TEST AND MEASUREMENT TACKLING THE CHALLENGES OF ISAC EVOLVING ON THE PATH TO 6G

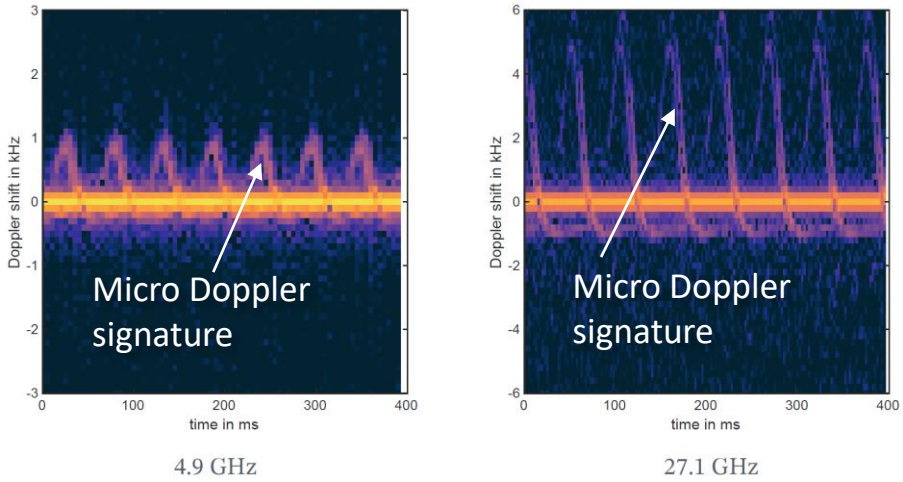
Reiner Stuhlfauth
Technology Manager Wireless

ROHDE&SCHWARZ
Make ideas real

Time-domain channel measurements for FCAS research

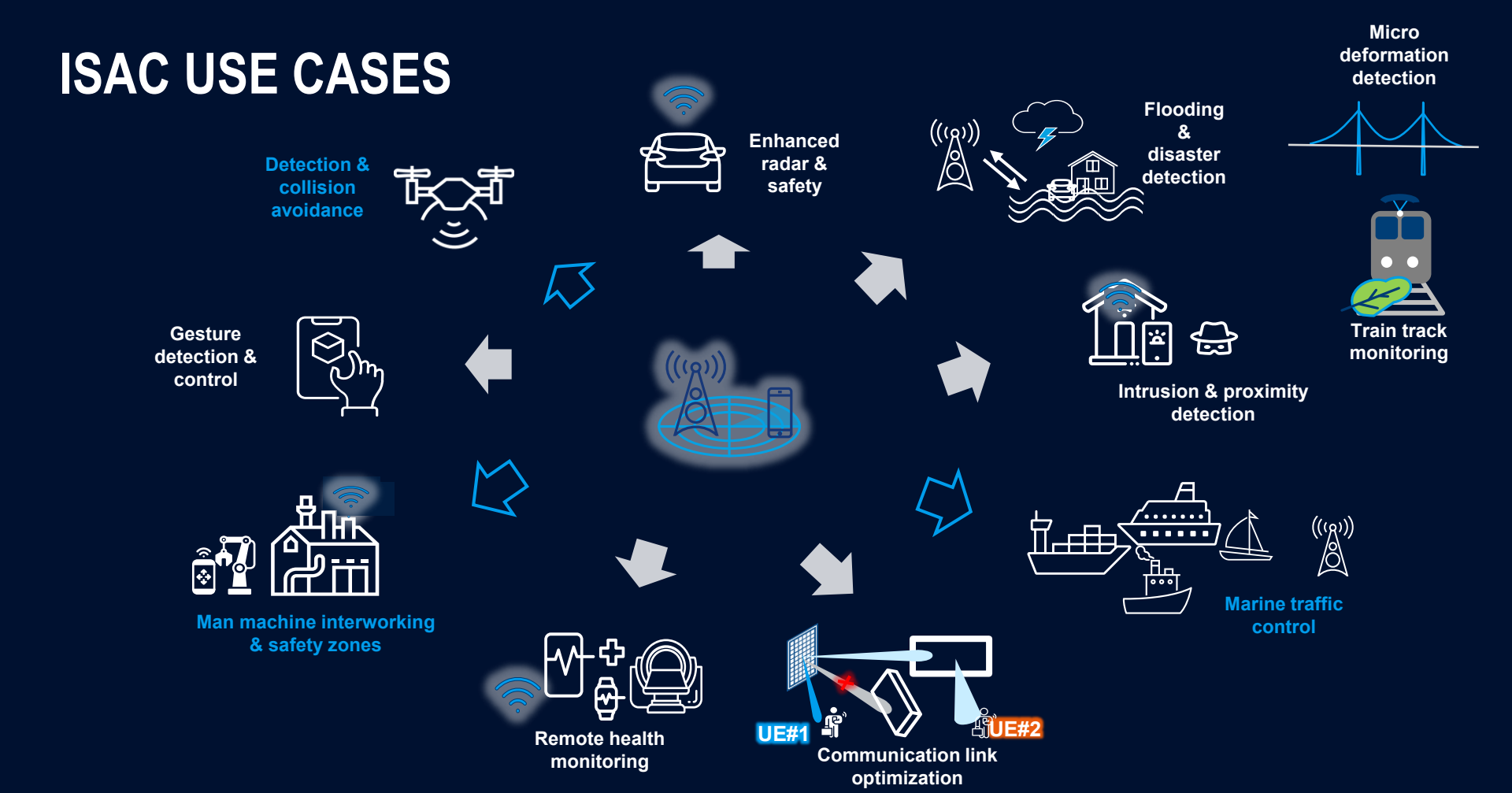
Characterization of Helicopter Rotor Blade Modulation in UHF and Microwave Bands

Doppler Spectrogram CH53 Helicopter



"Characterization of Helicopter Rotor Blade Modulation in UHF and Microwave Bands", submitted to MILCOM2024

