

Overview of 3GPP ISAC Standardization: From 5G-A to 6G

China Telecom

June 2026

1. Overview
2. 5G-A ISAC Standardiation
3. 6G ISAC Standardization
4. ISAC Field Test

Timeline for 6G Standardization

2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

ITU-T

Use case and
requirements



ITU-R

Tech. Trends and Vision

KPI and pre-evaluation

Evaluation and Specification



2025.03

2025.06

2027.03

2029.03

Rel-20

Rel-21

6G workshop

6G LOGO
(Apr. 2024)

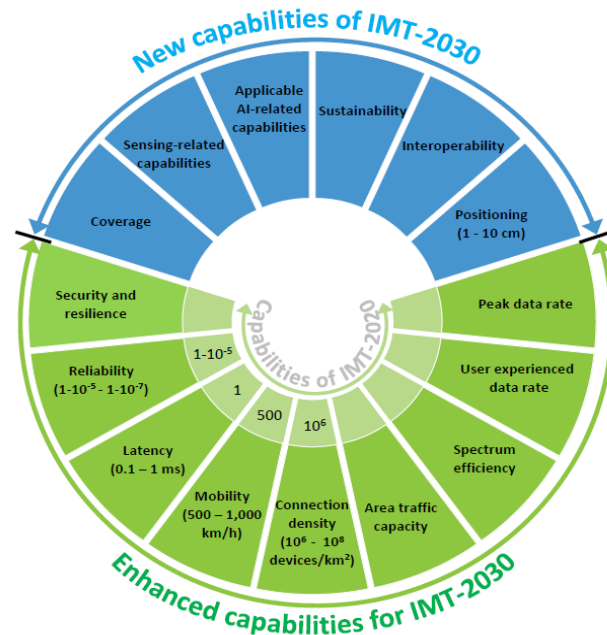
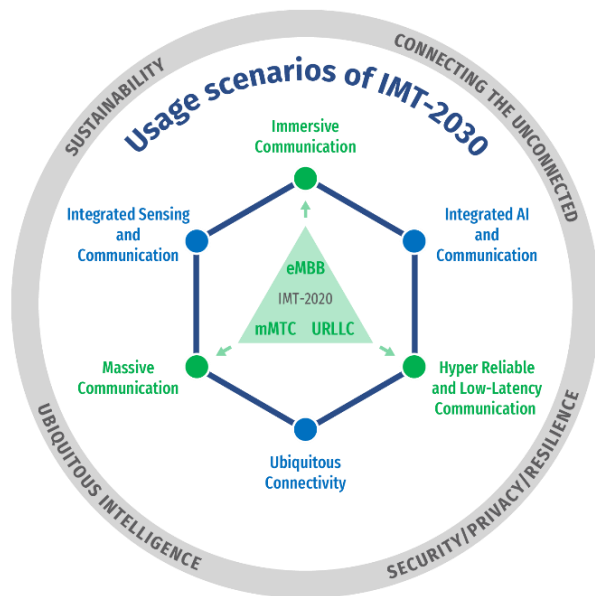


