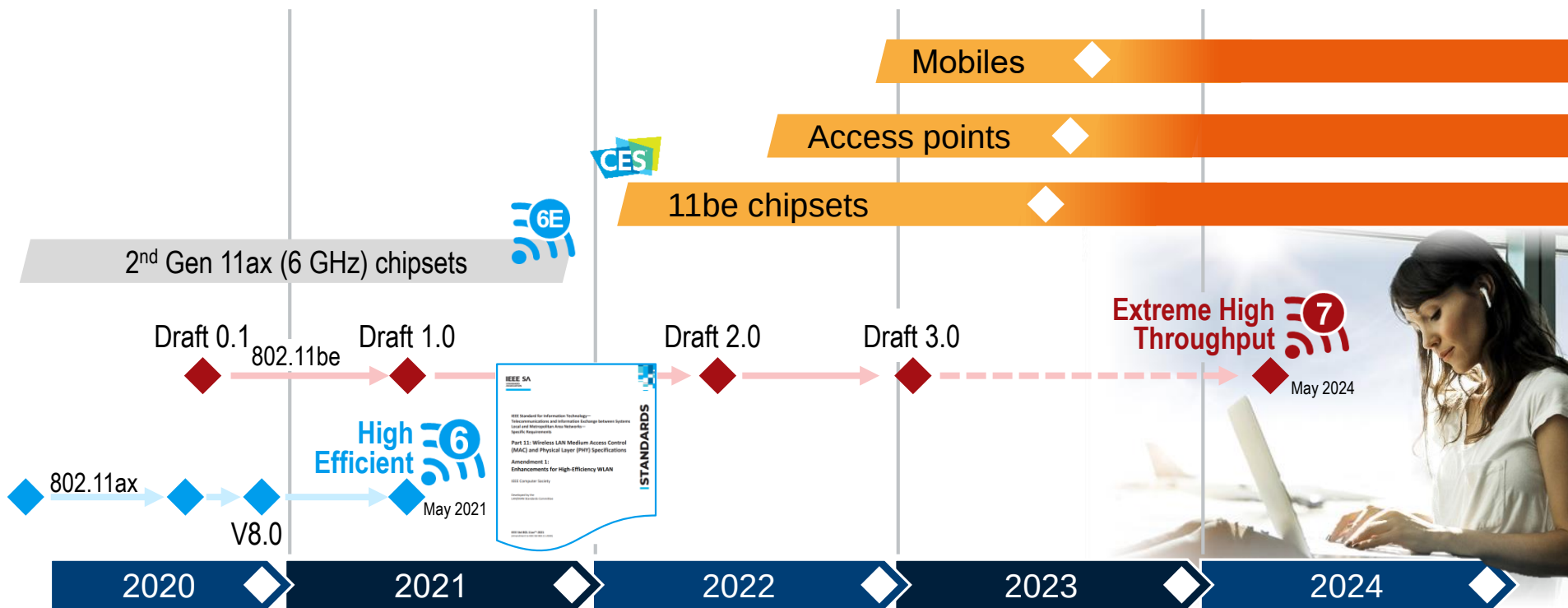
An immersive virtual environment, merging virtual, augmented, and physical reality



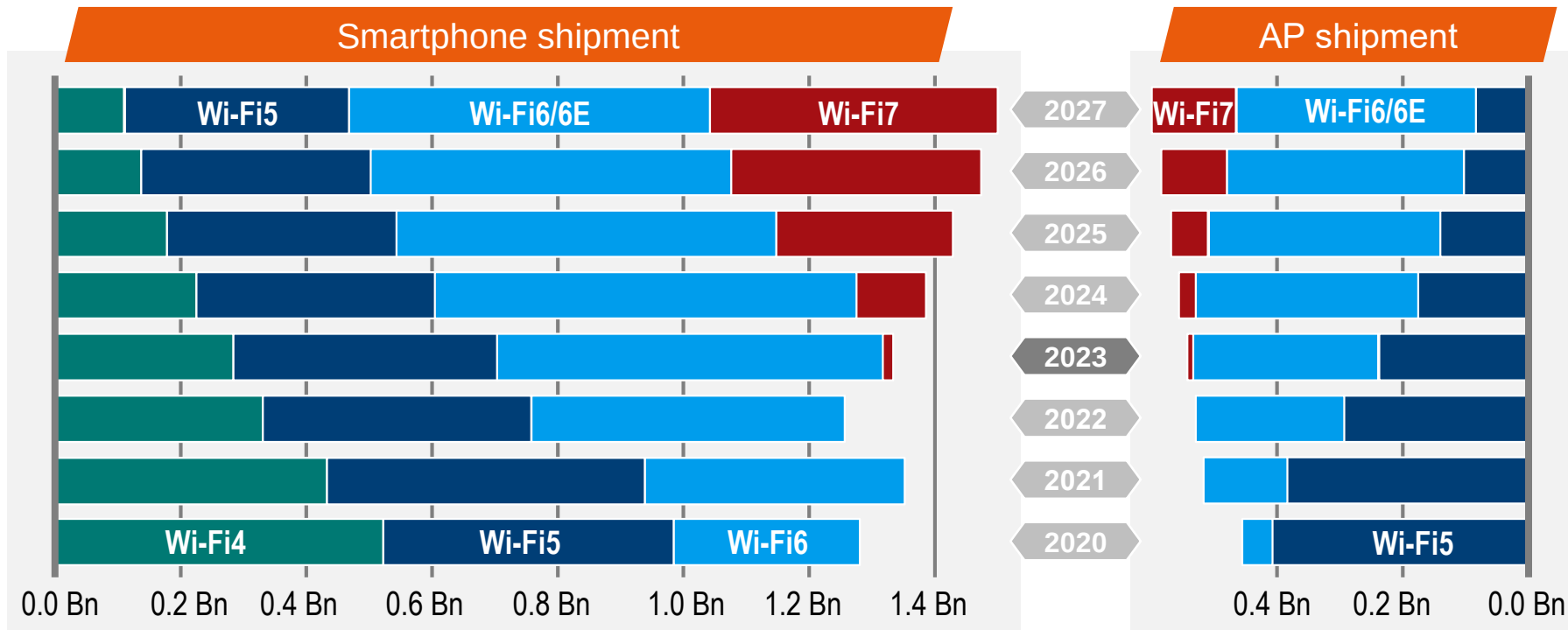
Home is where
Wi-Fi connects
automatically



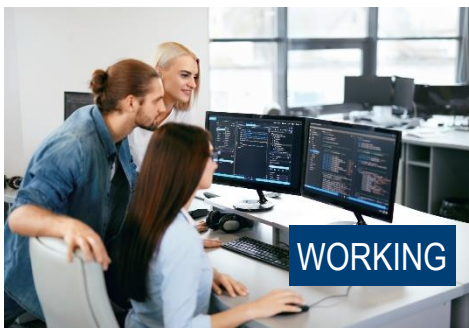
Extreme high throughput WLAN (EHT – IEEE 802.11be – Wi-Fi7) is entering the market with amazing speed



1st mobile Wi-Fi7 devices expected to be released in 2H2023



Source: Techno System Research, 2022 Wireless connectivity market analysis, summary report, June 2022
<https://iotbusinessnews.com/download/2022-TSR-Wireless-Connectivity-Market-Report-Summary.pdf>