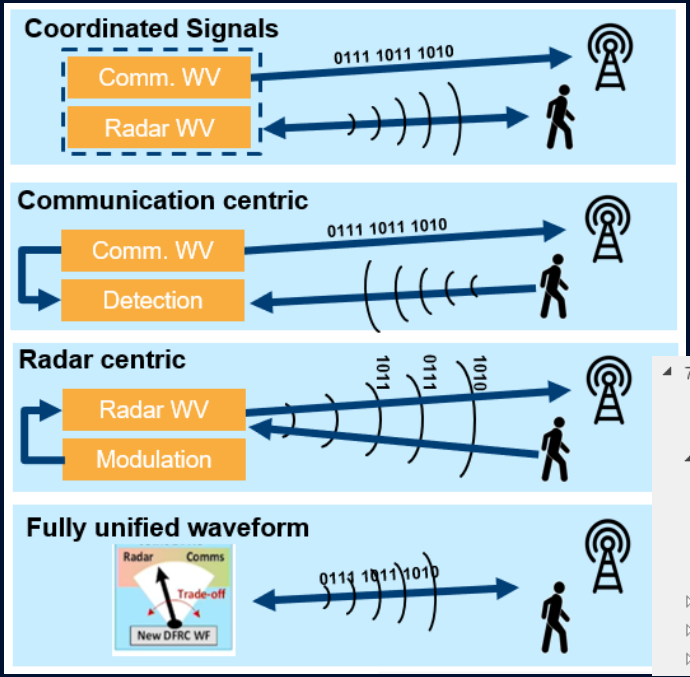
ISAC USE CASES



T&M tackling challenges of ISAC and path to 6G

THE CONCEPT OF INTEGRATED COMMUNICATION AND SENSING

KEY DRIVERS FOR ISAC: Dense network | Wide bandwidths | AI and signal processing | MIMO beamforming

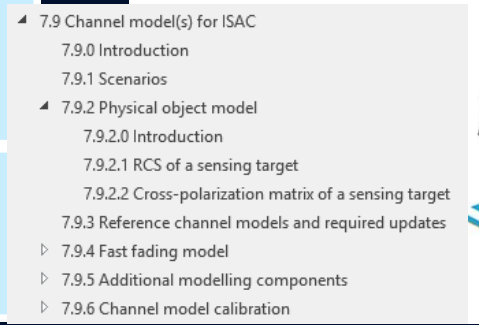


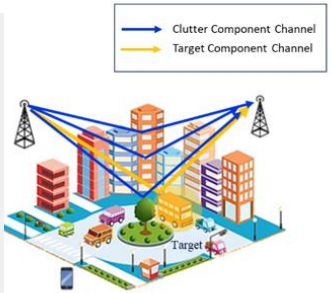
ISAC CHANNEL MODELLING

3GPP TR 38.901 V19.0.0 (2025-06)
Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Study on channel model for frequencies from 0.5 to 100 GHz
(Release 19)

- Starting point is **TR 38.901**
- Basic framework for the ISAC channel model is agreed: $H_{ISAC} = H_{target} + H_{background}$
  - **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



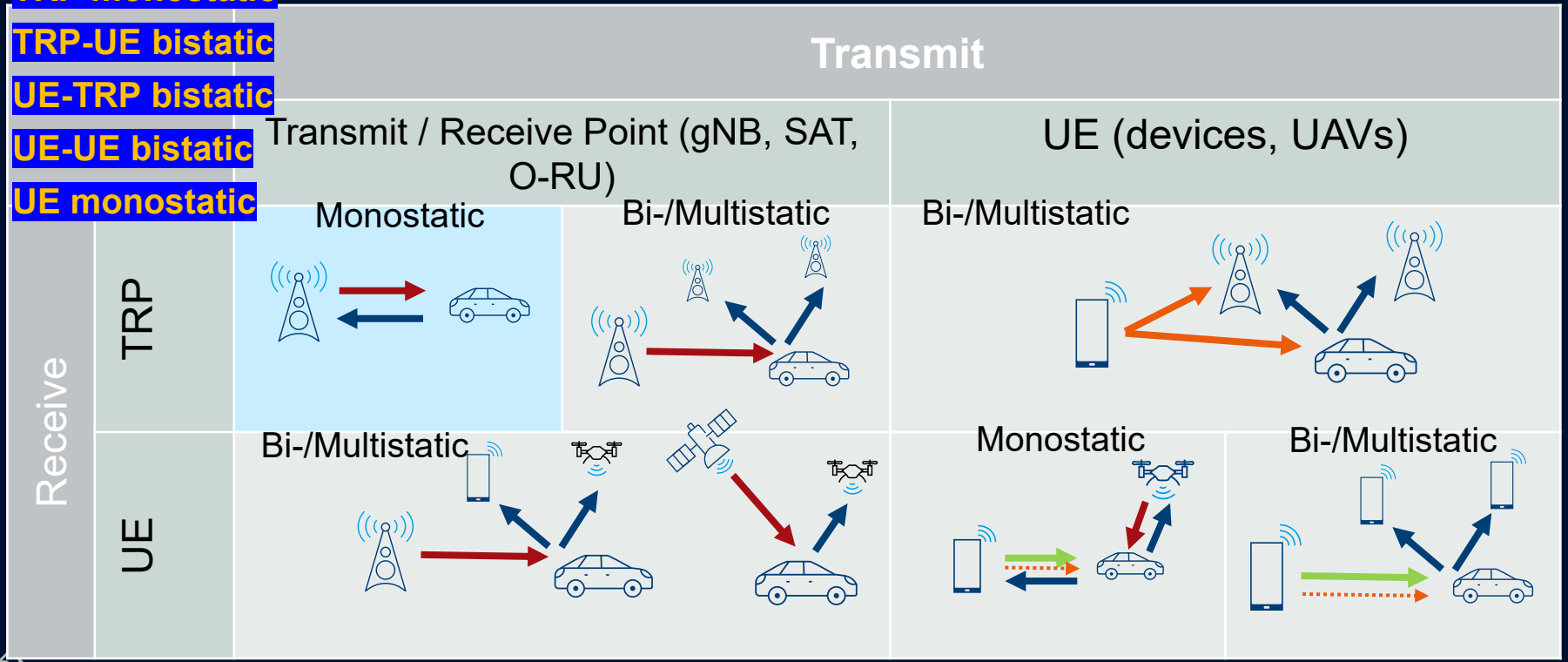


Bistatic ISAC architecture

Monostatic ISAC architecture

SENSING ARCHITECTURES

- There are six unique sensing modes:
  - **TRP-TRP bistatic**
  - **TRP monostatic**
  - **TRP-UE bistatic**
  - **UE-TRP bistatic**
  - **UE-UE bistatic**
  - **UE monostatic**



