INTEGRATED SENSING AND COMMUNICATION (ISAC) FROM 5G-ADVANCED TO 6G

Mr. Meik Kottkamp
Technology Manager Wireless
Rohde & Schwarz

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Make ideas real

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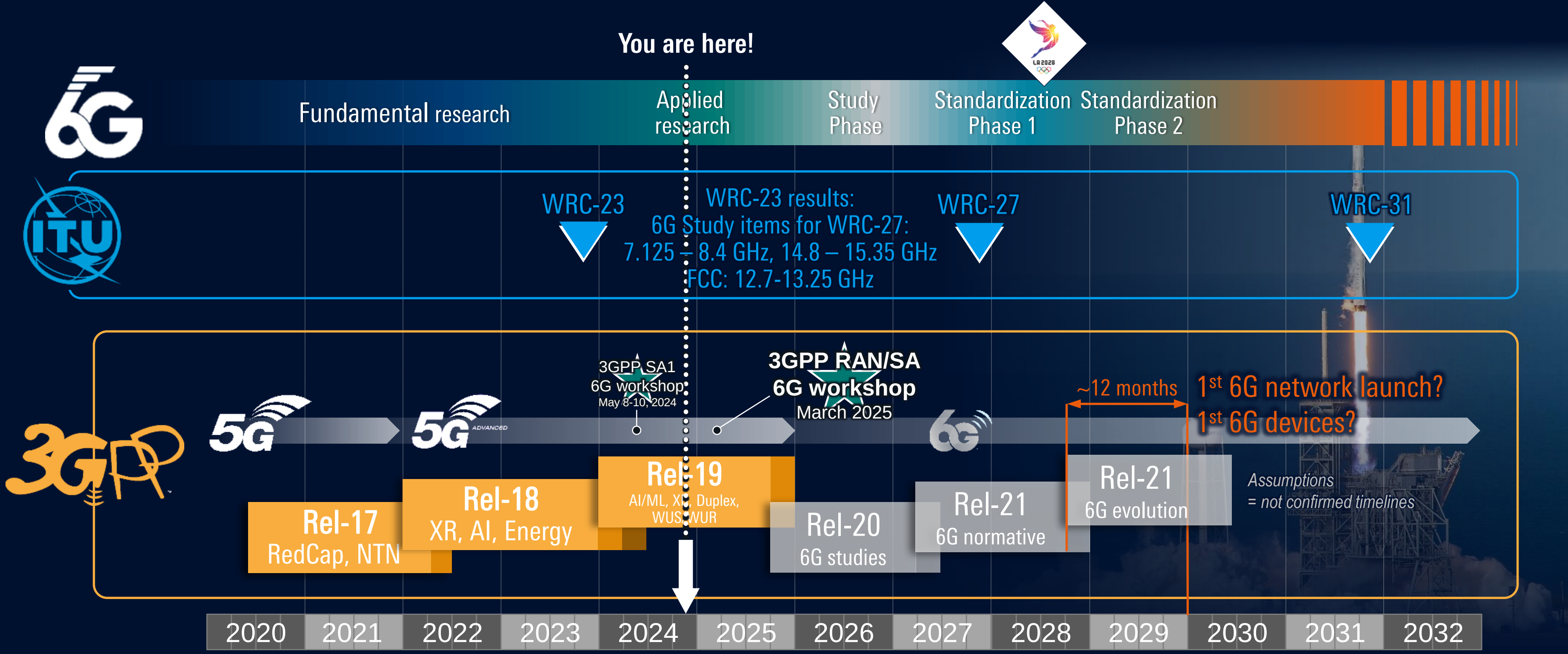
Standardization, regulation, and industry timelines
An overview