Phase 1
2024
Requirements

Phase 2
2025
Tech. study

Phase 3
2027
Specification

2029
Freeze of first 6G
version



5G Extension

- Immersive Comm.
- Massive Comm.
- HRLLC

+ New Scenarios

- Integrated AI
- Integrated Sensing
- Ubiquitous Connectivity

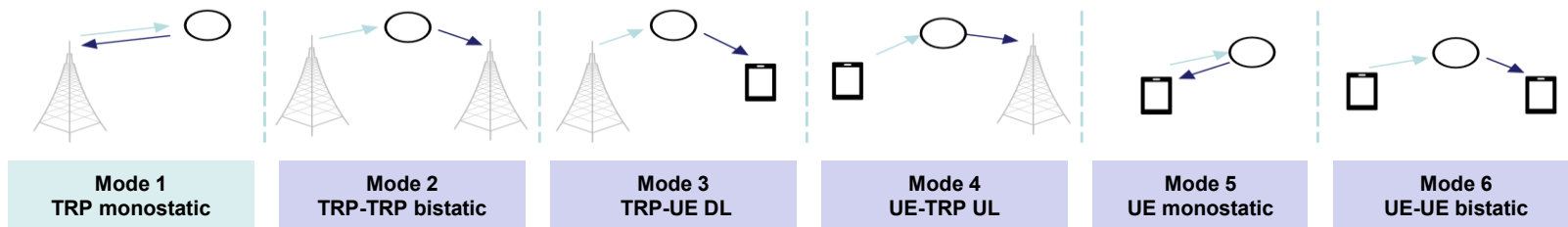
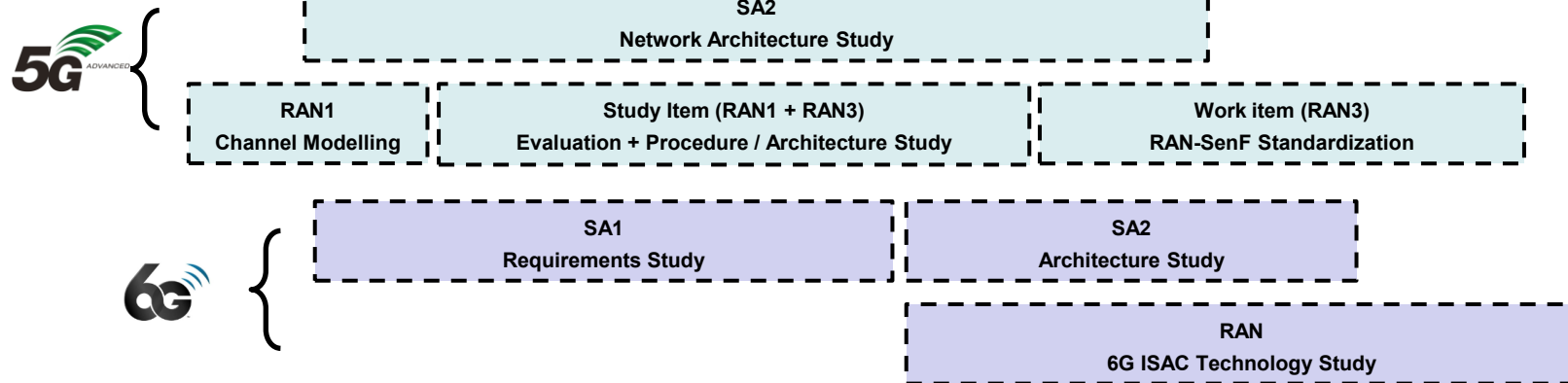
Enhancement

- Connection density
- Mobility
- Latency
- Reliability
- Security & resilience
- Peak data rate
- User data rate
- Spectrum efficiency
- Area traffic capacity