RADAR CROSS SECTION σ

- Radar cross section (RCS or σ) defines the energy that a radar target in range R intercepts and scatters back toward the radar
- $Received\ reflected\ power = TX\ Isotropic\ power\ density * TXgain * RCS * Aperture\ of\ the\ RX\ antenna$

$$P_r = \frac{P_t G_t}{4\pi R^2} \sigma \frac{A_e}{4\pi R^2}$$

P_t: Transmit power

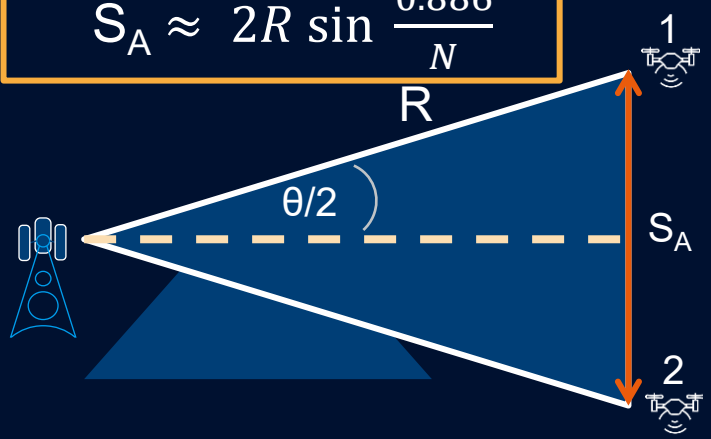
G_t: Transmit gain

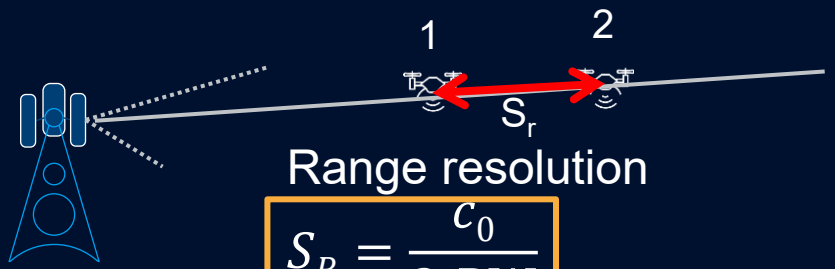
A_e: Effective receive area

R: Radius (distance)

N: number of antennas (in either azimuth or elevation)

$$S_A \approx 2R \sin \frac{0.886}{N}$$





Range resolution

$$S_R = \frac{c_0}{2\ BW}$$

MAIN STANDARDIZATION ACTIVITIES 3GPP AND ETSI ISG

Work in progress

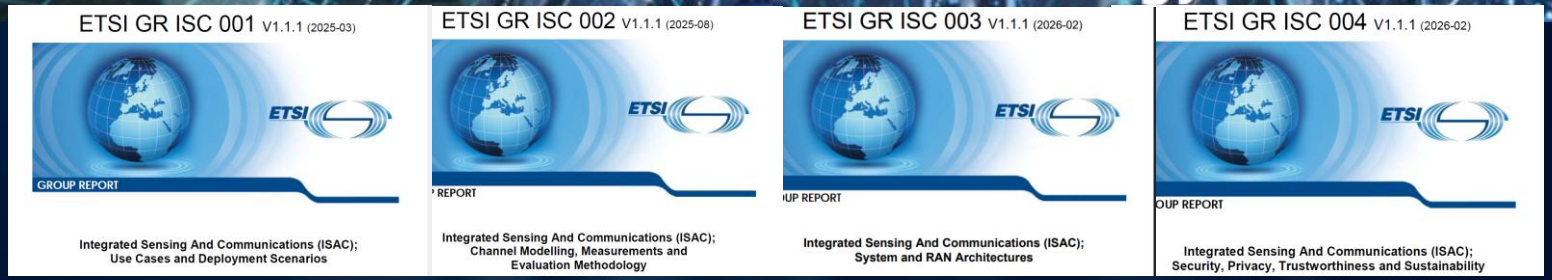
RAN catagorization of topics based on Rel-19 Workshop contributions

- AI/ML Air Interface
- MIMO Ev.
- Duplex Ev.
- Ambient IoT
- Network Energy Saving Enh.
- Mobility Enh.
- NTN Ev.
- XR Ev.
- AI/ML for NG-RAN
- SON / MDT
- Chanel modelling

& possibly additional aspects (ISAC, etc) for further

DGR/ISC-005 (GR ISC 005) Integration of Computing with ISAC
DGR/ISC-006 (GR ISC 006) Enhanced System and RAN Architectures for ISAC
DGR/ISC-007 (GR ISC 007) Security, Privacy, Resilience and Trustworthiness for ISAC
DGR/ISC-008 (GR ISC 008) AIML and Data Handling for ISAC
DGR/ISC-009 (GR ISC 009) Demonstrability, Adoption, and Technology Evolution for ISAC

ETSI Launches a New Group for Integrated Sensing and Communications, a Candidate Technology for 6G



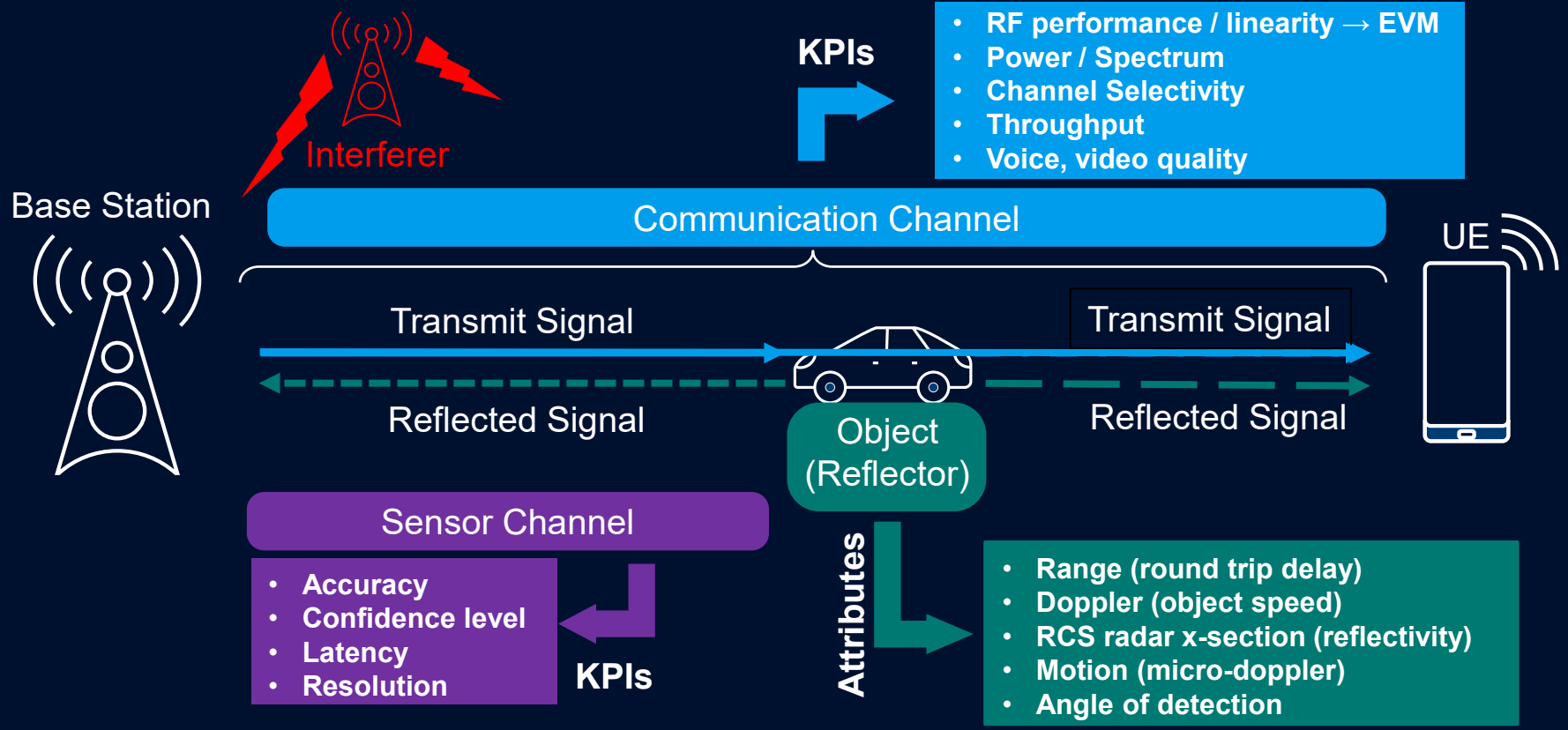
SENSING SERVICES AND KPI UNDER CONSIDERATION:

- **Point cloud** – for the target area indicated by the sensing service request
- **Object *detection*** – for the target area indicated by the sensing service request
- **Object *localization***
- **Object *kinematics*** (speed, accelleration)
- **Object *classification*** (object type: Person, drone, car, UAV,…)
- **Object *identification*** – of objects belonging to an object class
- **Object *tracking***
- **Object shape**
- **Object material identification**
- **Single instance/periodic/aperiodic**

Accuracy of ***locatization*** (distance, angle)
Accuracy of ***kinematics*** information (velocity, speed)
Accuracy of object ***shape***
Confidence *level* (of detection)
False negative probability / False positive probability
Sensing service ***latency***
Refreshing rate
Sensing resolution (discriminating objects close to each other)
Range resolution (multiple objects behind each other)
Horizontal / vertical (objects close to each other)

Source: ETSI GR ISC 003 V1.1.1 (2026-02)

ISAC SENSING – TESTING CONSIDERATIONS



TESTING CONSIDERATIONS – ISAC

Interferer

Base Station:
Signal generator SMW200A
Signal analyzer FSW
Viavi TM500 O-DU emulator

KPIs

- RF performance / linearity → EVM
- Power / Spectrum
- Channel Selectivity
- Throughput
- Voice, video quality

Communication Channel

Transmit Signal

Reflected Signal

Target Emulator AREG800A

Transmit Signal

UE or UE emulator
Signal analyzer FSW
Viavi TM500 UE emulator

Sensor Channel

KPIs

- Accuracy
- Confidence level
- Latency
- Resolution

Attributes

- Range
- Doppler
- RCS
- Angle
- Motion

ISAC SENSING UE TESTING CONCEPT – E2E signaling

Interferer

KPIs

- RF performance / linearity → EVM
- Power / Spectrum
- Blocking
- Throughput
- Voice, video quality

UE /
UE emulator
Viavi TM500

Communication Channel

Base Station
Emulator CMX500

Transmit Signal

Transmit Signal

Reflected Signal

Target
Emulator
AREG800A

Attributes

- Range
- Doppler
- RCS
- Angle
- Motion

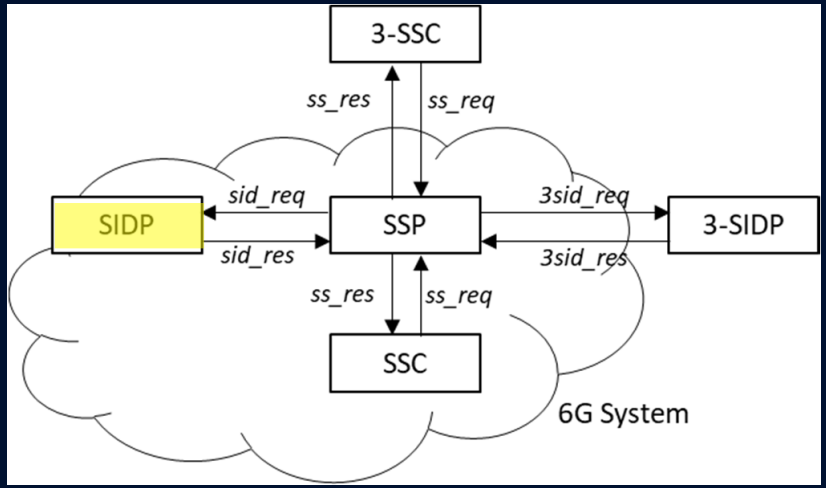
Sensor Channel

- Accuracy
- Confidence level
- Latency
- Resolution

KPIs

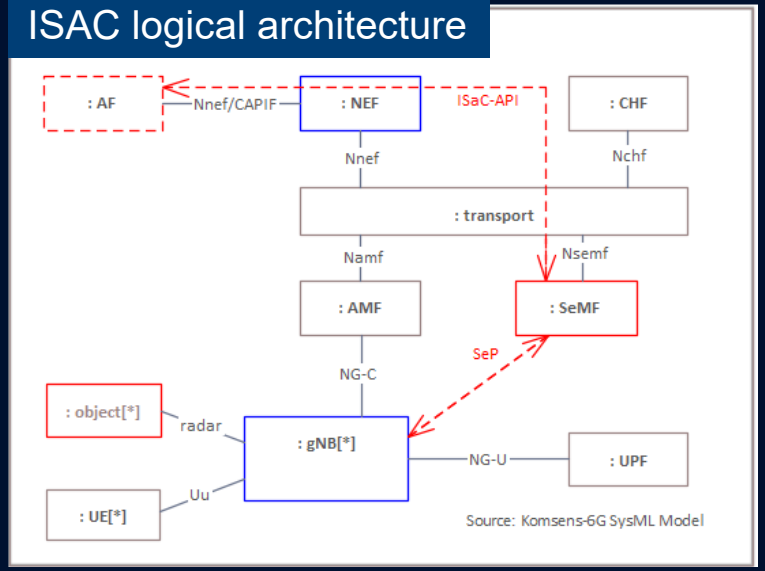
6G SENSING REFERENCE MODEL
ETSI GR ISC 003 V1.1.1 (2026-02)

- Sensing Service Producer (SSP):
  6GS entity providing the 6G Sensing Service(s)
- **SIDP:** Sensing Input Data Provider
  - **may include UEs** and Access Nodes
- 3-SIDP: 3rd party Sensing Input Data Provider
  - e.g.Wi-Fi sensing
- SSC: Sensing Service Consumer
  - may include UEs, Access Nodes, and Core Network Functions
- 3-SSC: 3rd party Sensing Service Consumer