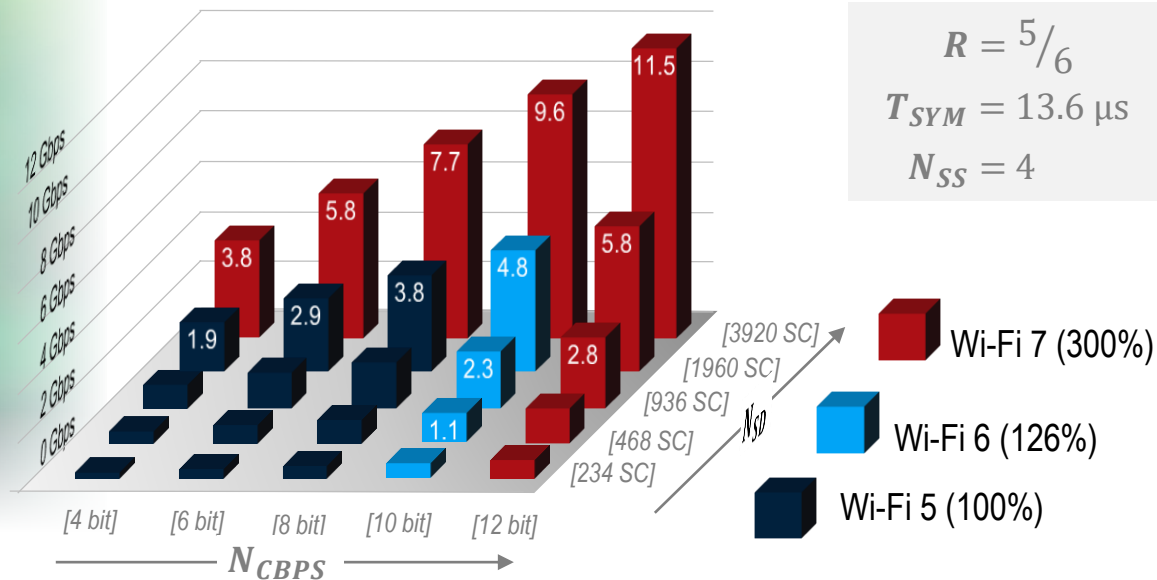


The 7th generation of Wi-Fi for
Extreme High Throughput (EHT) at home, offices and factories

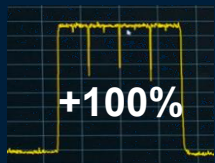
How to achieve extreme high throughput with Wi-Fi 7



$$\text{Max physical data rate} = \underbrace{N_{SD}}_{\substack{\text{\# of data carriers} \\ \text{symbol time}}} \underbrace{\frac{N_{CBPS} \cdot R}{T_{SYM}}}_{\substack{\text{\# modulated bits} \\ \text{code rate}}} \underbrace{N_{SS}}_{\substack{\text{\# spatial streams}}}$$



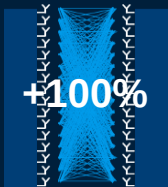
The four cornerstones of IEEE 802.11be to achieve extreme high throughput