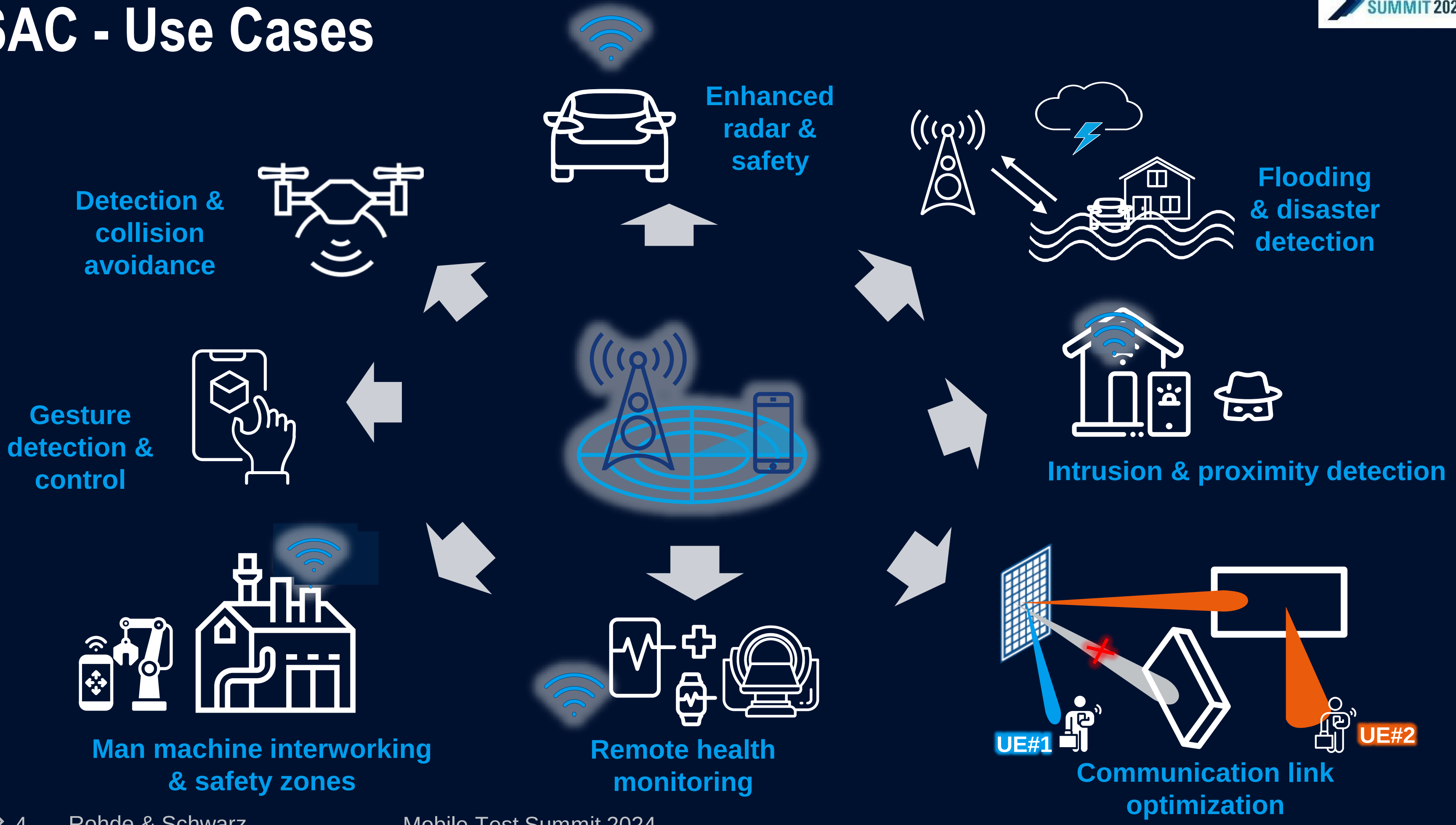


What is ISAC?
How ETSI and 3GPP describe it

- ETSI: Sensing refers to the use of radio signals to detect and estimate characteristics of target objects in the environment. By integrating sensing into the communications network, the network acts as a "radar" sensor, using its own radio signals to sense and comprehend the physical world in which it operates. This allows the network to collect data on the range, velocity, position, orientation, size, shape, image, materials of objects and devices.
  - Source: https://www.etsi.org/technologies/integrated-sensing-and-communications

- 3GPP: 5G Wireless sensing is a technology enabler to acquire information about characteristics of the environment and/or objects within the environment, that uses radio waves to determine the distance (range), angle, or instantaneous linear velocity of objects, etc. The 5G wireless sensing service relies on analyzing the transmissions, reflections, and scattering of wireless sensing signals.
  - Source: TR 22.837 V19.4.0