+ New Capability

- Sensing
- AI
- Sustainability
- Coverage
- Interoperability
- Positioning

Timeline for ISAC Standardization



Typical Scenarios for ISAC

Low-altitude Economy



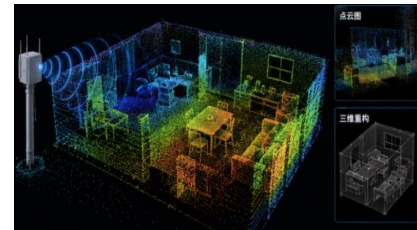
Intelligent Transportation



Smart Manufacturing



Environment Reconstruction



Smart City



Smart Home



Intrusion Detection

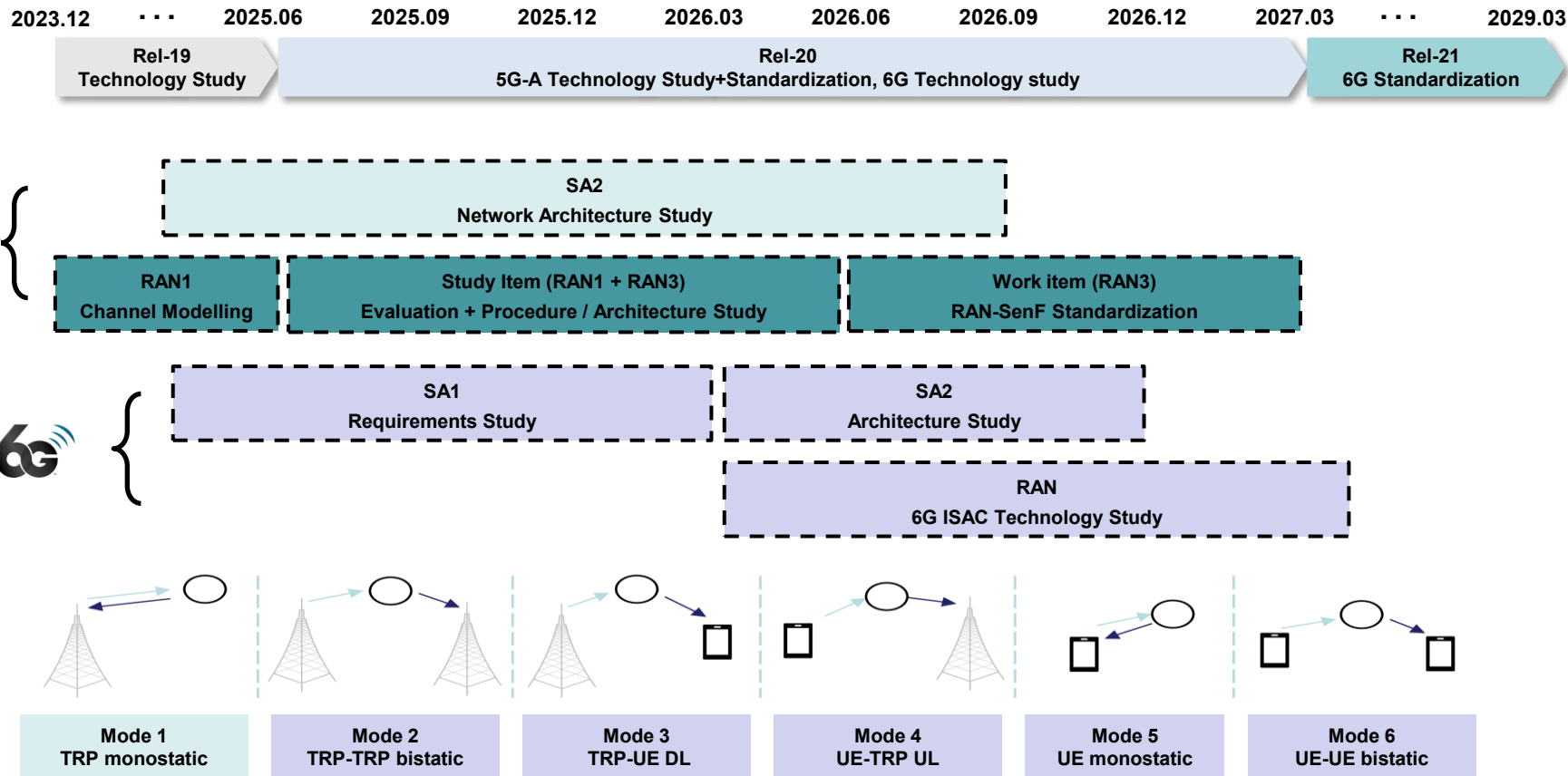


Sensing-assisted Communication

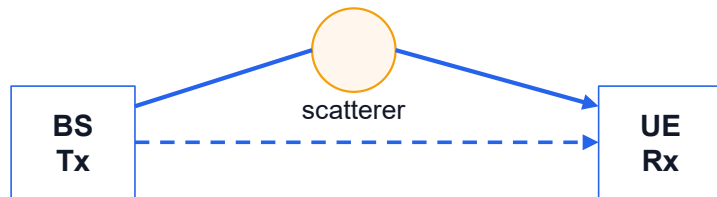


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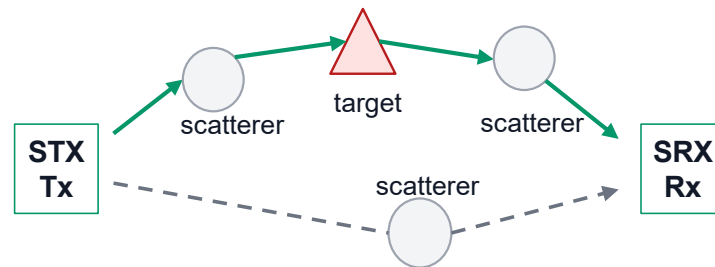
Communication Channel



Channel = sum of propagation paths

- **Modelling object:** **BS-UE propagation paths**; no explicit sensing target is required.
- **Attenuation:** Communication signal experiences Tx-Rx **one-way attenuation**.
- **Characteristics:** Modelling of **power**-related characteristics, such as **path loss, shadowing, and multi-path propagation**.
- **KPI:** Received power, coverage, SNR, delay spread and BER.

ISAC Channel



Channel = target component + background component

- **Modelling object:** Signal interaction with **sensing targets** and **surrounding background**.
- **Attenuation:** Signal follows Tx-target-Rx **double-trip attenuation**; links are concatenated.
- **Characteristics:** Modelling of **phase**-related characteristics, including **distance-dependent phase shifts and Doppler frequency shifts**.
- **KPI:** Target information such as **range, angle, velocity, RCS and phase**.

Rel-19 ISAC channel modelling SI was completed in June 2025 (TR 38.901).

