

# Welcome to our 6G Tech Talk

"Is 6G getting an additional sense?"

## JOINT COMMUNICATION AND SENSING

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Technology Manager



# THE FUTURE



# JOINT COMMUNICATION AND SENSING

## POSSIBLE VERTICAL APPLICATIONS – OUTDOOR/INDOOR

► In terms of vertical applications there are several fields, like:

- Sensing as a Service
- Remote Sensing and Geoscience
- Vehicle-to-Everything (V2X)

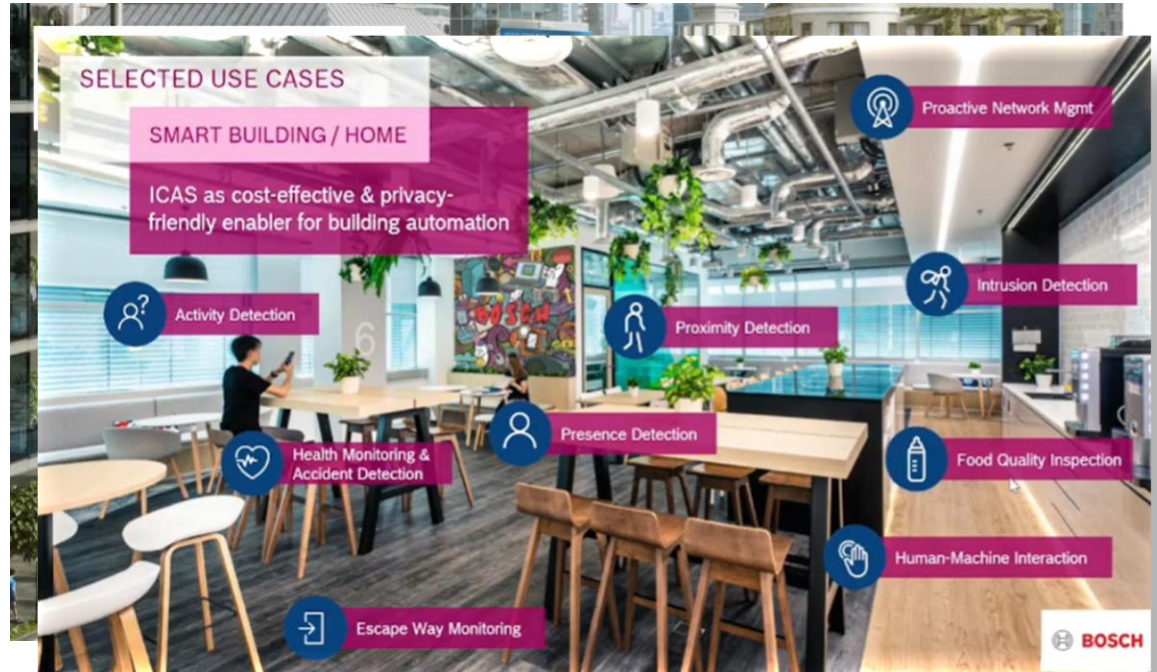


# JOINT COMMUNICATION AND SENSING

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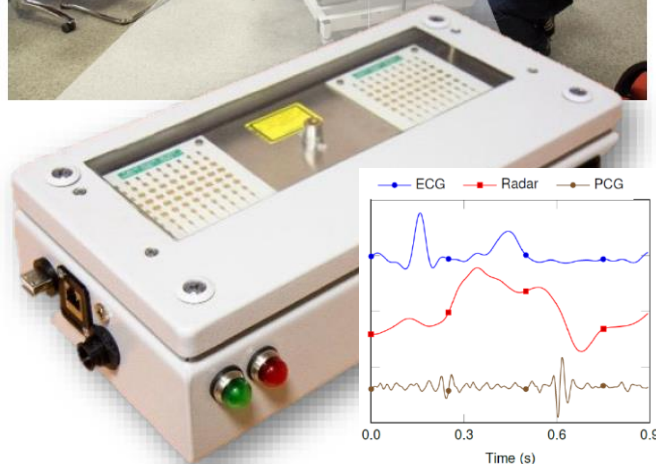
► In terms of vertical applications there are several fields, like:

- Sensing as a Service
- Remote Sensing and Geoscience
- Vehicle-to-Everything (V2X)
- Smart Home and building automation
- Smart Manufacturing and IIoT



# JOINT COMMUNICATION AND SENSING POSSIBLE VERTICAL APPLICATIONS - INDOOR

- ▶ eHealth
- ▶ Touch-free monitoring
  - Through blankets and cloths
  - Comfortable continuous long term real time monitoring
- ▶ Diagnostics
  - Respiration
  - Heart activity
  - Pulse wave velocity



# THE EVOLUTION OF THE HUMAN MACHINE INTERFACE FOR CELLULAR DEVICES

Face



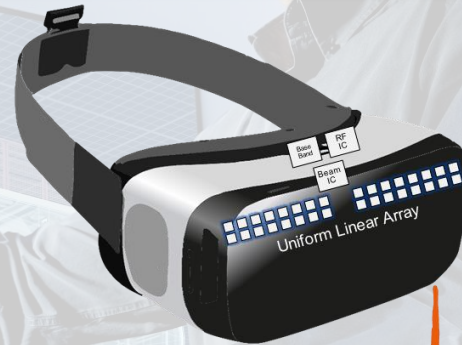
Gesture

Voice

Touch

# WIDER BANDWIDTHS ENABLE HIGHER RESOLUTION

- ▶ Use of phased arrays antennas (e.g. linear arrays) to “monitor” the space in front of the person, that is using the AR/VR headset, for motion of one or both arms, hands & fingers
- ▶ Required range  $\leq 1.5$  m, but what about resolution?
- ▶ Higher resolution required to detect particular movements → wider bandwidths required → move to higher frequency, i.e. sub-THz (e.g. **140 GHz** or 300 GHz)