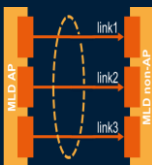
**320 MHz
channel**



**4096QAM
modulation**



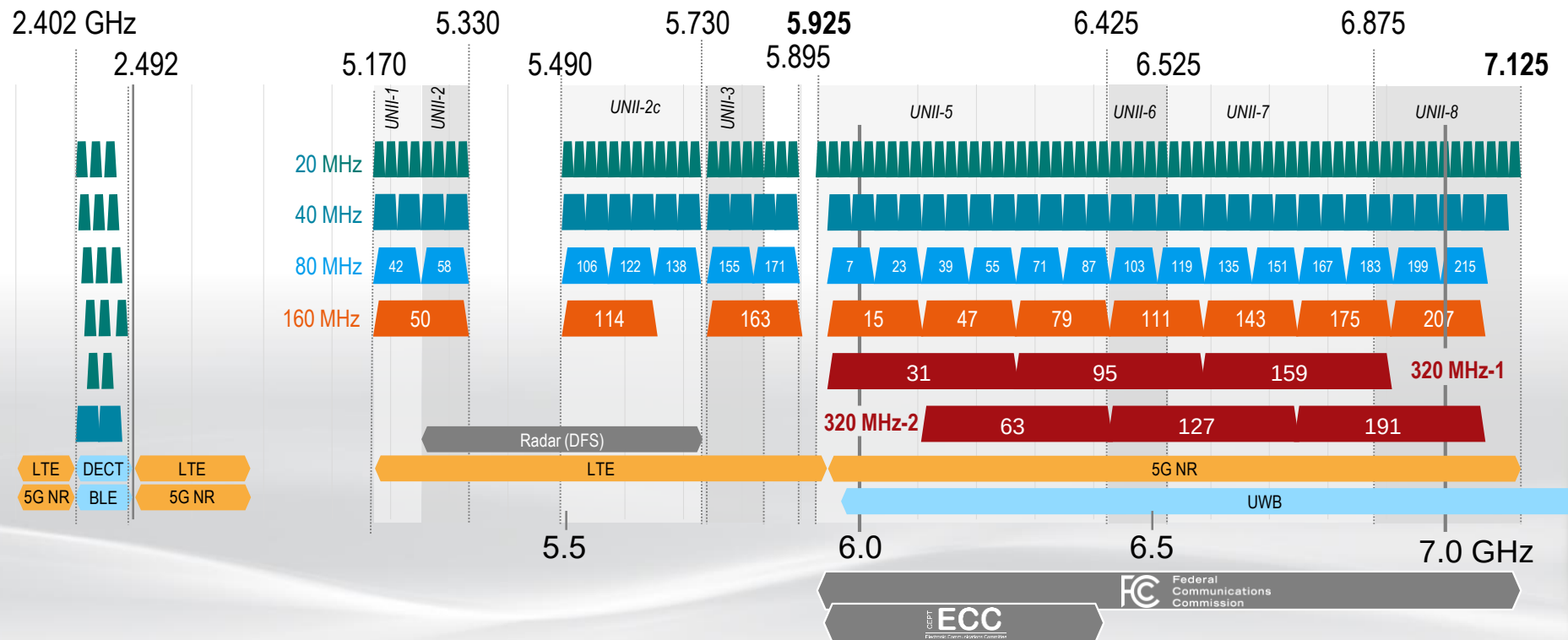
**16x16
MIMO**



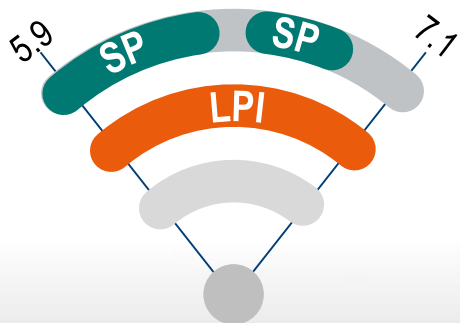
**Multi-link
operation**

*Ready for the
next generation*

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



6 GHz band regulation in a nutshell, based on FCC and CEPT



Standard Power
AP: EIRP: 36 dBm (AFC)
UE: EIRP: 30 dBm

Low Power Indoor
AP: EIRP: 30 dBm
UE: EIRP: 24 dBm

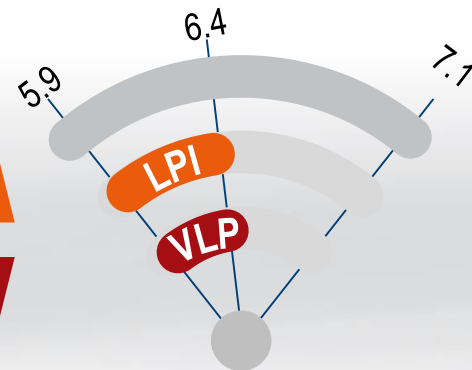
Very Low Power



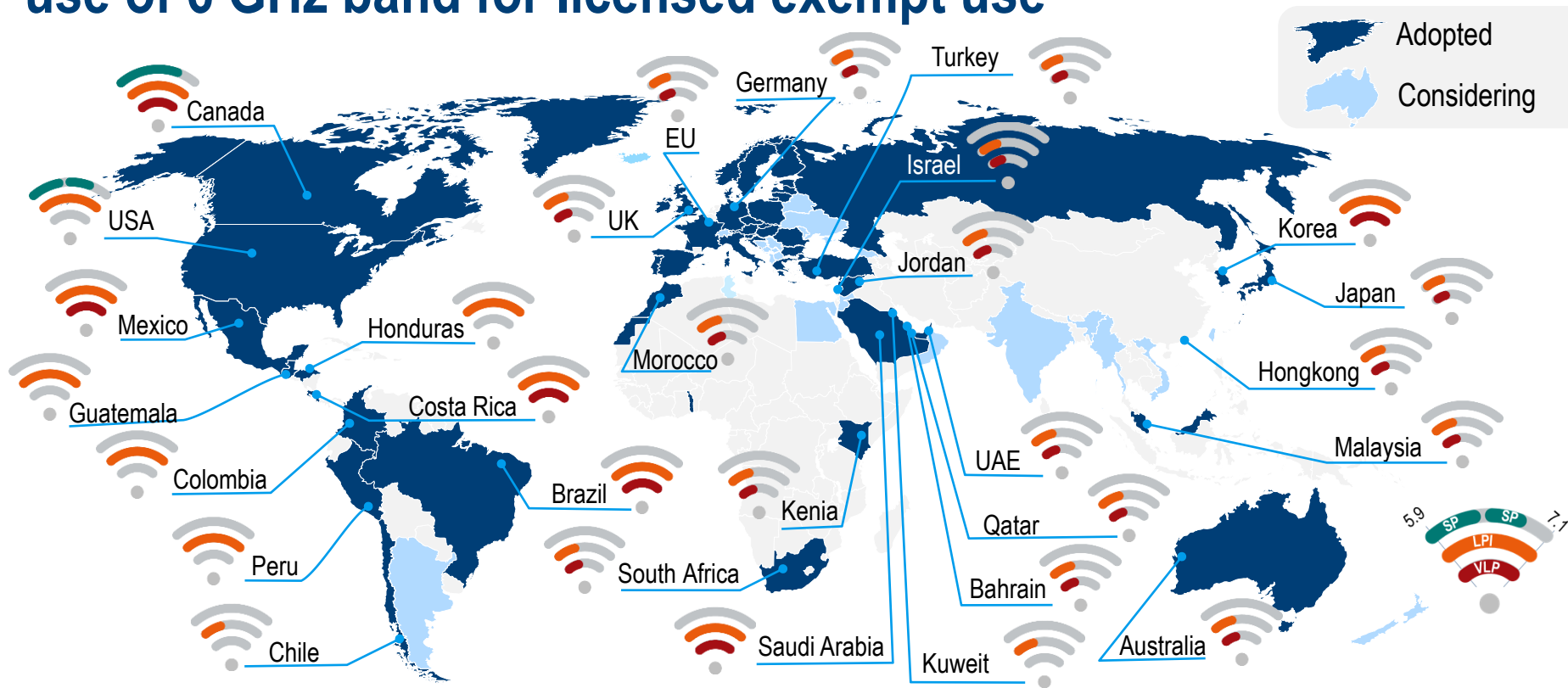
Standard Power

Low Power Indoor
AP: EIRP: 23 dBm
UE: EIRP: 23 dBm

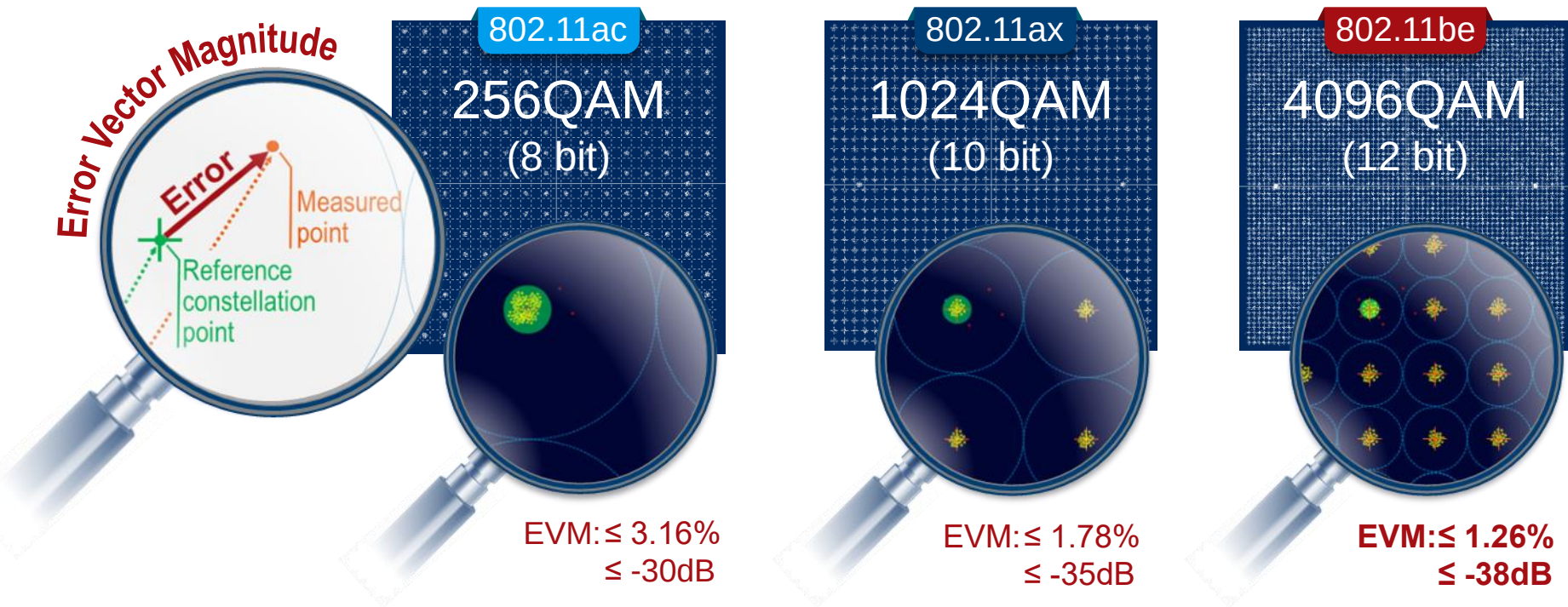
Very Low Power
AP: EIRP: 14 dBm
UE: EIRP: 14 dBm



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

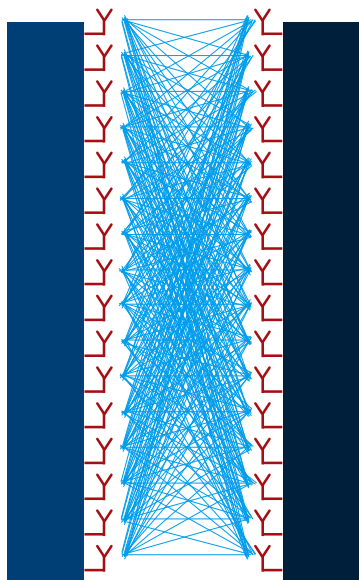


Wi-Fi7 pushes RF performance requirements and test equipment quality to the next level

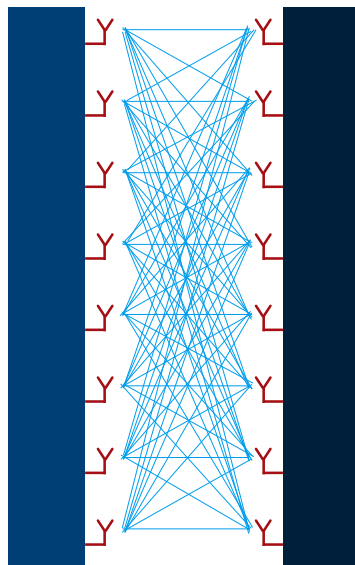


MIMO accounts for almost 50% of the Wi-Fi shipments: 2x2, 3x3 and 4x4 stay mainstream – 8x8 for “geeks”

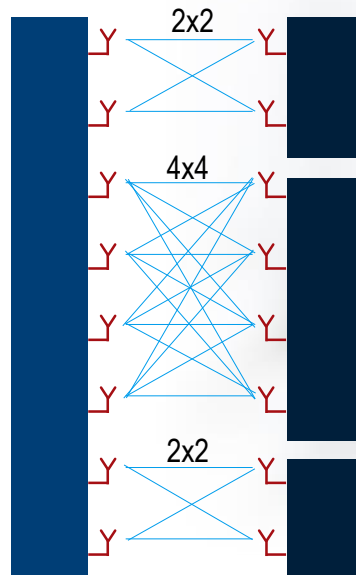
802.11be vision
(max $N_{SS} = 16$)