ISAC - Use Cases



The current focus of work in 3GPP
Requirements and channel modelling

► Requirements (3GPP SA1):

- 5G wireless sensing service functional requirements (authorization, exposure, security and privacy, charging)
- 5G wireless sensing performance requirements (accuracy of positioning / velocity estimate, confidence level, sensing resolution, missed detection / false alarm probability, max sensing service latency, refreshing rate)

3GPP TS 22.137 V19.1.0 (2024-03)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group TSG SA;
Service requirements for Integrated Sensing and Communication;
Stage 1
(Release 19)

► Channel modelling (3GPP RAN1)

- The focus of the study is to define channel modelling aspects to support object detection and/or tracking
- Aim at a common modelling framework capable of detecting and/or tracking the following example objects and to enable them to be distinguished from unintended objects:
  - UAVs
  - Humans indoors and outdoors
  - Automotive vehicles (at least outdoors)
  - Automated guided vehicles (e.g. in indoor factories)
  - Objects creating hazards on roads/railways, with a minimum size dependent on frequency

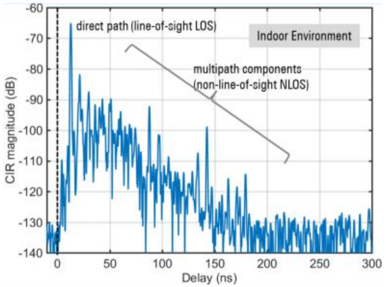
Why are channel models important?
What are they used for?

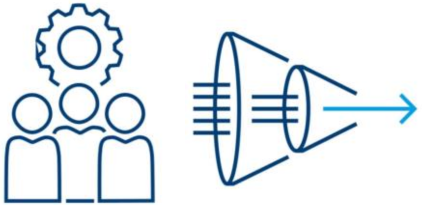
TR 38.901

Channel Model

Comparison of approaches incl. performance evaluation, system design and specification

Conformance test cases





Example: TS 38.104
Base Station (BS) radio transmission and reception

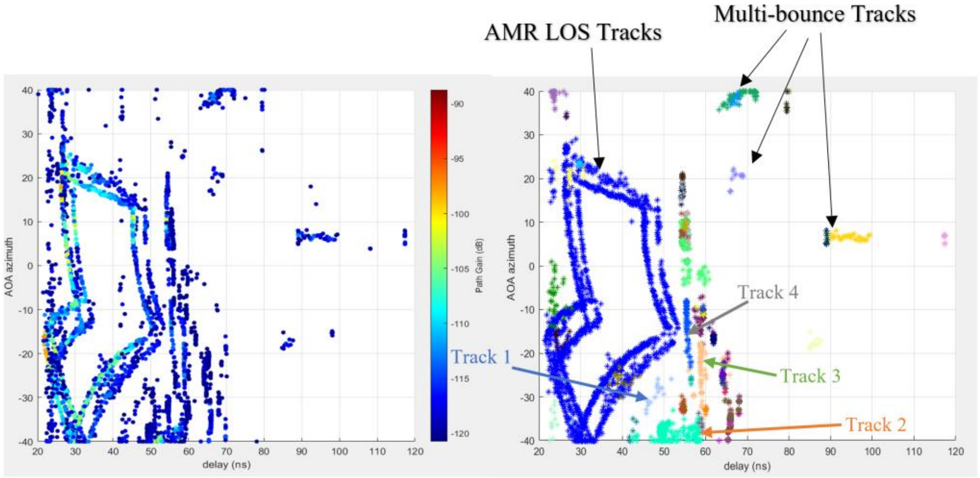
The performance requirement of PUSCH is determined by a minimum required throughput for a given SNR.