LOGICAL ARCHITECTURE FOR ISAC

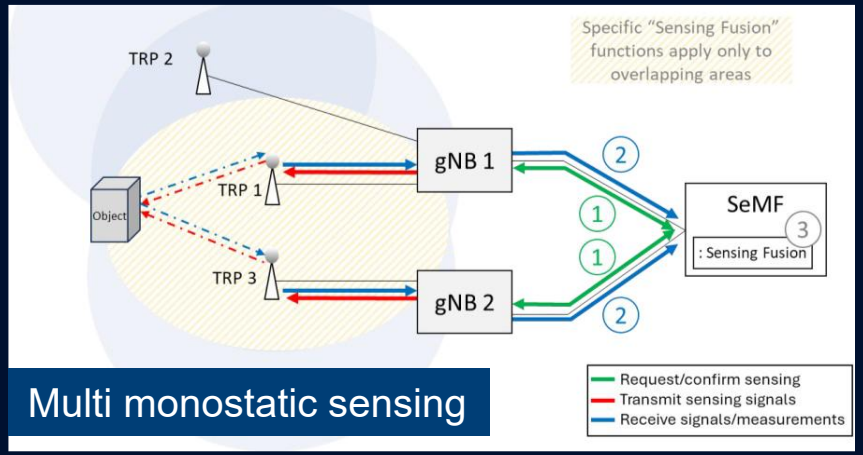
ISAC logical architecture



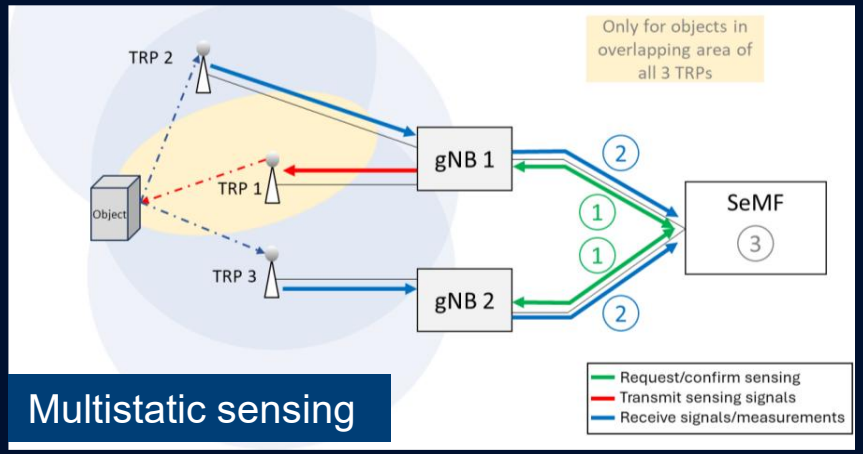
New core network function:
Sensing management function (SeMF)

[2411.10138] Architecture Proposal for 6G Systems Integrating Sensing and Communication

Komsens research project

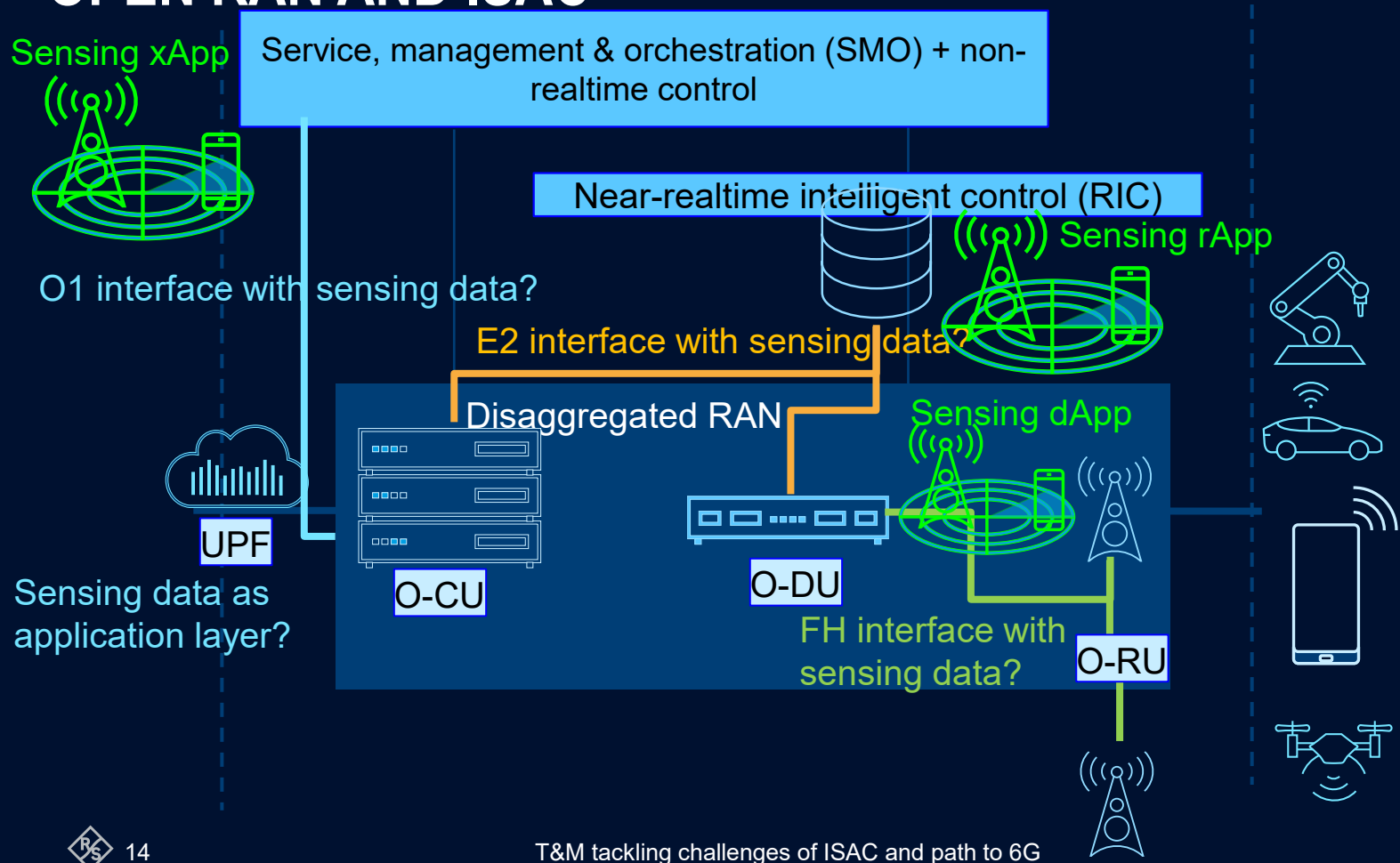


Multi monostatic sensing



Multistatic sensing

OPEN RAN AND ISAC



Making the RAN flexible, smart, agile and sensitive.

Open interfaces support exchange of sensing data. Sensing evaluation, detection, analysis done by SW-apps

OPEN RAN AND ISAC

Service, management & orchestration (SMO) + non-realtime control

Near-realtime intelligent control (RIC)

ISAC ethical discussion:

- Whom does the sensing data belong?
- How transparent is ISAC?
- ISAC privacy?