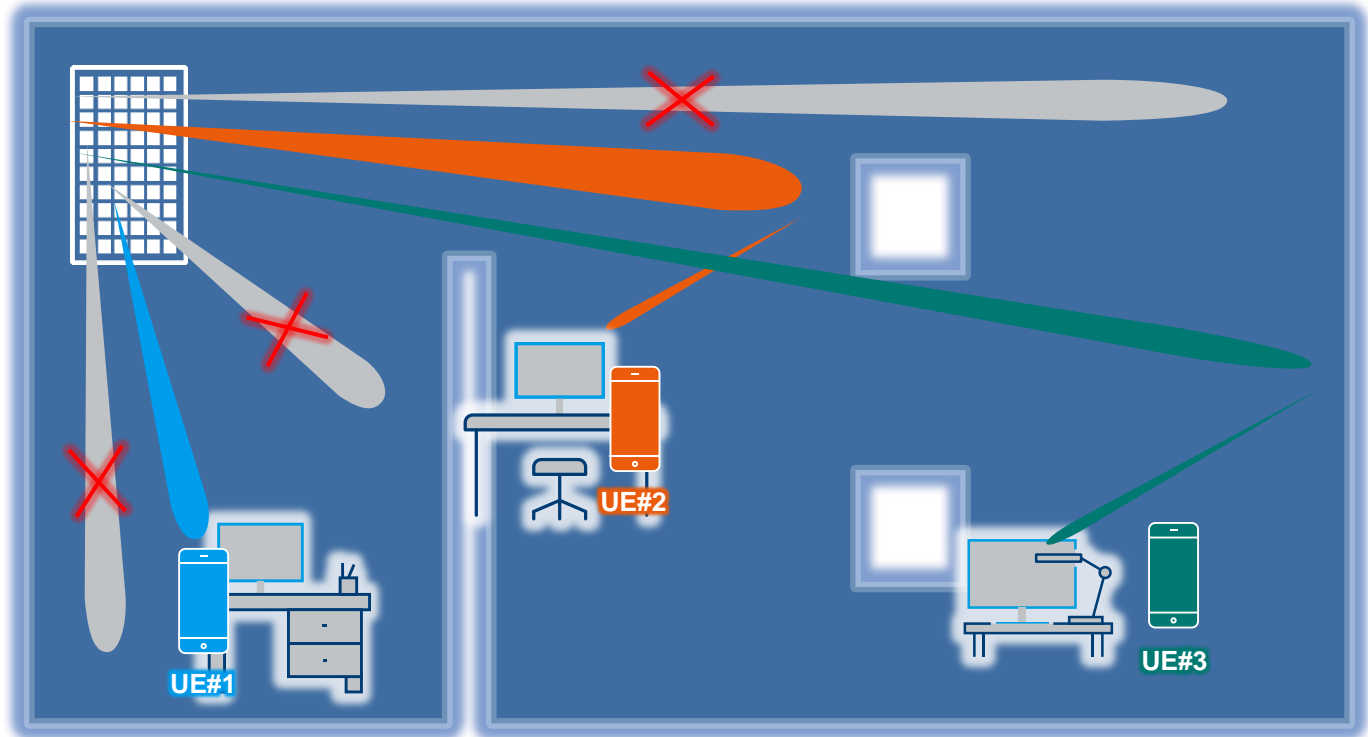




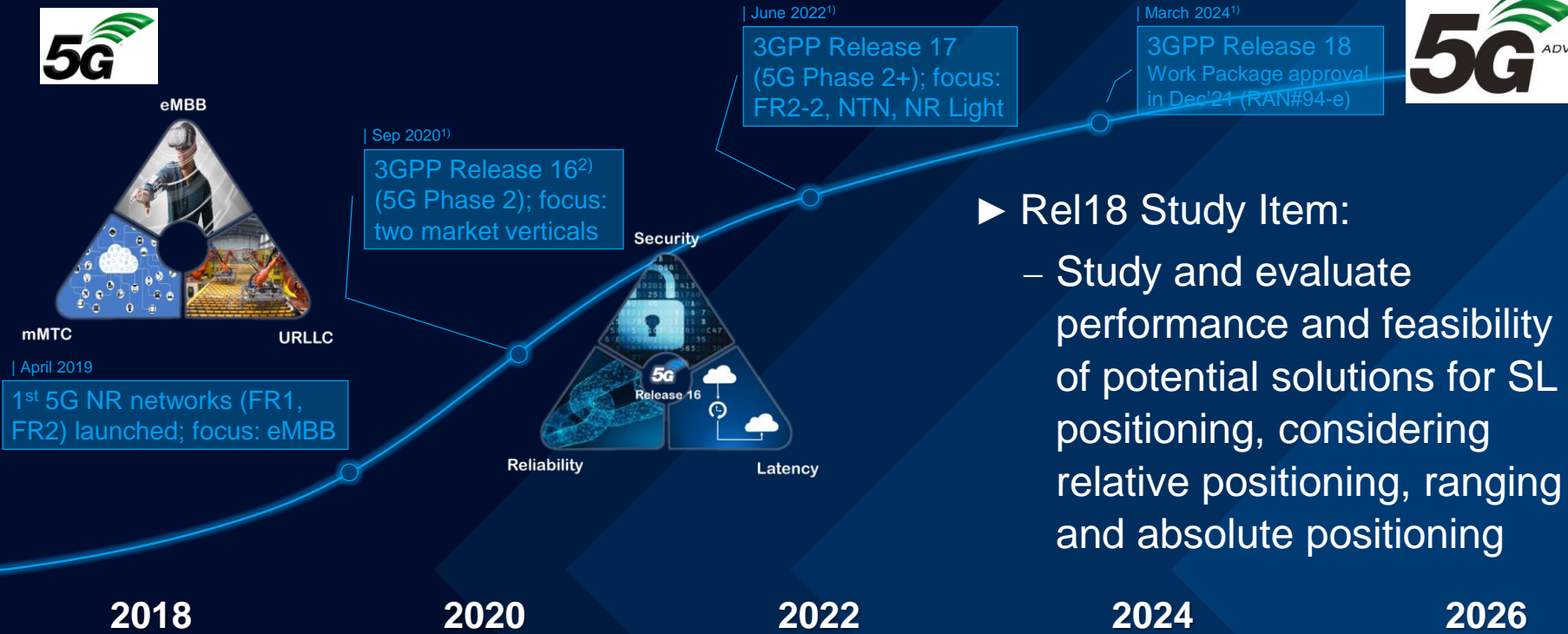
# JOINT COMMUNICATION AND SENSING

## ONE MORE IMPORTANT MOTIVATION

- Sensing-assisted communication by utilizing sensed information to aid beam management / alignment, CSI acquisition, medium-aware links, interference mitigation etc.