802.11be Draft 0.3
(max NSS = 8)



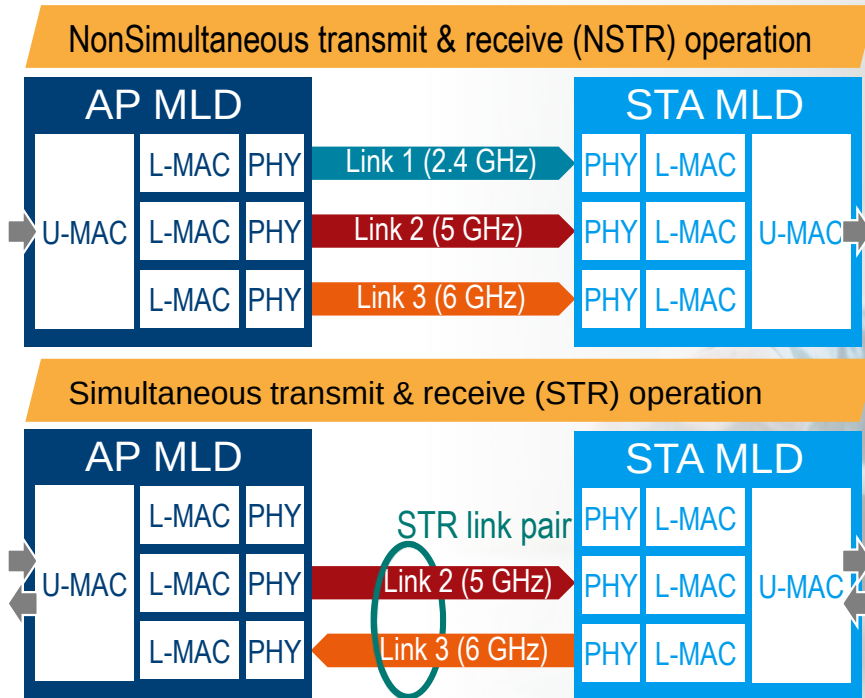
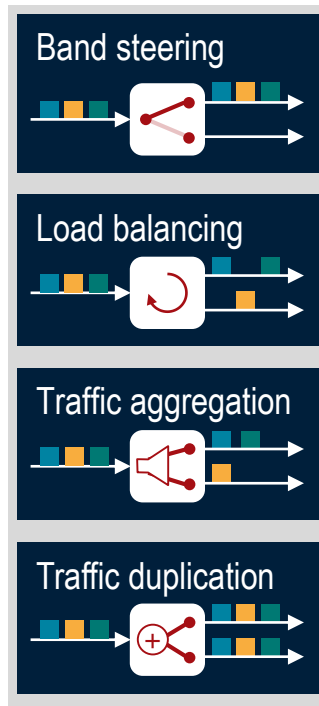
SU-MIMO
 ≤ 8 streams in total



MU-MIMO
 ≤ 8 users per RU (≥ 248)
 ≤ 4 streams per user
 ≤ 8 streams in total



Further improve throughput, latency and efficiency with introducing **multi-link operation (MLO)**



Receiver and transmitter requirement based on IEEE 802.11be

Spectral flatness

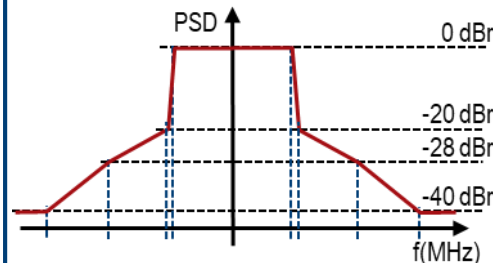
Center freq. leakage

Min. input sensitivity

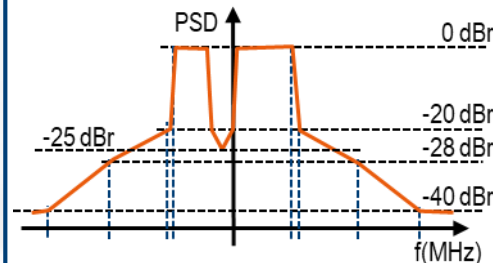
Channel rejection

Maximum input level

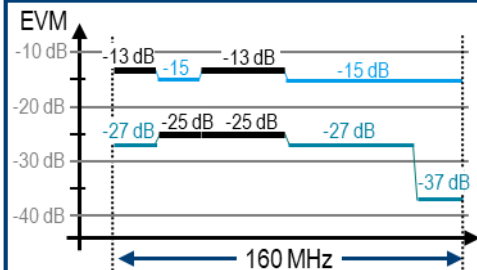
320 MHz spectrum mask



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	4096-QAM	5/6	-38 dB	-38 dB	-38 dB

Absolut power accuracy

Relative power accuracy

RSSI meas. accuracy

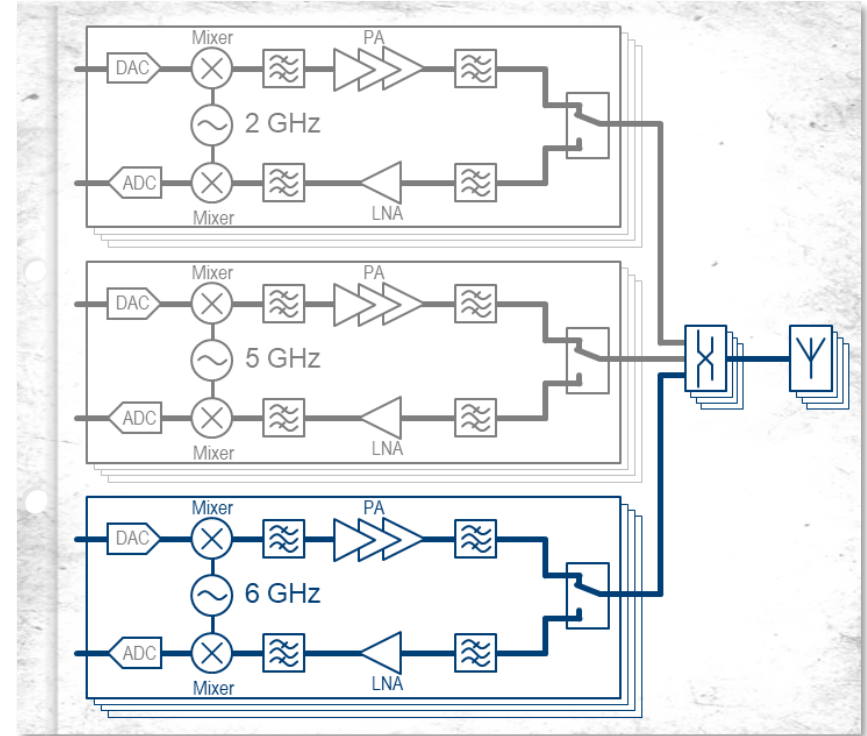
Carrier frequency offset

Timing drift

High demand for efficient and easy-to-use multi channel testing

Rising demand for multi channel testing

- ◆ 2x2, 4x4 MIMO, ...
- ◆ Dualband, Tripleband, Quadband ...
- ◆ Multi-link operation (NSTR, STR)
- ◆ Multi-technology (Wi-Fi, Bluetooth, Thread)