Supported sensing target scenarios



ISAC-UAV

Outdoor UAVs in urban or rural areas



ISAC-Automotive

Vehicles on urban streets and highways



ISAC-Human

People in indoor and outdoor locations



ISAC-AGV

Automated guided vehicles inside factories



Road / rail hazards

Humans, animals or objects creating hazards

What ISAC channel modelling differs

Physical objects

Objects are classified as **sensing targets** (ST) or **environment objects** (EO).

Target response

Targets are represented by scattering points with **RCS** and **polarization**.

Channel components

The ISAC channel is separated into **target channel** and **background channel**.

Sensing geometry

STX/SRX can be TRPs or UEs; **mono-static** and **bi-static** modes are supported.

Fast fading path

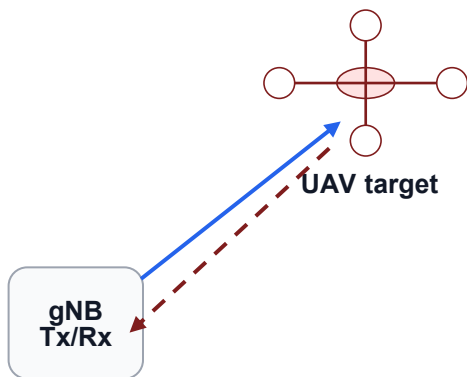
Target links are built through STX-ST and ST-SRX links, then **concatenated**.

Scene effects

Spatial consistency and **blockage** are optional extensions.

The ISAC channel modelling is scenario-specific.

gNB-based UAV sensing



**Baseline: NR
waveform + RS**

No UE impact

Study scope

Performance evaluation

Evaluate gNB-based mono-static sensing for UAV use case.

Metrics and measurements

Study sensing metrics, measurements and quantization for UAV use case.

Sensing signal

Use existing DL NR waveform and DL NR reference signals as evaluation baseline.

Procedures / architecture

Study RAN-CN signalling and network architecture to support ISAC.

Study constraints

No UE impacts, no inter-gNB coordination

Key evaluation assumptions

Scenario	UMa-AV, 500m inter-site distance
Target	UAV sensing; N = 5 targets per center-site sector
Mode	gNB monostatic
Frequency	FR1: 4 GHz or 4.9 GHz
Tx power	52 dBm or 37 dBm
Antenna	8 x 8 BS antenna array
Signal	CP-OFDM with PRS / CSI-RS

Metrics and KPI requirements

Missed detection probability (MD)	$\leq 5\%$
False alarm probability Type 1 (FA)	$\leq 5\%$
False alarm probability Type 2	$\leq 5\%$
Horizontal / vertical position (H-pos / V-pos)	10 m @90%
Velocity accuracy	5 m/s @90%

Evaluation Motivation: Whether gNB-based monostatic sensing can meet UAV sensing KPIs?