# 5G NR TECHNOLOGY EVOLUTION – THE NEXT PHASE

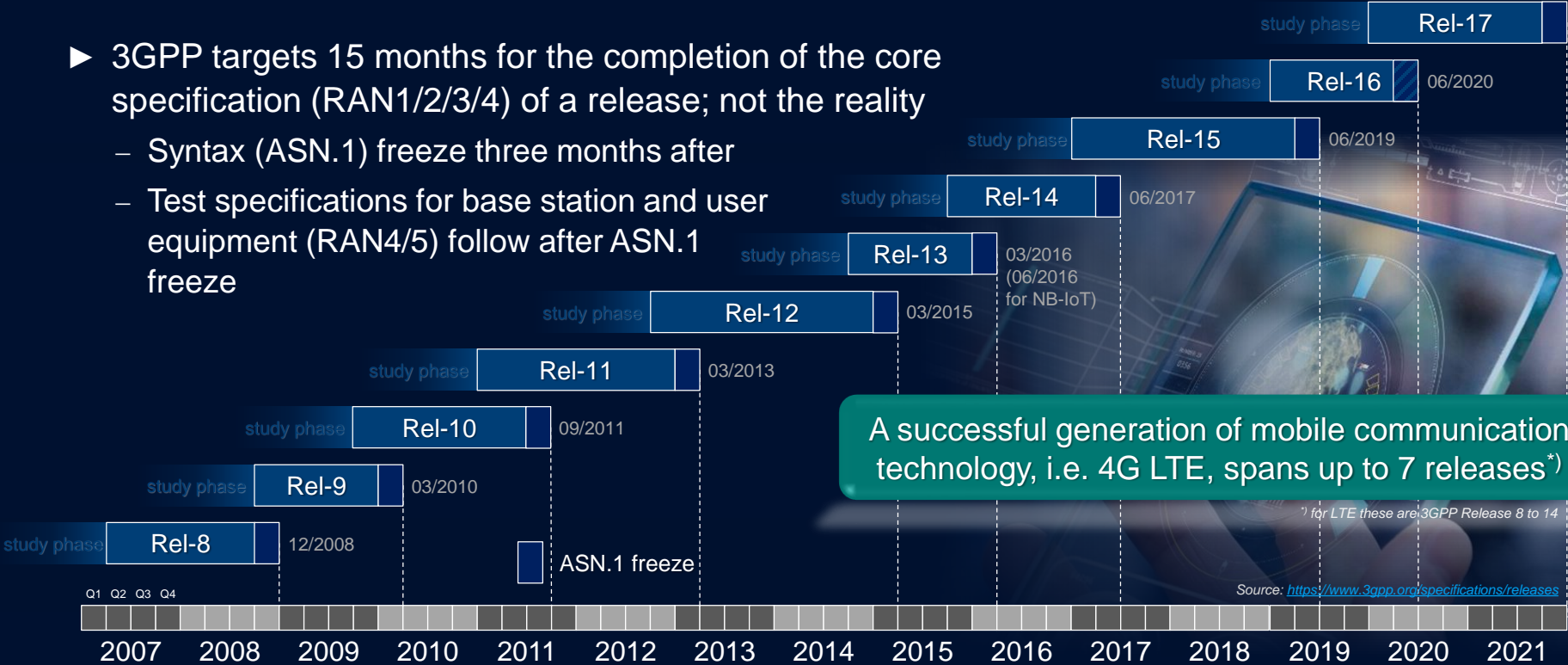


- ▶ Rel18 Study Item:
  - Study and evaluate performance and feasibility of potential solutions for SL positioning, considering relative positioning, ranging and absolute positioning

<sup>1)</sup> Marks ASN.1 freeze, Stage 3 protocol freeze 3 months earlier <sup>2)</sup> Rel-16 includes additional features: positioning, power saving, NR-U, MIMO enhancements, DCA enhancements  
eMBB: enhanced Mobile Broadband  
URLLC: Ultra-Reliable Low Latency Communication  
mMTC: massive Machine Type Communication

# TIMELINE OF RECENT AND ACTUAL 3GPP RELEASES

- ▶ 3GPP targets 15 months for the completion of the core specification (RAN1/2/3/4) of a release; not the reality
  - Syntax (ASN.1) freeze three months after
  - Test specifications for base station and user equipment (RAN4/5) follow after ASN.1 freeze



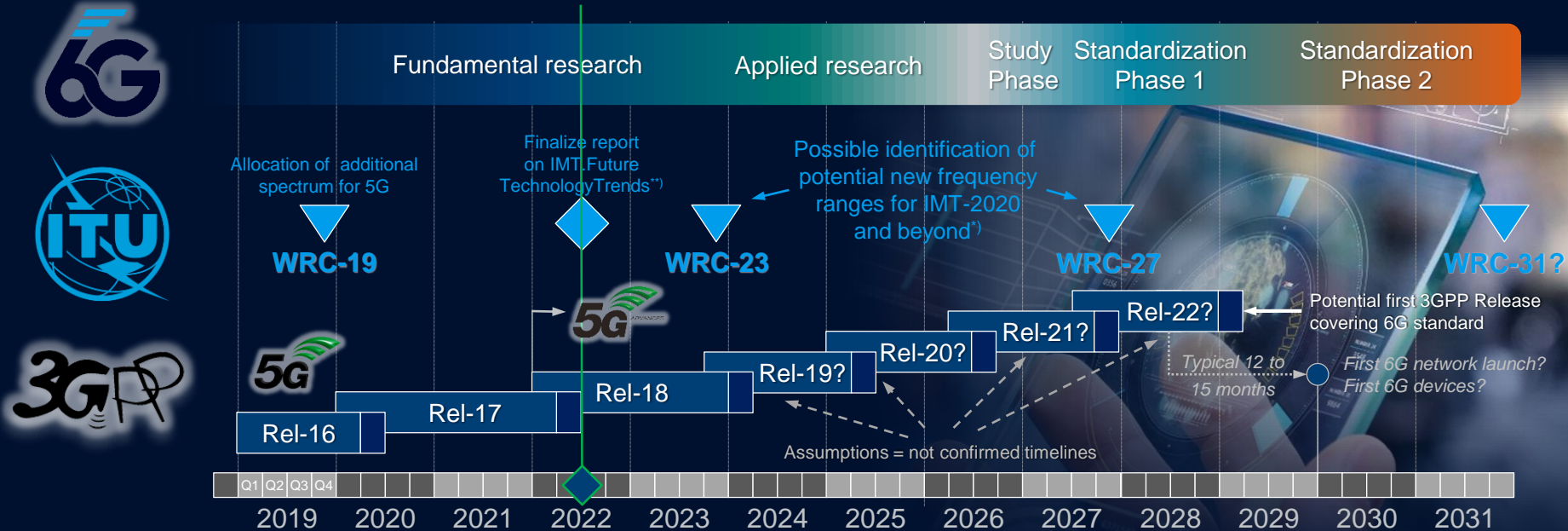
A successful generation of mobile communication technology, i.e. 4G LTE, spans up to 7 releases\*)