O-CU

O-DU

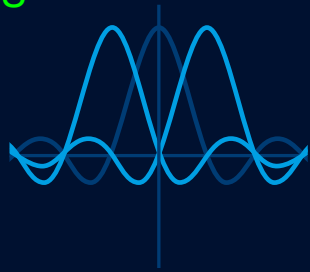
C-plane: New O-RU scheduling (ISAC)

U-plane: Sensing as additional data. Capacity?

M-plane: New O-RU capability (ISAC)

Sensing O-RU

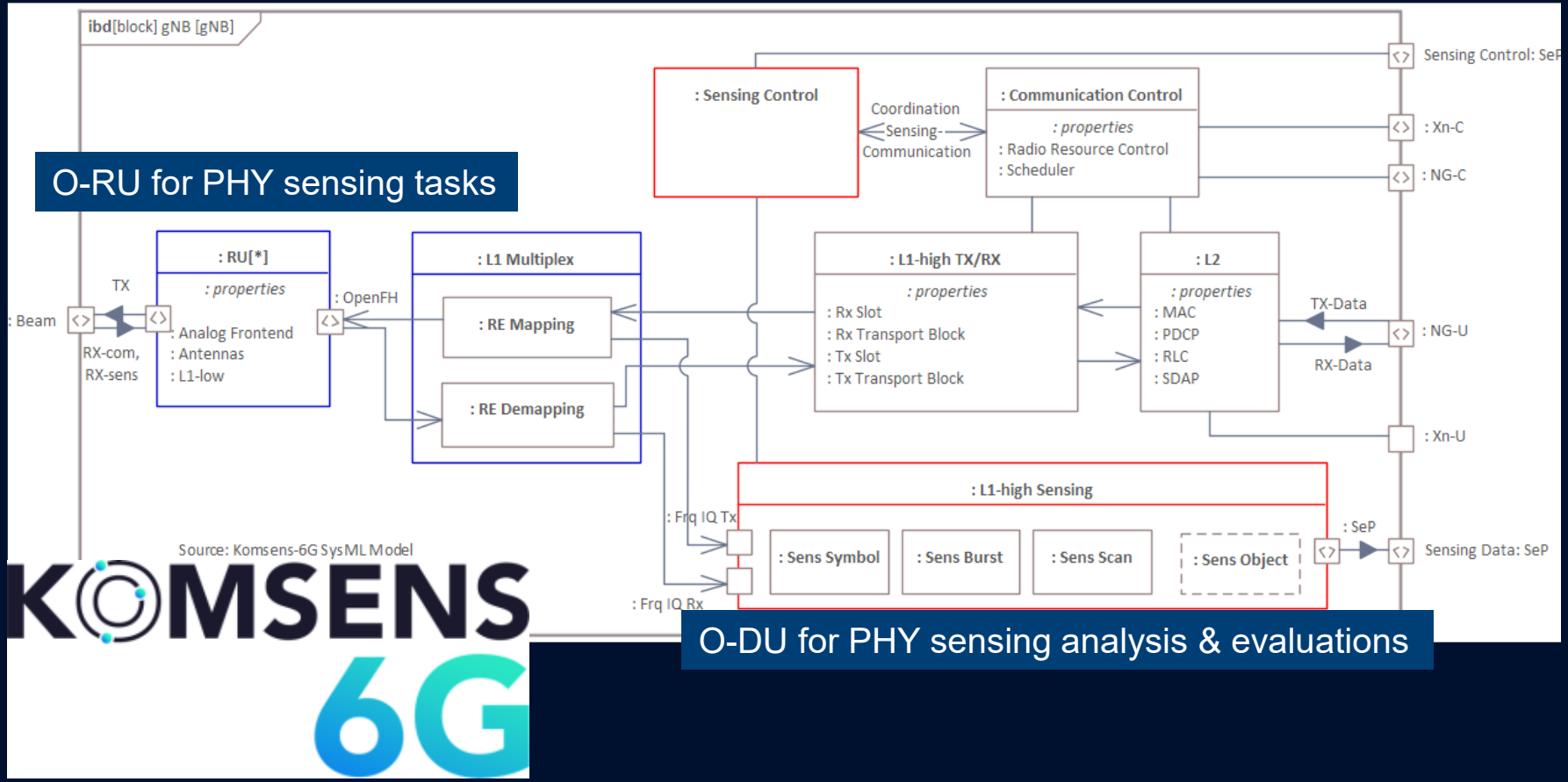
O-RU



Sensing data:
Full BW or only DMRS/SRS used for sensing?
Waveform for sensing?

Bistatic sensing O-RU, exchange via FH-interface?

OPEN RAN AND ISAC



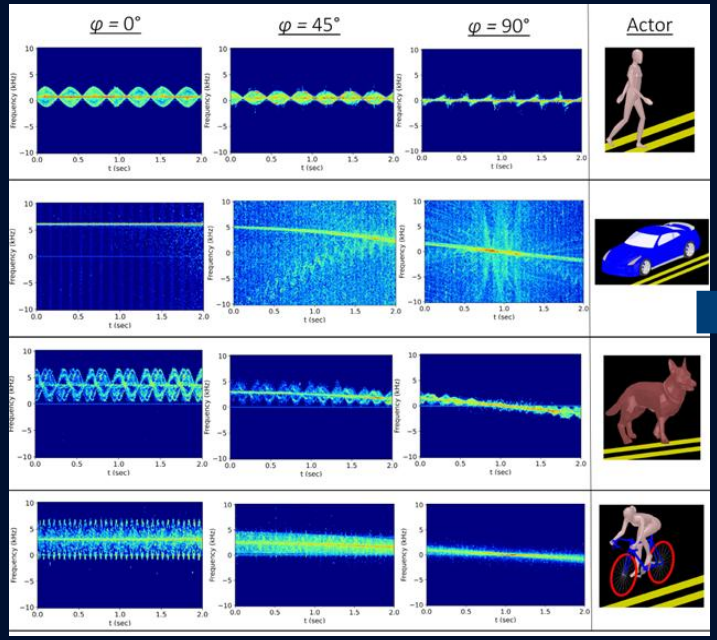
O-RU for PHY sensing tasks

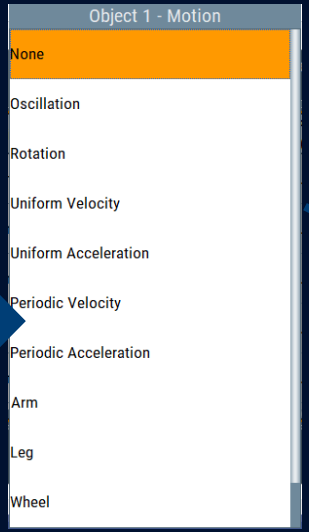
O-DU for PHY sensing analysis & evaluations