Wi-Fi test solutions for today and tomorrow



Conformance



R&S®TS8997

RF performance



R&S®CMW500/270



R&S®CMP180

Production



R&S®TS7124



R&S®DST200



R&S®CMW100



R&S®CMP180



Make ideas real



R&S®ZNA



R&S®FSW



R&S®SMM100A



R&S®VSE

RF design and compliance



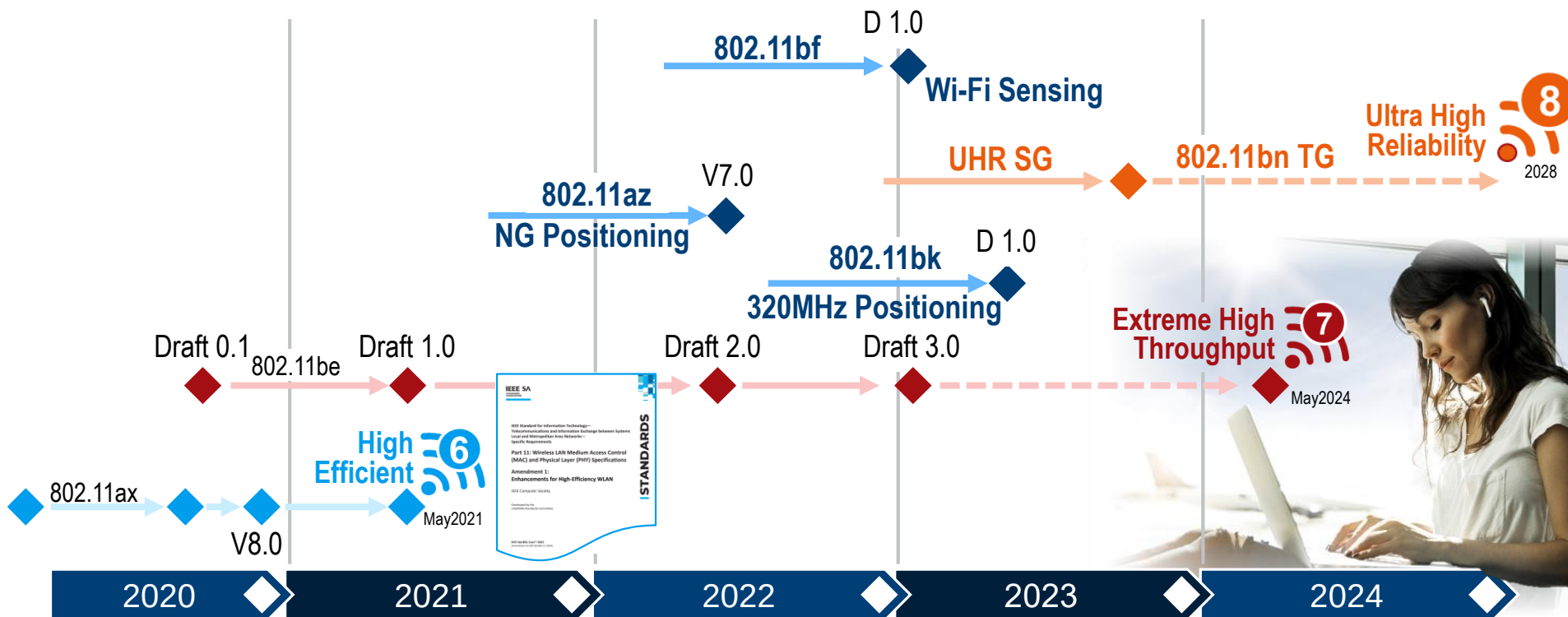
R&S®NGU



R&S®RTP

Embedded design & power

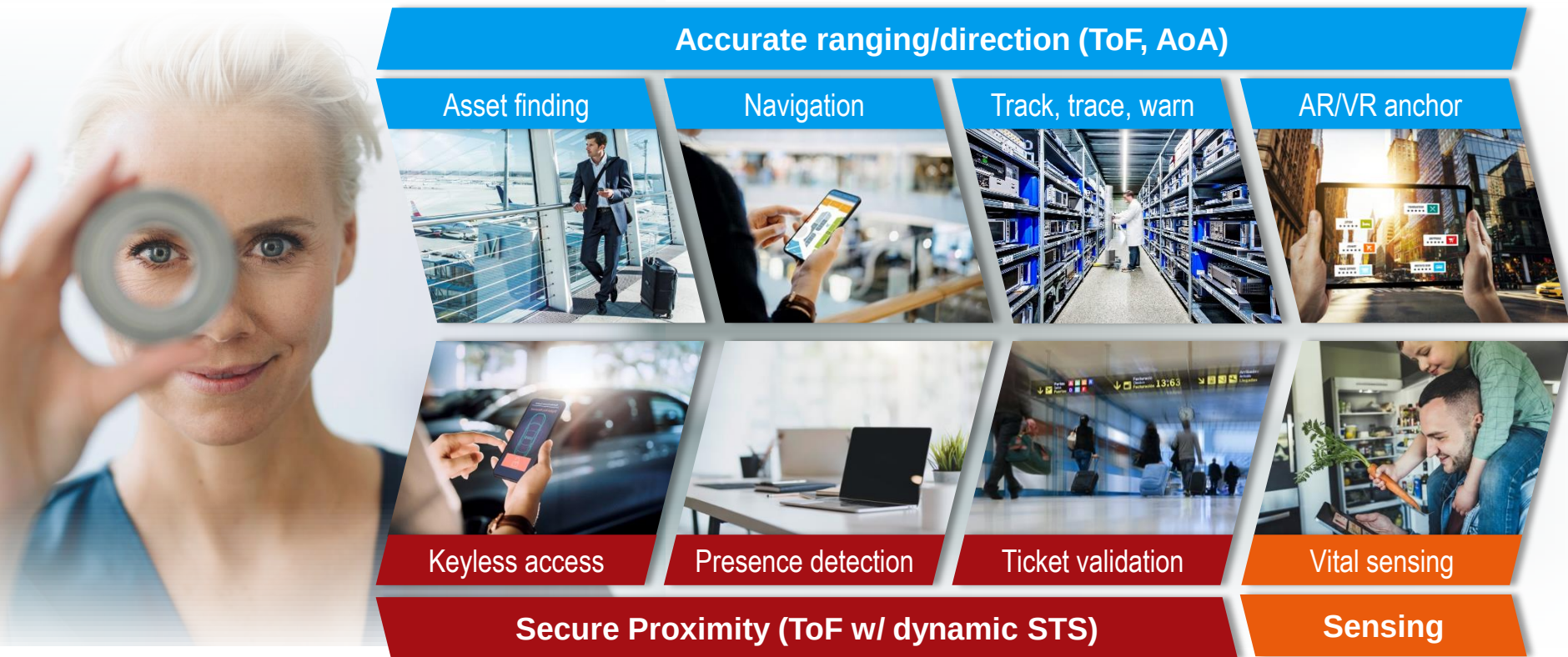
What else and what next in Wi-Fi?



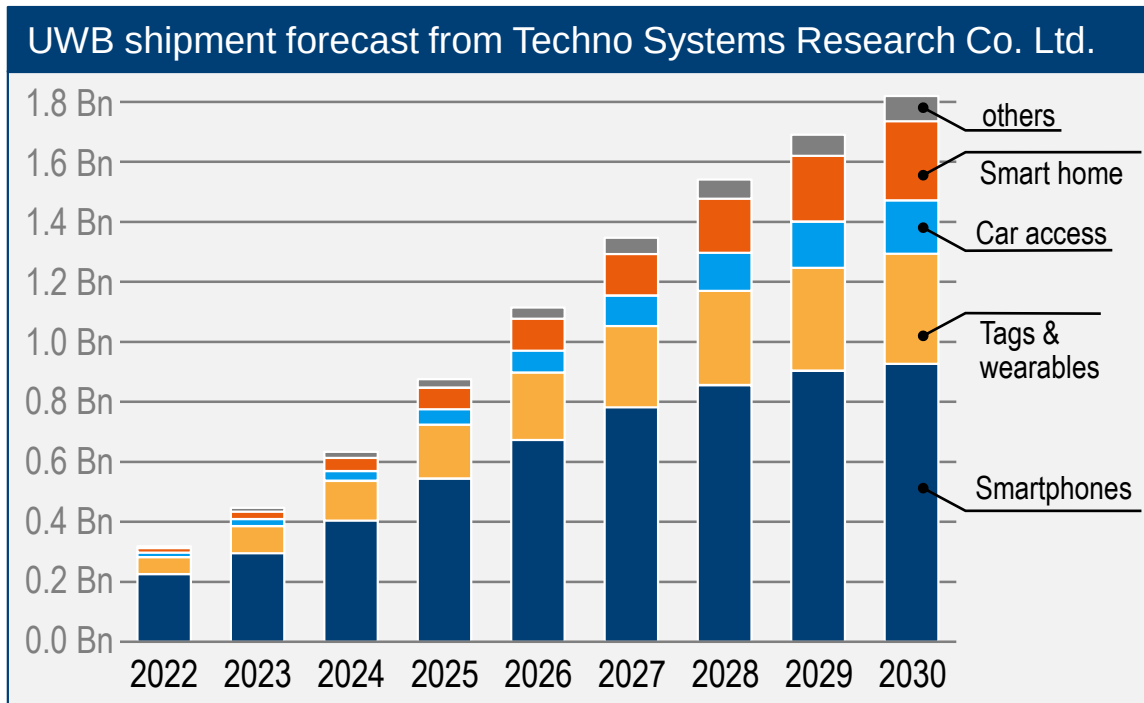
UWB because
distance & location
matter



More and more applications relying on UWB capabilities



Global forecast: More than 300 M UWB units shipped in 2022 and more than 1.8 Bn units shipped by 2030.