\*) for LTE these are 3GPP Release 8 to 14

Source: <https://www.3gpp.org/specifications/releases>

# FUTURE STANDARDIZATION AND REGULATORY ROADMAP

You are here



<sup>\*)</sup> IMT-2020 systems are called 5G

<sup>\*\*)</sup> The ITU has already started a new technology trend report to prepare the work on "IMT-2020 and beyond" that is likely to become 6G

# VEHICLE-IN-THE-LOOP TESTING OF AUTOMOTIVE SENSORS

**ROHDE & SCHWARZ**

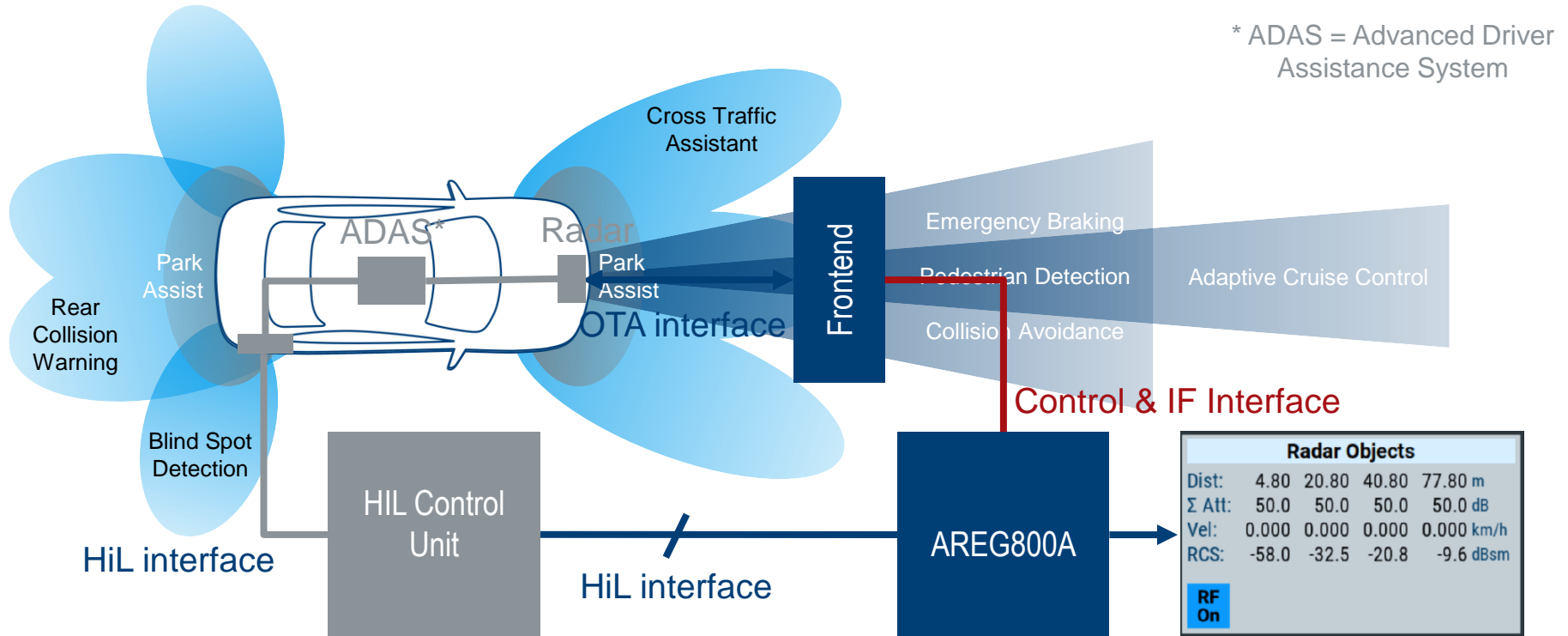
Make ideas real



**AVL**



# WHERE ARE WE COMING FROM? ADAS / AD RADAR TESTING



# WHERE ARE WE COMING FROM? RADAR TARGET SIMULATION

AREG100A



- ▶ Analog Design
- ▶ Focus on Production Testing in Anechoic Chambers
- ▶ Limited Bandwidth and fixed Object Parameter Sets

AREG800A



**Is this Instrument suitable for Testing  
the sensing part of JCAS?**

# CELLULAR COMMUNICATION FROM VOICE CENTRIC TO DATA CENTRIC



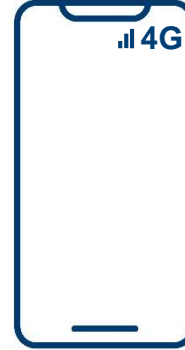
**1G**



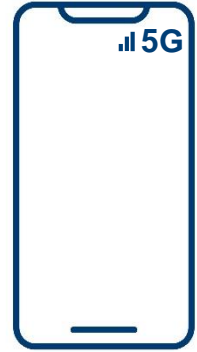
**2G**



**3G**



**4G**



**5G**



# CELLULAR COMS TESTING: WHERE ARE WE COMING FROM? DEVICE TESTING – ALL LAYERS



There's no need to be, our platform is designed to support over 20 Gbps.