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix (Annex G)	Fraction of maximum throughput	FRC (Annex A)	Additional DM-RS position	SNR (dB)
		Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-2.3
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	10.1
	2	Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	12.3
		Normal	TDLA30-10 Low	70 %	G-FR1-A9-1	pos1	19.1
		Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-5.8
1	4	Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	6.2

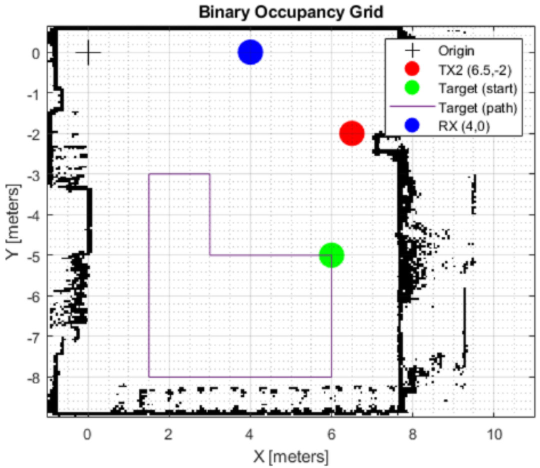
"The delay profiles are simplified from the **TR 38.901 TDL models**."

Measurements (NIST)
Example

► R1-2406211

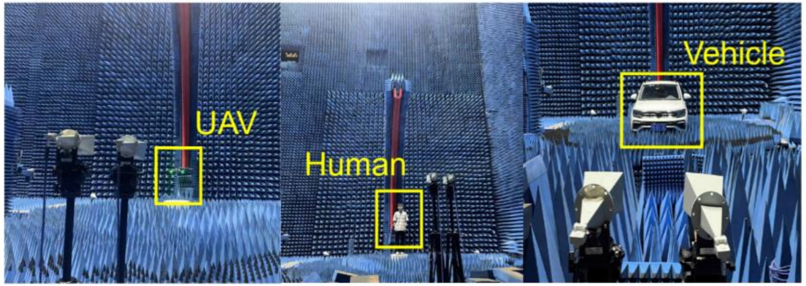


(a) Extracted MPCs with Path Gain (b) Denoised and Clustered MPCs



Measurements cont. (BUPT)
Rader Cross Section (RCS)

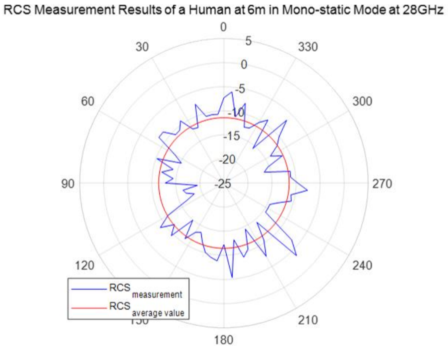
► R1-2406107

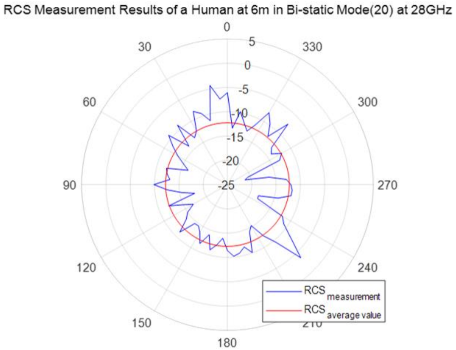


RCS measurement scenarios of three typical targets (UAV, Human, Vehicle) in an anechoic chamber

Table. 6 The RCS mathematical model with normal distribution for human in different measureme configurations.

Frequency	Distance	Sensing Mode	Parameters of Normal distribution	Value
4.9 GHz	6 m	Mono-static	μ	-6.539
			σ	2.6039
		Bi-static(20°)	μ	-7.0892
			σ	2.5254
	12 m	Mono-static	μ	-5.6785
			σ	2.2575
		Bi-static(20°)	μ	-7.0887
			σ	2.2575
15 GHz	6 m	Mono-static	μ	-8.7949
			σ	2.6182
		Bi-static(20°)	μ	-8.8218
			σ	2.4021
		Bi-static(30°)	μ	-9.1677
			σ	2.5381
		Bi-static(40°)	μ	-10.0311
			σ	2.0882
	12 m	Mono-static	μ	-7.5161
			σ	2.7074
		Bi-static(20°)	μ	-8.2129
			σ	2.6069