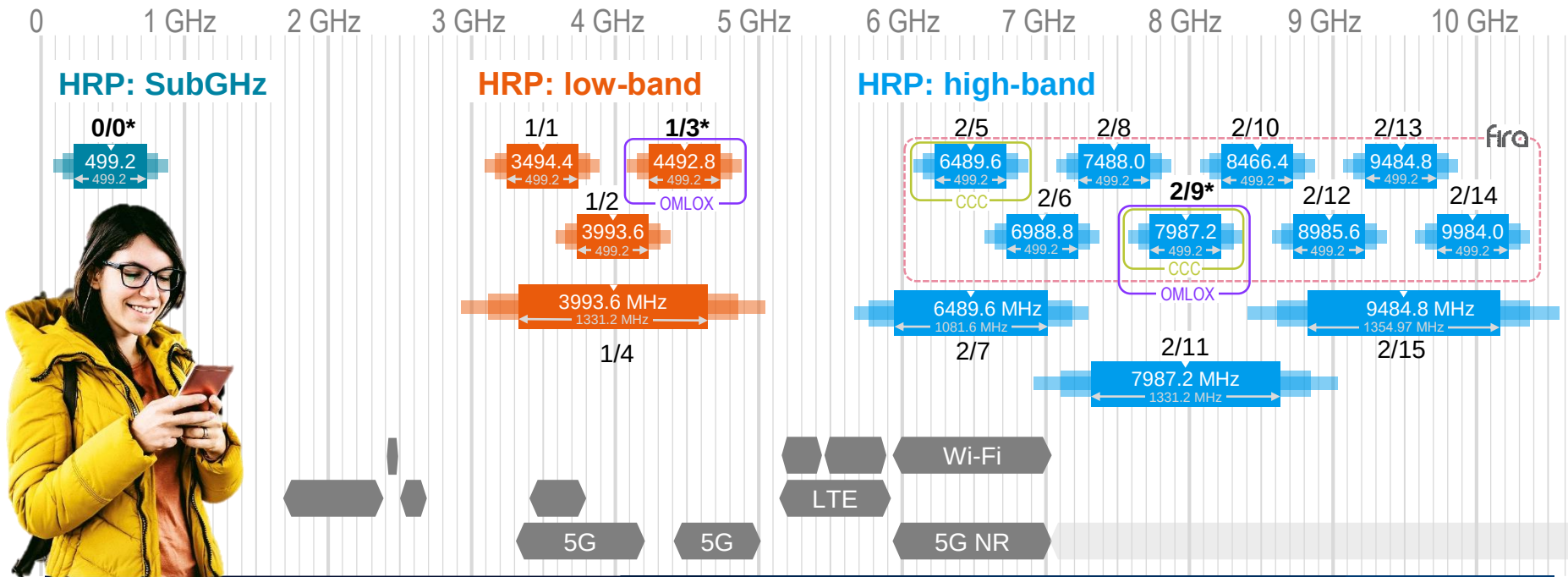


<https://www.eetasia.com/global-uw-b-market-shipment-to-reach-317-million-units-in-2022/>



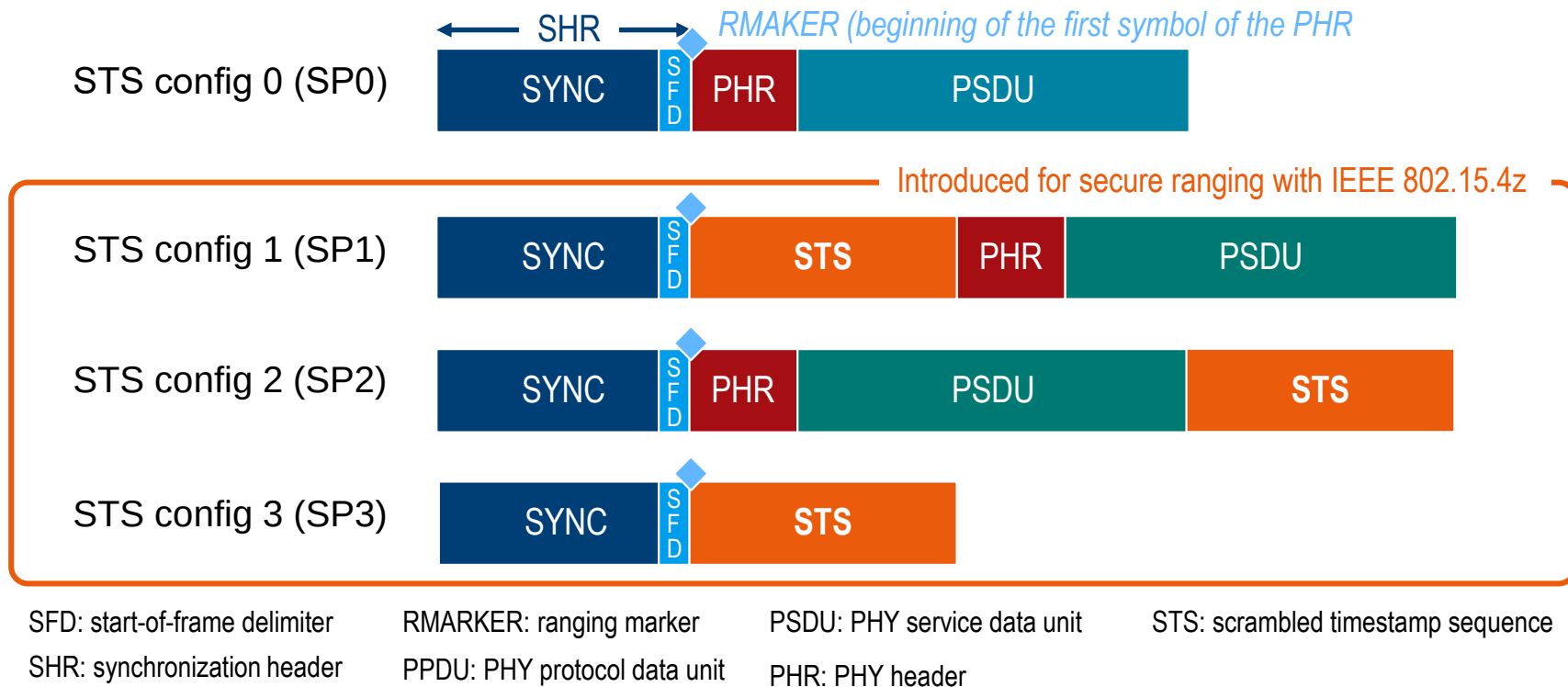
Impulse radio ultra-wideband (IR-UWB) standardization by IEEE driven by a strong ecosystem