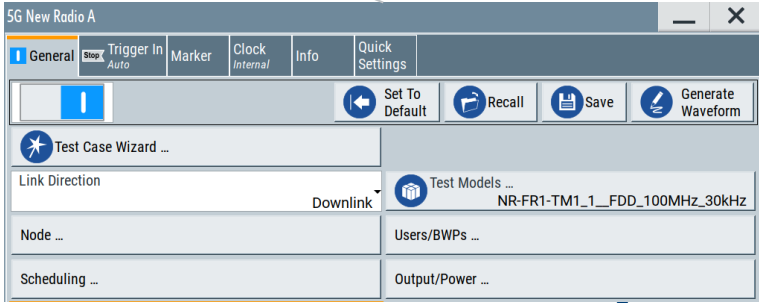
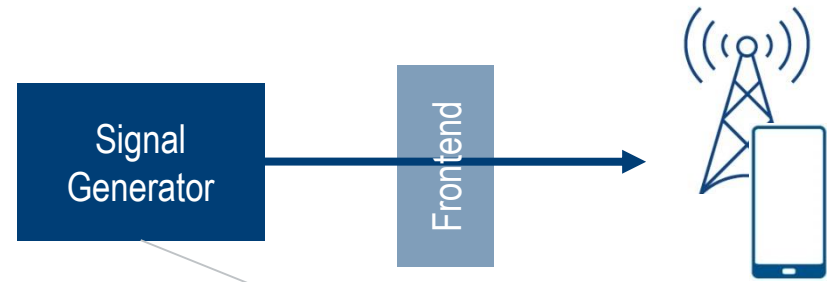
<https://youtu.be/QY-ORKADXW4>



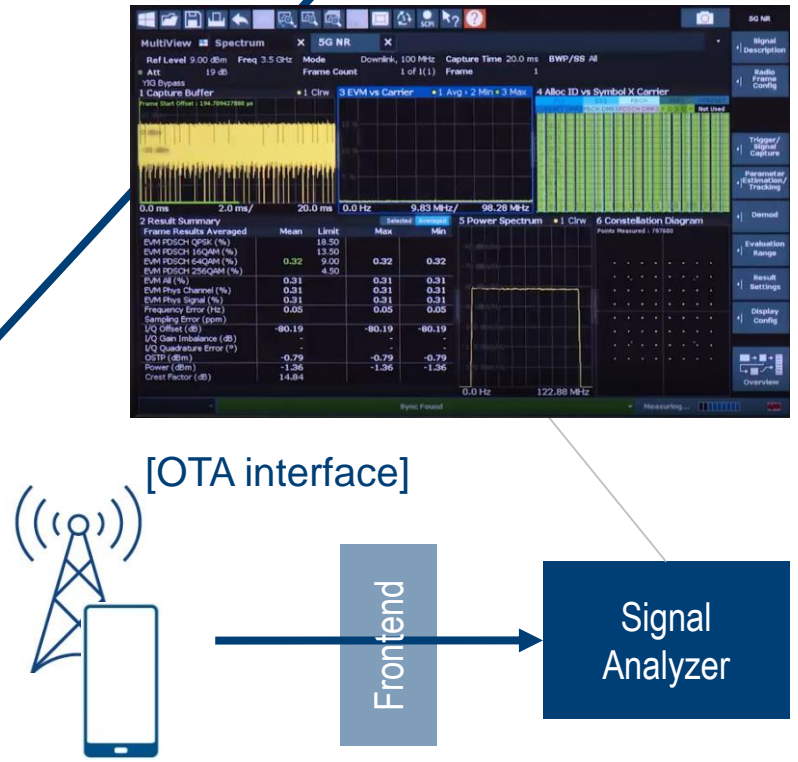
# CELLULAR COMS TESTING: WHERE ARE WE COMING FROM?

## COM TESTING WITH LAYER1/RF FOCUS

### DUT Rx Test



### DUT Tx Test



# WHERE ARE WE COMING FROM?

## COM TESTING WITH LAYER1/RF FOCUS - ILLUSTRATION



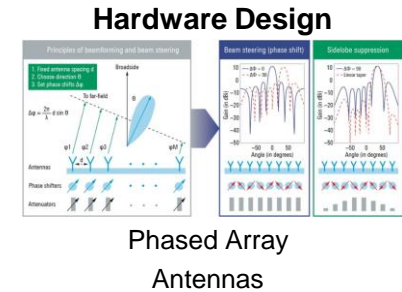
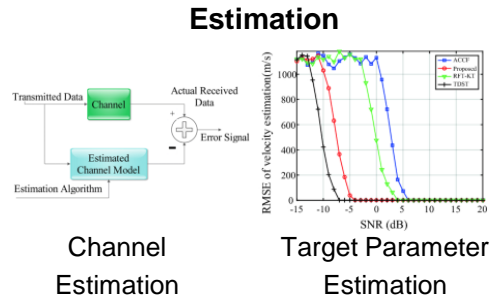
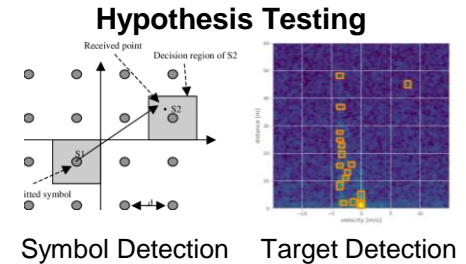
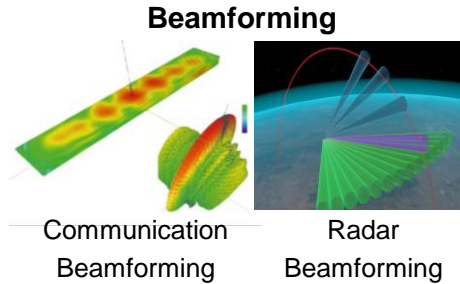
# OVER THE AIR TESTING