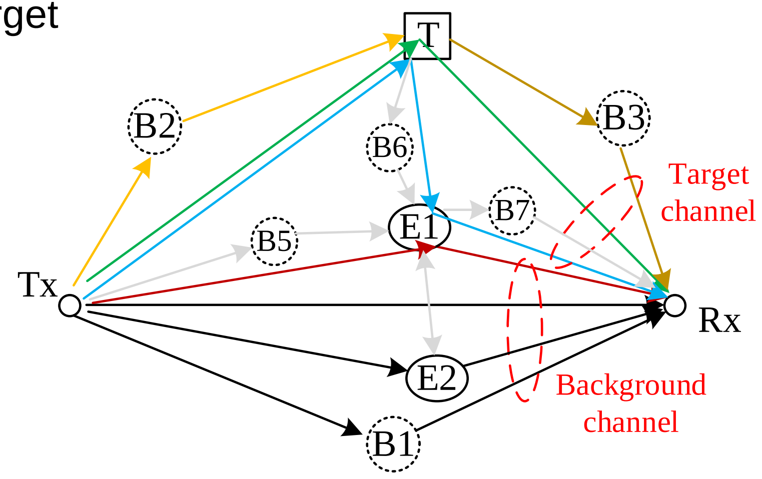


3GPP RAN1 channel modelling study
Some details and initial agreements

- At high level three modeling parts:
  - Physical object (RCS), target channel and background channel → $H_{ISAC} = H_{target} + H_{background}$
  - Target channel contains the components impacted by the sensing target(s)
  - Background channel are other components not impacted by the sensing target
- Multiple sensing targets can be modeled between a pair of sensors
- Multiple sensors can be modeled to sense the same target

Bistatic ISAC architecture

Monostatic ISAC architecture



3GPP RAN1 channel modelling study
Remaining work – study will end mid 2025

- Physical object modelling
  - Exact RCS value/pattern for each target type
  - Details on modelling object with multiple scattering points
  - …
- Target channel
  - Details on generating power of direct/indirect path
  - Number of direct paths for a target with single scattering point
  - …
- Details on combining target channel and background channel

Mobile World Congress demonstrations Feb 2023

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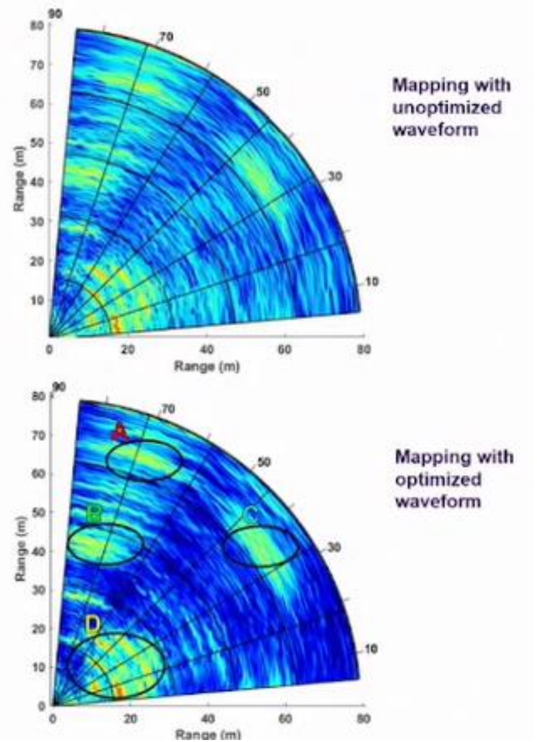
- ► Quite some demonstrators were showcased already 2023 based on existing 5G NR FR2 implementation.
- ► Focus on distance and speed estimation of passive objects.