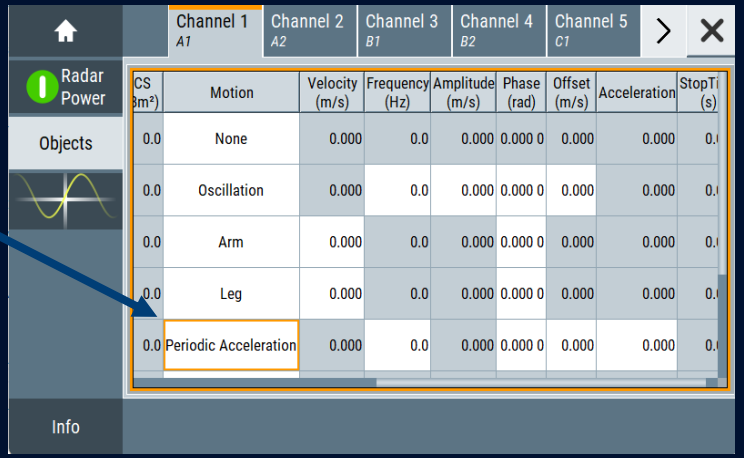
Source: Komsens-6G SysML Model

KOMSENS 6G

MICRO DOPPLER EMULATION FOR ISAC VERIFICATION





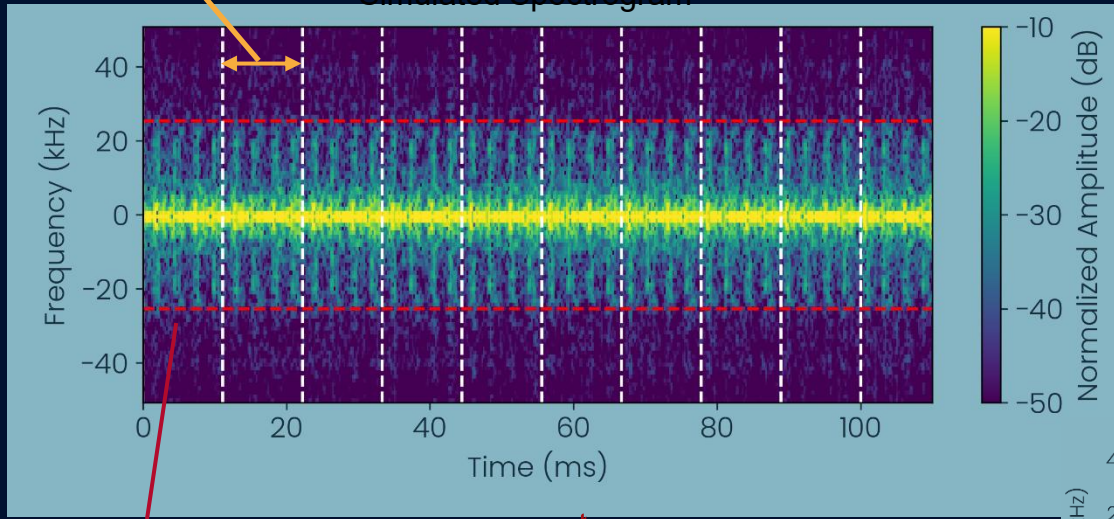


- Basic set of distinct micro doppler motions for the AREG800A
- 8 micro doppler per AREG800A channel settable