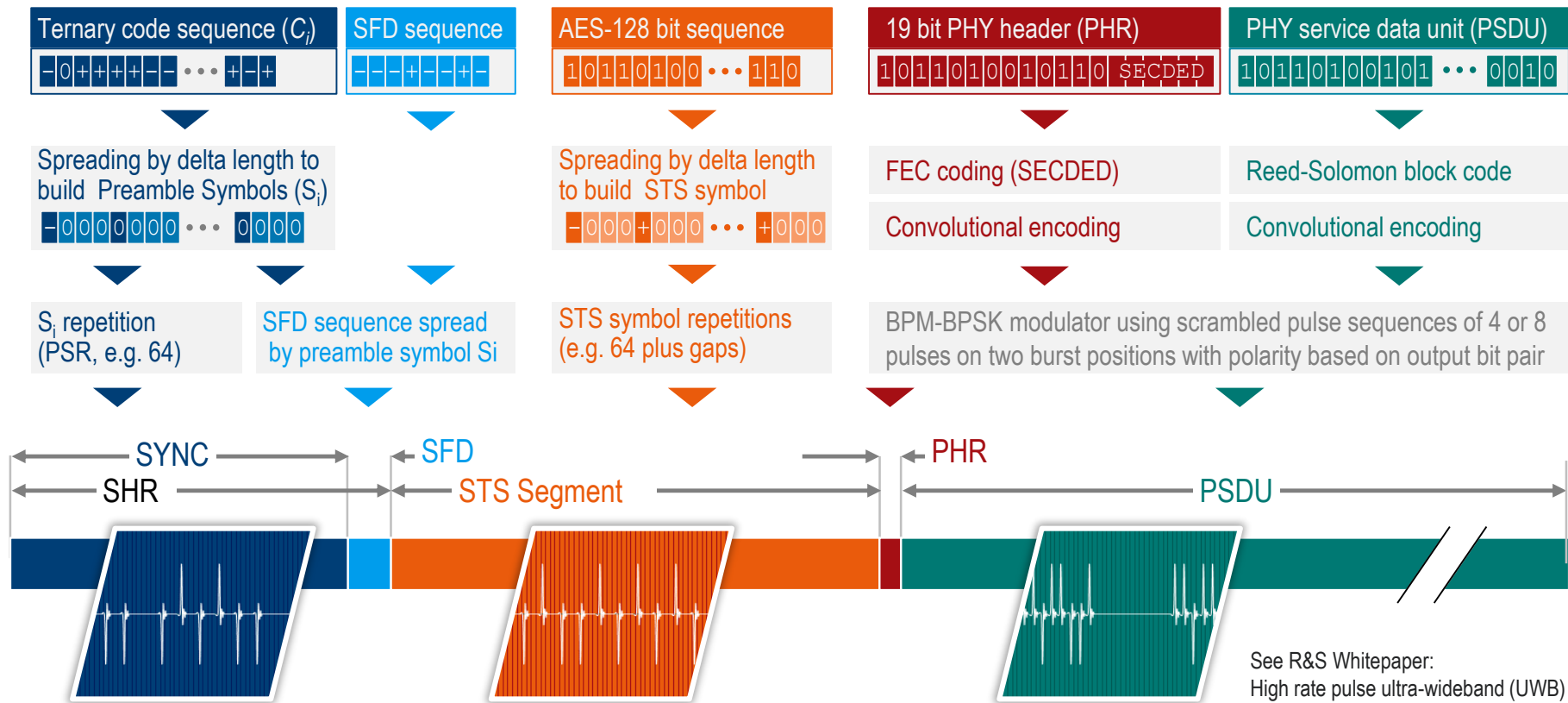


UWB channel allocation based on IEEE 802.15.4z-2020 (HRP)

Secure ranging using a scrambled timestamp sequence (STS) generated by AES-128 based deterministic random bit generator



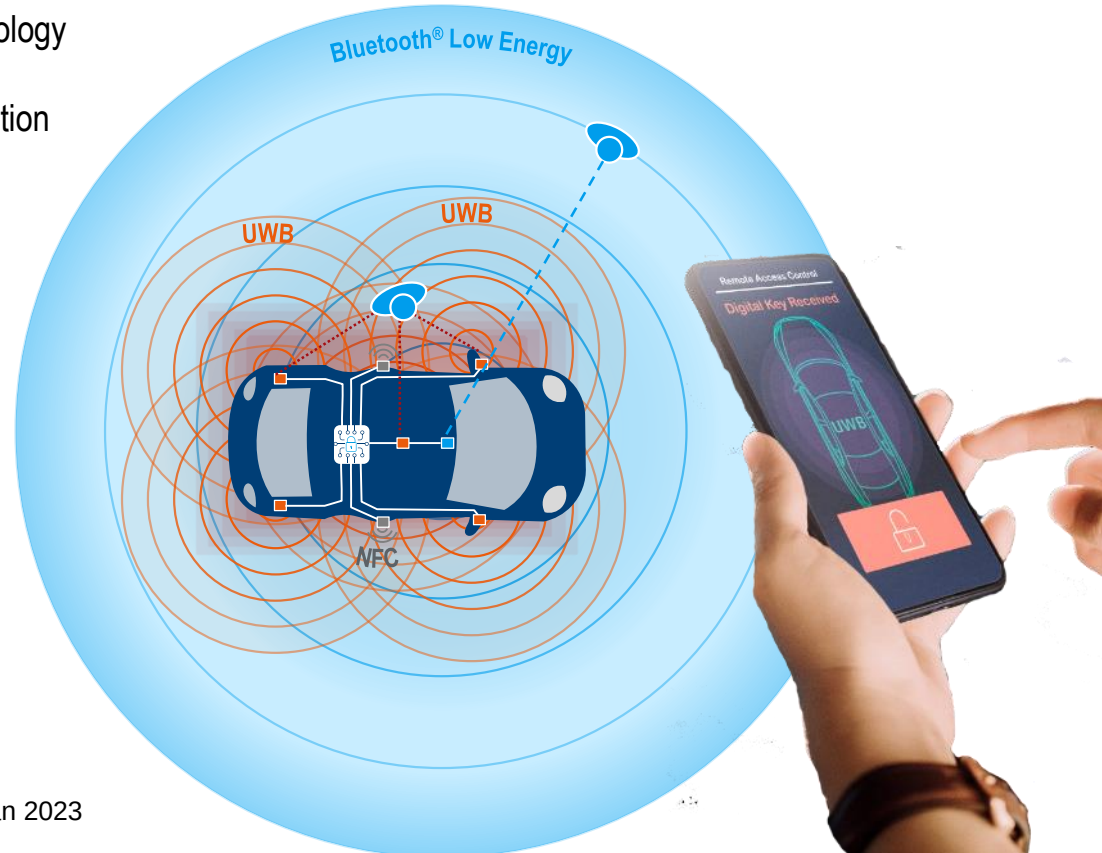
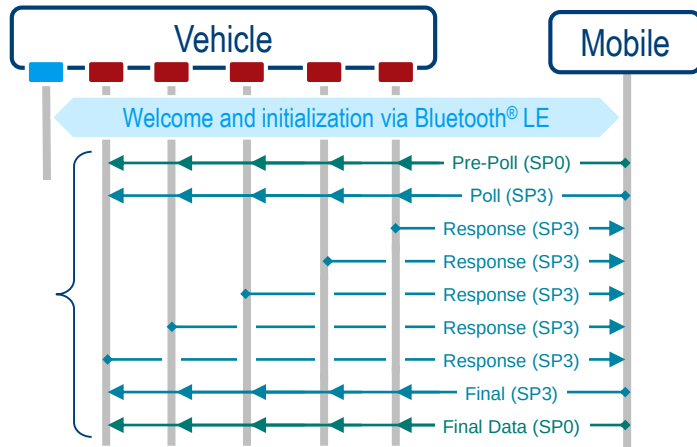
UWB packet structure in a nutshell (HRP-ERDEV: HPRF SP2)