Integrated Sensing and Communication

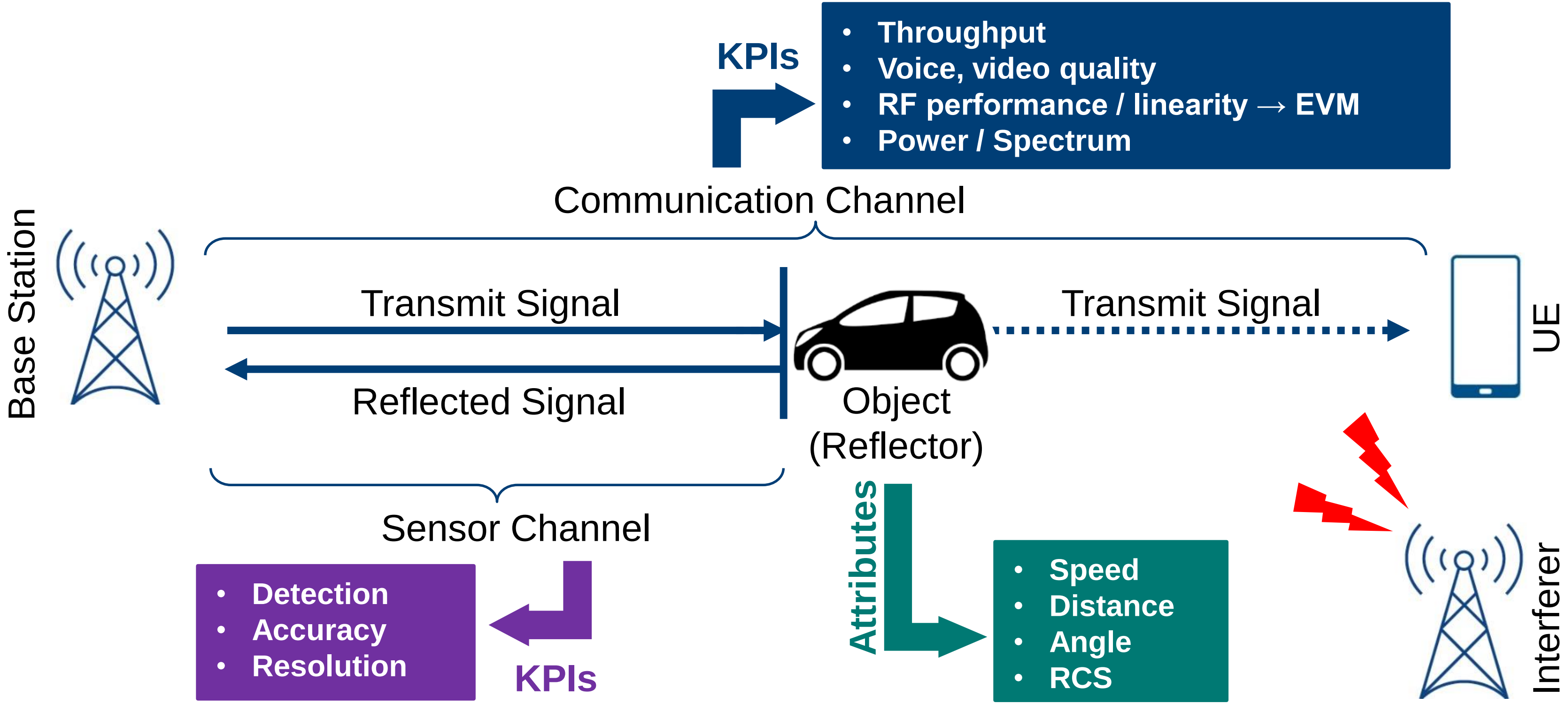
Example of Waveform Optimization

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

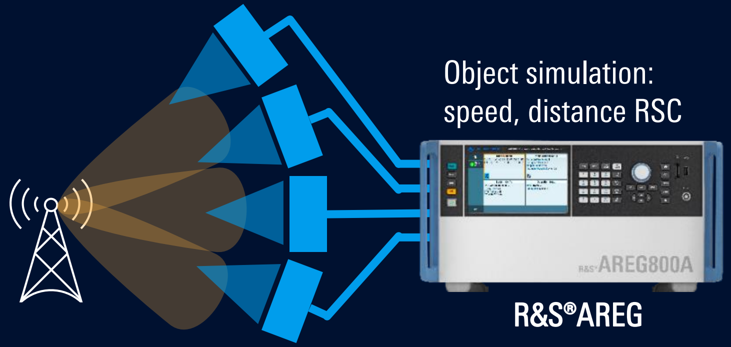


- 5G NR baseline waveform (20 OFDM symbols, 264 PRBs, 120 kHz subcarrier spacing, 400 MHz channel) at 28 GHz is used for outdoor mapping
- Range ambiguity of the radar profile is minimized, by optimizing amplitude and phase of the radar subcarriers of the waveform
- Optimized waveform allows for better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

Integrated Sensing And Communication
Principle Testing Considerations



Integrated sensing and communication
Test solution



Berlin 6G Conference
July 2024

MWC
Feb 2024

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Test. Measure. Innovate

THANK YOU
VERY MUCH

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