# JOINT COMMUNICATION AND SENSING TRENDS

## RADAR AND COMMUNICATION COMMONALITIES

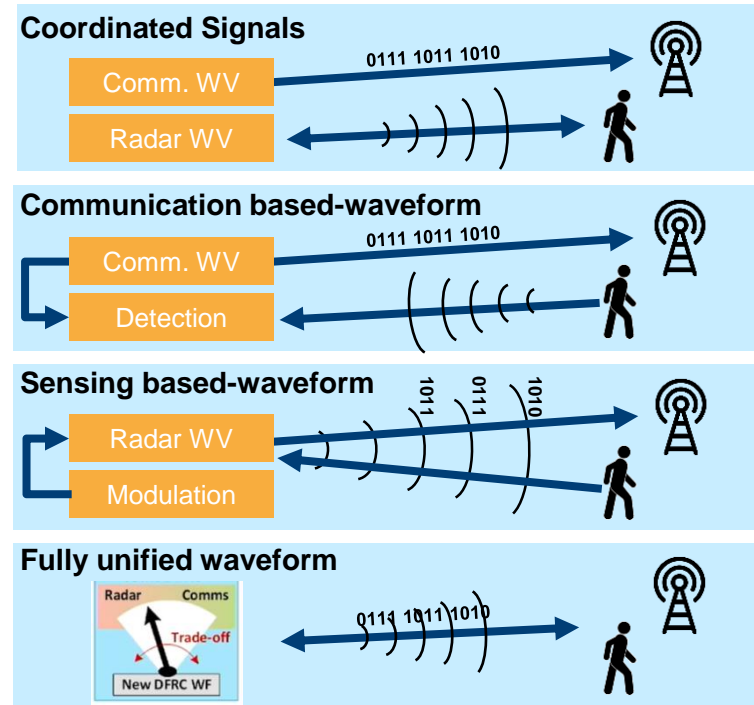
- ▶ Why merging Communication and Sensing capabilities?
- ▶ First of all, both technologies deal with quite common challenges and hardware architectures
- ▶ Both benefit from recent trends in processing, AI or use of higher frequencies
- ▶ High levels of JCAS integration therefore promise
  - Cost Efficiency (e.g. better PAE)
  - Spectral Efficiency
  - Mutual Functional Benefit



# JOINT COMMUNICATION AND SENSING TRENDS

## APPROACHES FOR JCAS WAVEFORM DESIGN

- ▶ Coexisting systems sharing same resources
- ▶ Integrated systems, sharing HW but separately transmitting signals (e.g. spatial, TDM, CDM or FDM)
- ▶ Integrated JCAS System using single transmitted waveform and full-duplex operation
  - Communication-centric design, with guaranteed communication performance (e.g. OFDM-based)
  - Radar-centric design, optimized for sensing performance (e.g. using chirp signals as information carriers → PC-FMCW)
  - Jointly optimized design, with freely scalable S&C performance trade-off



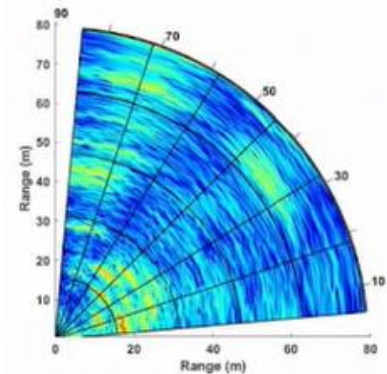
# JOINT COMMUNICATION AND SENSING TRENDS

## EXAMPLE OF WAVEFORM OPTIMIZATION

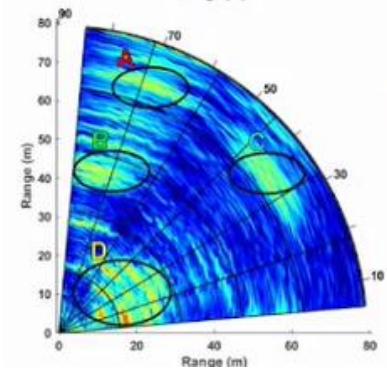


Source: "Experimenting Joint Vehicular Communications and Sensing with Optimized 5G NR Waveform", Tampere University

- ▶ 5G NR baseline waveform (20 OFDM symbols, 264 PRBs, 120 kHz subcarrier spacing, 400 MHz channel) at 28 GHz is used for outdoor mapping
- ▶ Range ambiguity of the radar profile is minimized, by optimizing amplitude and phase of the radar subcarriers of the waveform
- ▶ Optimized waveform allows for better side-lobe performance, while simultaneously minimizing the PAPR of the waveform.