MICRO-DOPPLER SIMULATION

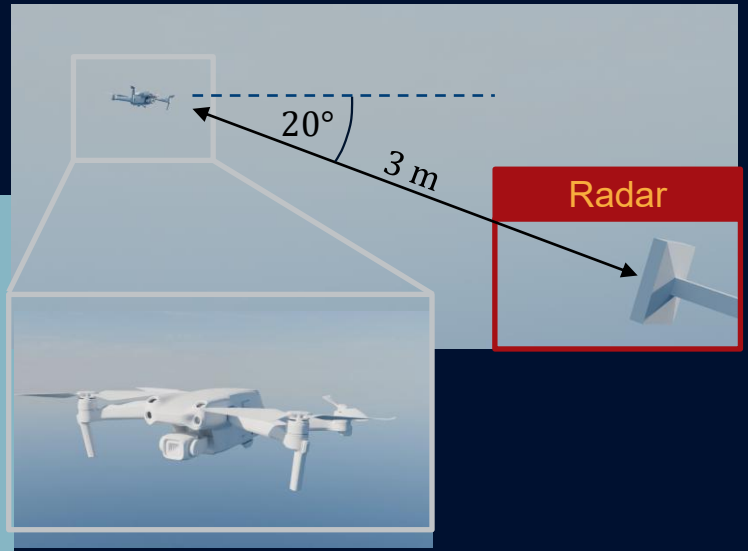
Rotor Period

Simulated Spectrogram

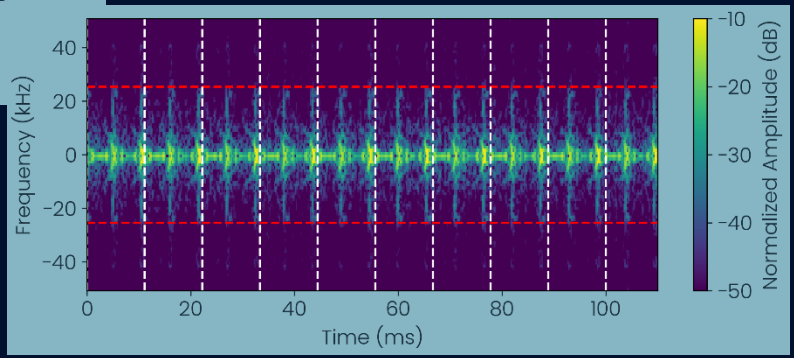


Doppler of Rotor tips

Labeling

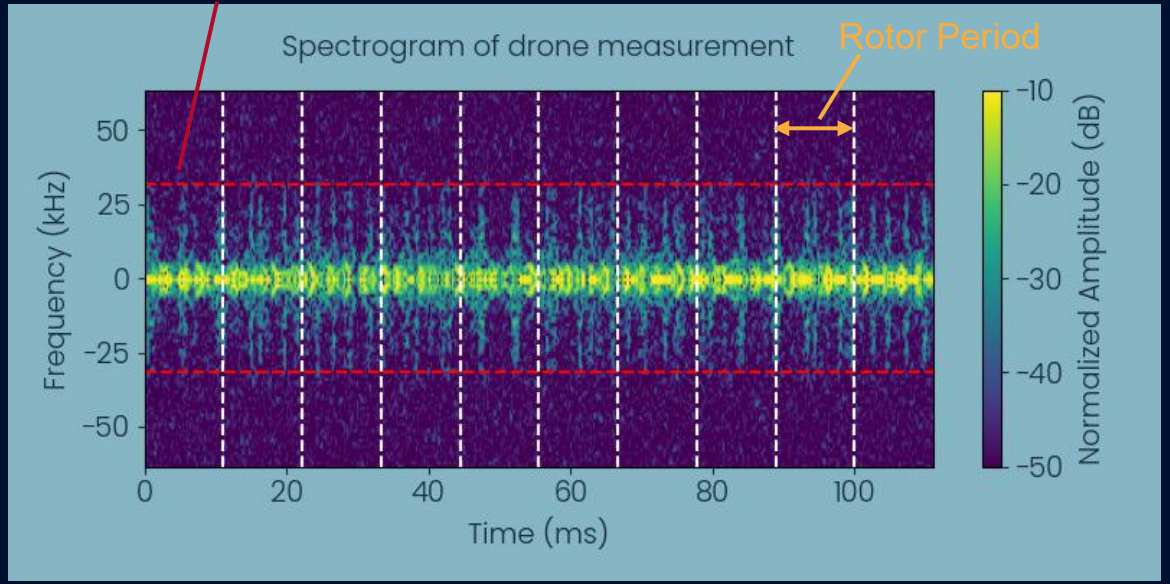


→ Extraction of individual rotor signatures



MEASUREMENT VALIDATION

Doppler of Rotor tips



ISAC TEST SOLUTION IN PRACTICE
VERIFICATION OF TRACKING ALGORITHMS

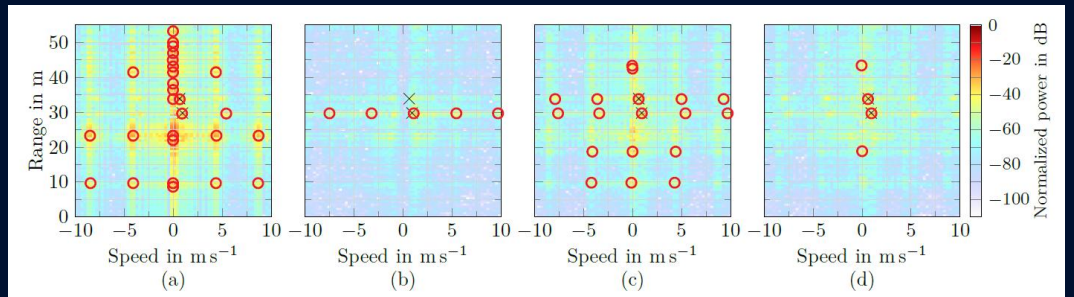


Fig. 5: Examples of measured periodograms after different steps of the processing pipeline. The ground truth objects are marked with (×) and the CFAR-detections with (○). (a) Original periodogram directly from the PoC, (b) after clutter removal with ECA-C, (c) after clutter removal with CRAP, (d) final version after TDD peak detection.

Demonstrating Multi-Object Tracking in Integrated Sensing and Communications with Real Hardware

Maximilian Bauhofer*, Marcus Henninger†, Meik Kottkamp‡, Lucas Giroto†, Philip Grill‡
Alexander Felix†, Thorsten Wild†, Stephan ten Brink*, and Silvio Mandelli†
*University of Stuttgart, Stuttgart †Nokia Bell Labs, Stuttgart ‡Rohde & Schwarz, Munich, Germany
E-mail: bauhofer@inue.uni-stuttgart.de

Source: Joint Nokia/R&S paper

OPEN QUESTIONS AROUND SENSING

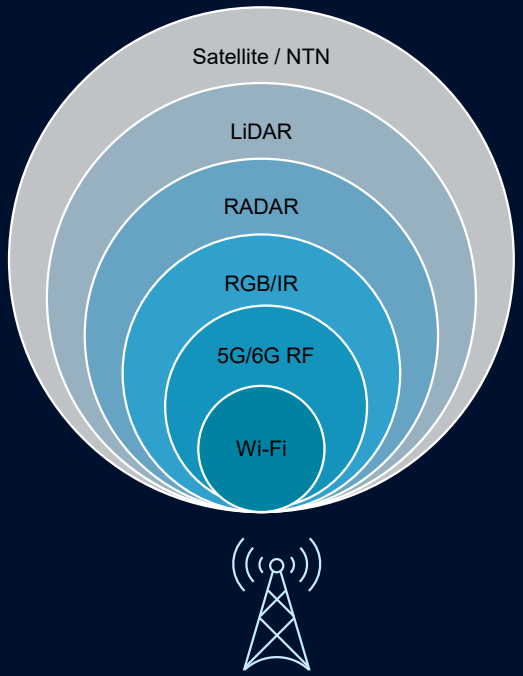
6GS sensing results types:

- Sensing data (raw, compressed)
  - Data content, format and transport interface?
    - Over-the-top on fronthaul? (possible option to start with)
- Processed sensing data
  - Object detection, localization, tracking, kinematics
  - Object classification, identification
  - Sensing related device/infrastructure capabilities

Testing considerations:

- Evaluation of sensing measurements
  - **What is reported back?**
  - External loopback: TCP/IP?
  - Evaluation inside UE/gNB based on to be agreed test models?
- KPIs / limits according to TS 38.901
- Plus communication performance
  - Throughput, EVM, ACLR…
  - Ethical aspects (sensing vs. privacy?)

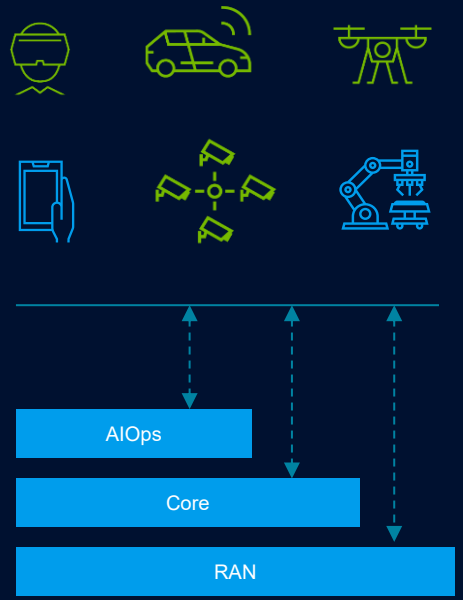
ISAC – SENSING CAPABLE NETWORKS - OUTLOOK



- Multi-modal sensor fusion
- Integrated sensing and communications (ISAC), multi-technologies

O-RAN ALLIANCE

- Extend existing xApp/rApp/dApp concepts for ISAC
- Extend interfaces to convey ISAC data
- Extend RIC, SMO concept to enable multi-technology ISAC
- Interworking for ISAC related use cases



- Integration of external apps
- Network exposure, real-time L1 integration and AI-related computing, agent protocols

THANK YOU

“No one can whistle a symphony. It takes a whole orchestra to play it.”

Halford E. Luccock (1885-1960)