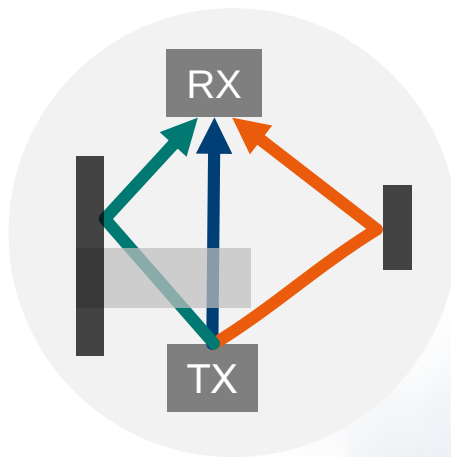
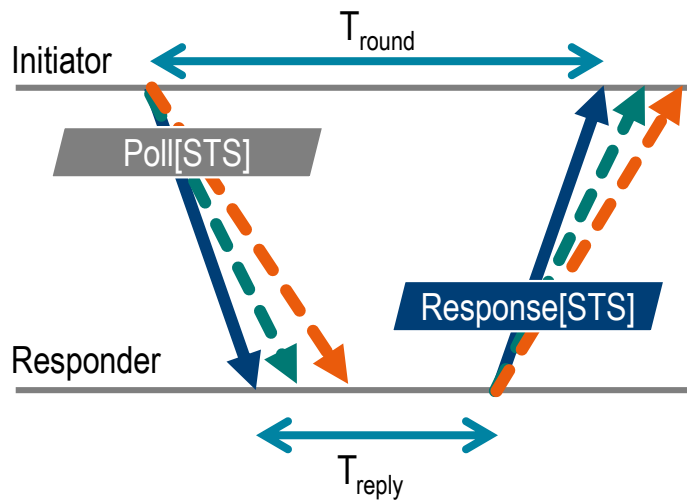
See R&S Whitepaper:
High rate pulse ultra-wideband (UWB)
physical layer test and certification

CCC Digital Key Release 3.0 adds hands-free, location-aware keyless access and location-aware features

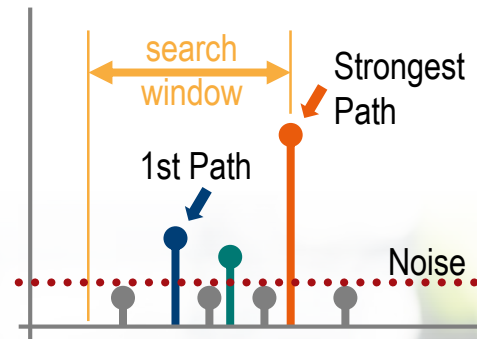
The CCC has adopted the UWB secure ranging technology based on High Rate Pulse repetition frequency (HRP) standardized in IEEE 802.15.4z (DS-TWR) in combination with standard Bluetooth® Low Energy connectivity.



Time of flight measurement in a real multi-path environment



Channel Impulse Response CIR(t)



In order to find the first tap (LoS) the receiver performs cross-correlation between received signal and the known STS sequence.



UWB physical layer test requirements

Standard conformance

- Operating frequency bands
- Channel assignments
- Baseband impulse response
- Transmit PSD mask
- Chip rate clock and chip carrier alignment

IEEE 802.15.4-2020
IEEE 802.15.4z-2020

Regulatory compliance

- Operating bandwidth
- Mean power spectral density
- Maximum value of peak power
- Other emissions
- Receiver spurious emissions
- Detect and avoid (DAA)
- Low duty cycle (LDC)

FCC part 15
§15.519, §15.517
ETSI EN 301 489-33 ,
EN 302 065, EN 303 883

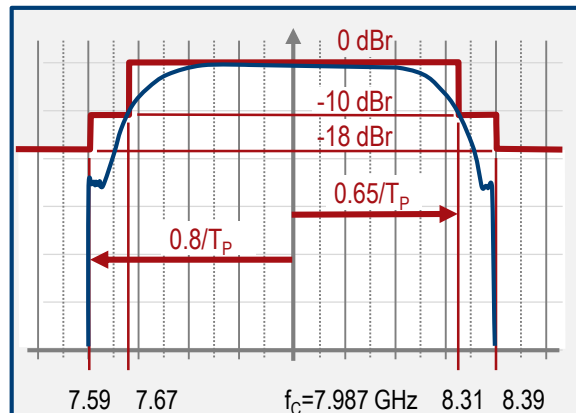
Interoperability certification

- Packet format
- Power spectral density mask
- Frequency tolerance, timing
- Baseband Impulse response
- NRMSE
- Packet reception sensitivity
- Dirty packet tests
- First path dynamic range

FiRa Consortium
UWB PHY Conformance
CCC Consortium
UWB PHY Test Suite

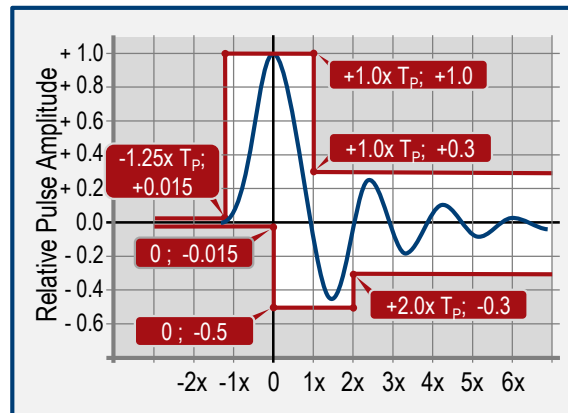
Specific UWB measurements (IEEE, FiRa)

Transmit Power Spectrum Density



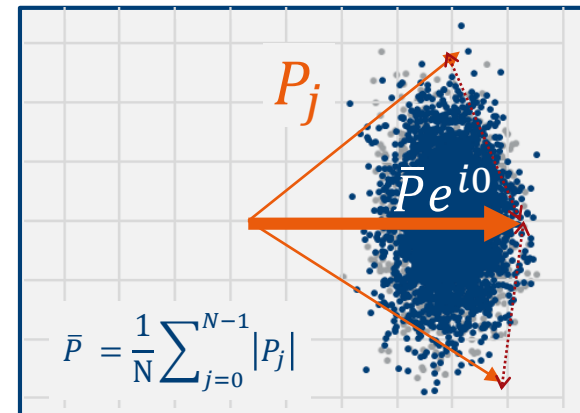
The transmitted spectrum shall be less than -10 dB relative to the maximum spectral density of the signal for $0.65/T_P < |f - f_c| < 0.8/T_P$ and -18 dB for $|f - f_c| > 0.8/T_P$.

Impulse response



The pulse shape should be constrained by the time domain mask where the peak magnitude of the pulse is scaled to a value of one, and the time unit is pulse duration T_P .

Transmitter quality (NRMSE)



The transmit signal quality should be measured using a normalized root mean square error (NRMSE) metric with the mean pulse amplitude $\bar{P}$

$$NRMSE = \sqrt{\frac{1}{N} \sum_{j=0}^{N-1} \frac{|P_j - \bar{P} e^{i0}|^2}{\bar{P}^2}}$$

UWB test and measurement solutions for all phases of the product lifecycle from the experts



Development



Integration



Conformance



Production



R&S®ATS800R



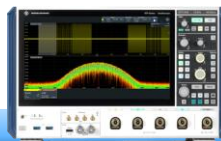
R&S®CMQ200 HS



R&S®CMP200



UWB PHY Test Suite



R&S®RTP+VSE



R&S®SMM100



R&S®FSW26



R&S®TS7124



Novel application requirements drive UWB standardization (802.15.4ab: NG-UWB) and related global regulation

Secure ranging



Vital sensing



Body worn devices



New frequencies (10.7-12.8 GHz), overlapping channels, wider channels (1.5 GHz)

New pulse shapes/masks, Narrowband (OQPSK @ 5GHz) assisted UWB

Interference handling in a more crowded spectrum environment (Wi-Fi, 5G/6G)

New power limits (indoor, fixed outdoor, body worn, vehicular)

The new playground of integrated sensing



Can see through
material/housing



Privacy protection
no pictures, no video



Works also in dark or
low-light environments



Able to detect fine moves
or even heart beats

TEST. MEASURE. INNOVATE.

**THANK YOU
VERY MUCH**

ROHDE & SCHWARZ

Make ideas real