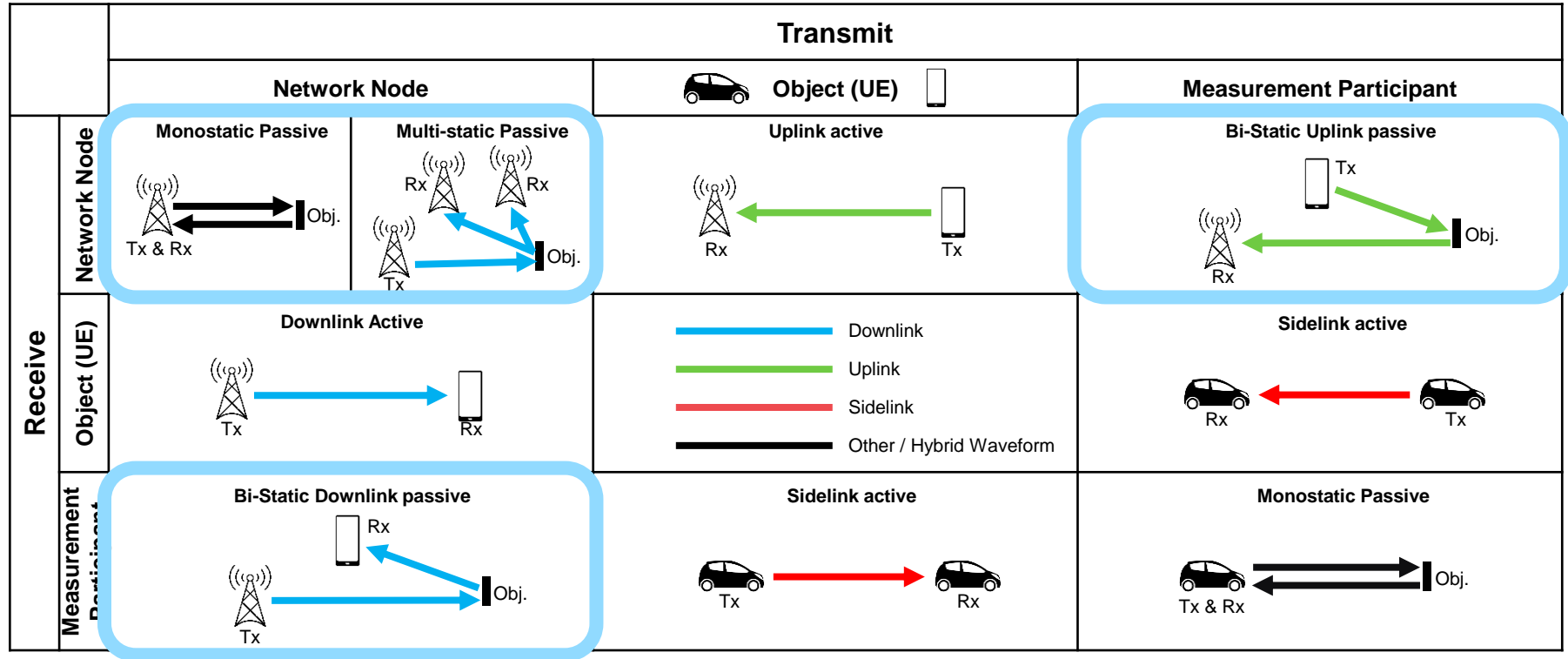
Mapping with unoptimized waveform



Mapping with optimized waveform

# JOINT COMMUNICATION AND SENSING TRENDS

## SENSING ARCHITECTURES





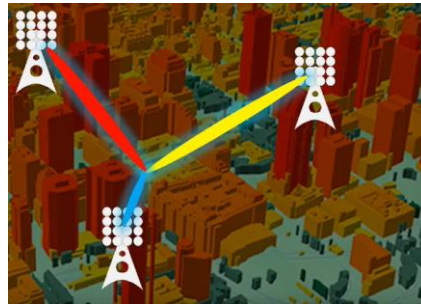
# JOINT COMMUNICATION AND SENSING TRENDS

## COMMON HARDWARE CHALLENGES

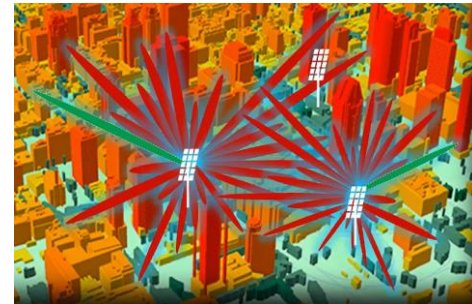
Some key differences can be perceived between multi-static and monostatic approaches:

- ▶ **Multi- and Bi-static** sensing has the big advantage of re-using existing infrastructure
- ▶ This limits the sensing accuracy due to:
  - Generally using FR1 frequencies
  - Clock offset between BS's and/or UEs
- ▶ **Monostatic** operation using FR2 frequencies or mmWave in general allow for much more precise sensing, but:
  - Require adaption/replacement of network
  - more costs involved (incl. operation)

Source: Huawei



Multi-static Sensing

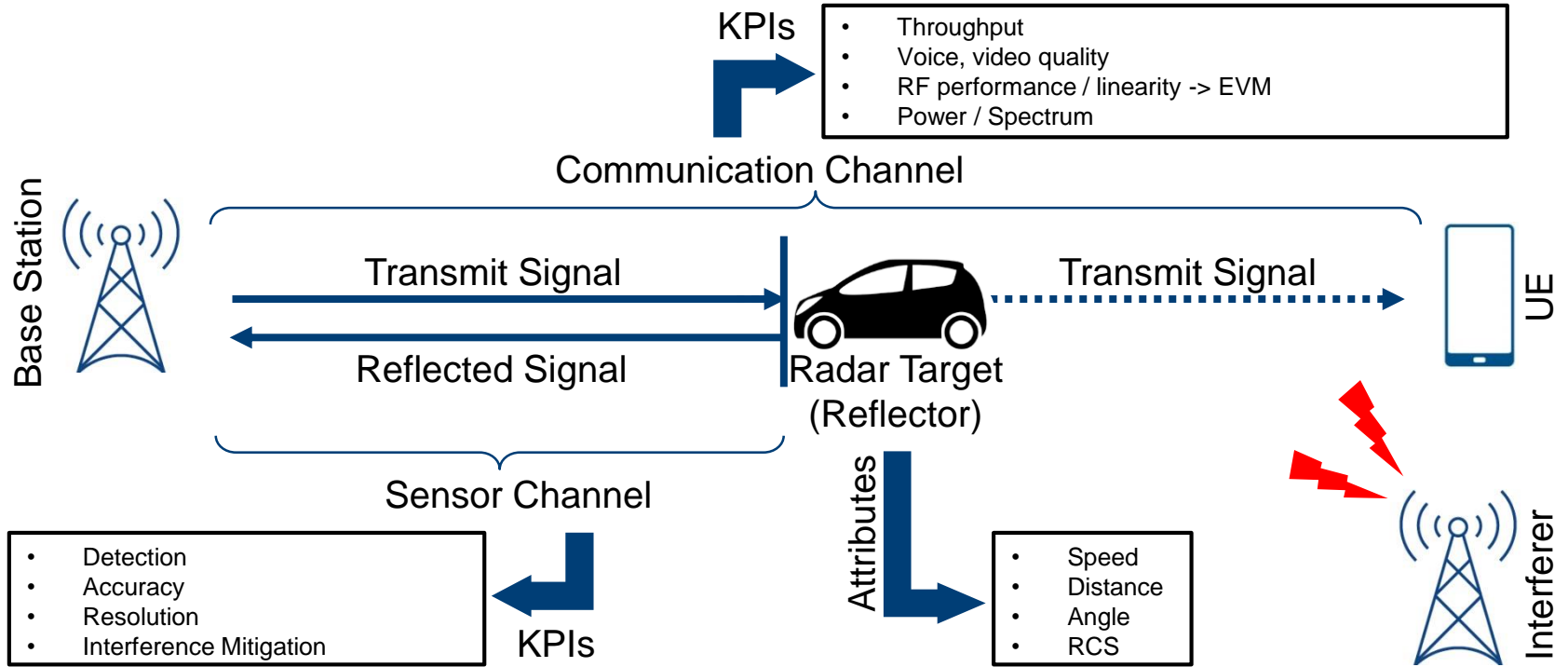


Monostatic Sensing

Types	Signals	Advantages	Disadvantages
Downlink (Active) Sensing - Monostatic	Reflects from a RRU/BS's own transmitted downlink comm signal	All data symbols can be used and are centrally known.	Generally require full duplex operation and other network modifications.
Uplink Sensing - Bistatic	Uplink communication signals from UE transmitters	<ul style="list-style-type: none"> <li>- Do not require full-duplexing.</li> <li>- Require almost no changes to communication infrastructure.</li> </ul>	<ul style="list-style-type: none"> <li>- Clock offset issue.</li> <li>- Transmitted information signals are not directly known.</li> <li>- Rapid channel variation when UEs are moving.</li> </ul>

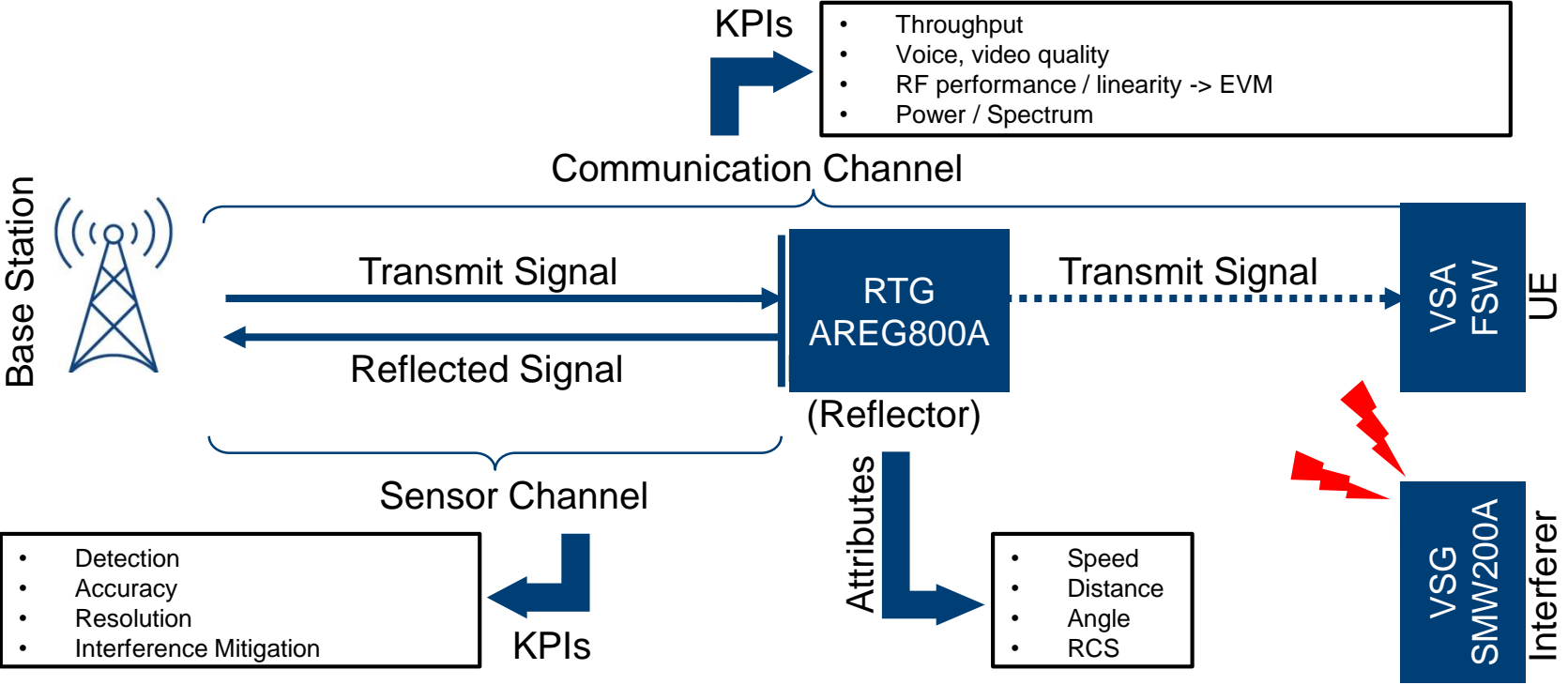
# JOINT COMMUNICATION AND SENSING TRENDS

## DIFFERENCES IN PERFORMANCE INDICATION



# JOINT COMMUNICATION AND SENSING TRENDS

## HOW TO TEST JCAS KPI



# JOINT COMMUNICATION AND SENSING ADAPTING THE SETUP FOR FR2 FREQUENCIES

- ▶ Demonstrated at the [7<sup>th</sup> IEEE 5G+ Summit Dresden in May 2022](#)
- ▶ Frontends support frequency bands from 24 GHz to 44 GHz



# 6G RESEARCH IN GERMANY SIGNIFICANT WORK ON THE WAY

13.09.2021 - 06.12.2021

## Bekanntmachung

Richtlinie zur Förderung der „6G-Industrieprojekte zur Erforschung von ganzheitlichen Systemen und Teiltechnologien für den Mobilfunk der 6. Generation“ im Forschungsprogramm für Kommunikationssysteme „Souverän. Digital. Vernetzt.“; Bundesanzeiger vom 13.09.2021

### 6G-ANNA

Ganzheitliche Ansätze für Mobilfunknetze der 6. Generation



### 6G-Forschungs-Hubs; Plattform für zukünftige Kommunikationstechnologien und 6G

Gegenstand der Fördermaßnahme im Rahmen der 6G-Initiative des BMBWF ist die Erforschung von zukünftigen Kommunikationstechnologien, um die Forschung und Entwicklung zu 6G in Deutschland gezielt zu unterstützen und auszubauen. Im Rahmen der Bekanntmachung sollen bis zu drei „6G-Forschungs-Hubs“ und eine begleitende „Plattform für zukünftige Kommunikationstechnologien und 6G“ gefördert werden.



- ▶ Additional projects are expected to be announced in near future

# SUMMARY

- ▶ Deployment of 5G networks is in full swing! Clear evolution path provided by the industry's standardization organization
- ▶ Academia and key industry players are exploring the boundaries and started looking into next generation of wireless communication aka 6G
- ▶ New, challenging technology components may complement the existing concept of cellular networks or even provide revolutionary aspects
- ▶ Rohde & Schwarz is actively engaged in this phase of fundamental research, providing our expertise in test and measurement to make ideas real

**ROHDE & SCHWARZ**

Make ideas real



All truth is simple...  
is that not doubly a lie?



THANK YOU!

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have a look at our open positions





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