Rel-20 Study Item for ISAC: Evaluation Results

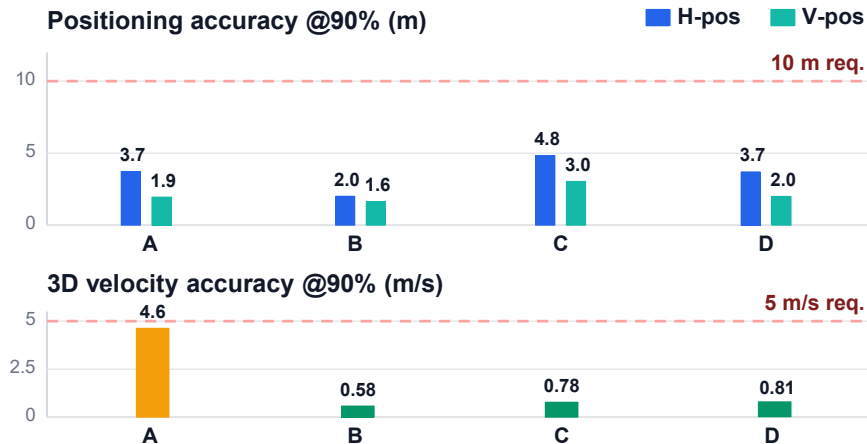
A Single-TRP, 52 dBm

B Multi-TRP, 52 dBm

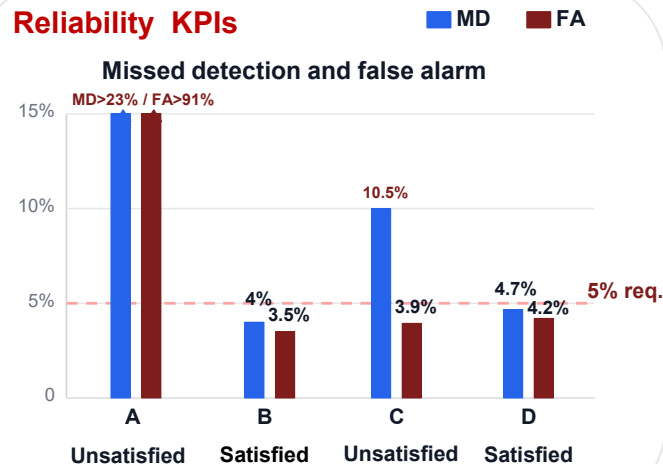
C Multi-TRP, 37 dBm

D Multi-TRP, 37 dBm, multi-beams

Accuracy KPIs



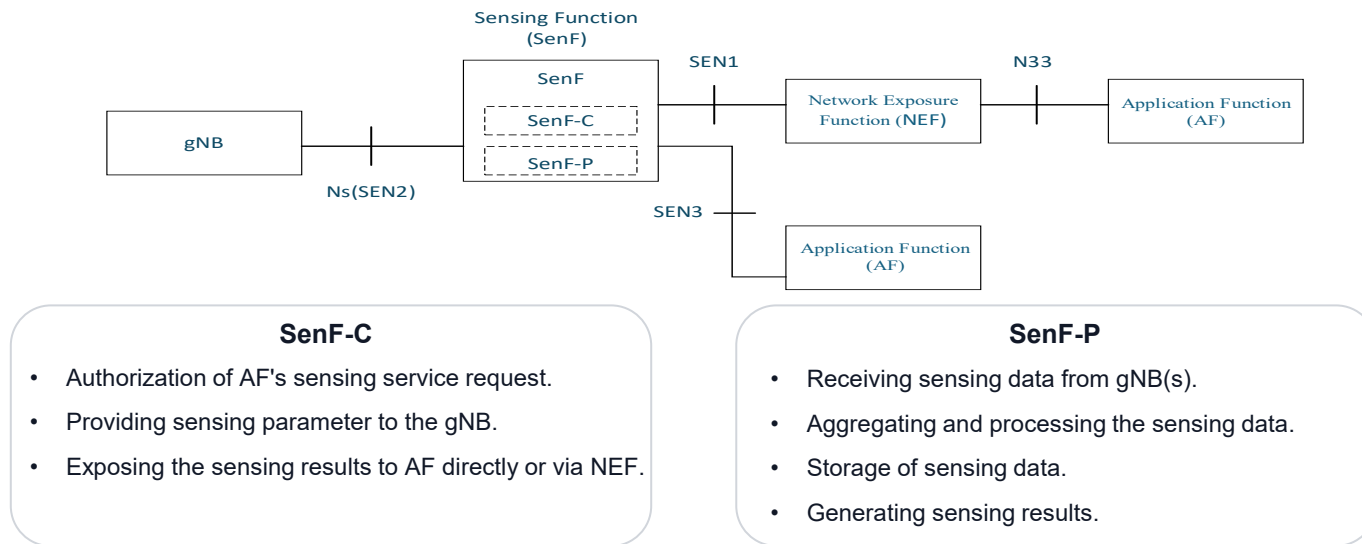
Reliability KPIs



What the evaluation results show

- **Accuracy related KPIs are easier to meet:** position & velocity accuracy can achieve the KPI requirements.
- **Multi-TRP improves performance:** cases B and D keep both MD and FA under the 5% threshold.
- **Single-TRP faces reliability challenges:** case A fails to meet MD and FA requirements.
- **Beam sweep improves performance:** case D outperforms case C, but at the cost of extra resource overhead.

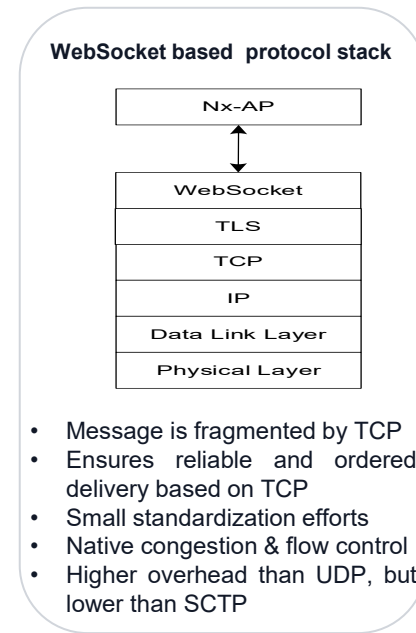
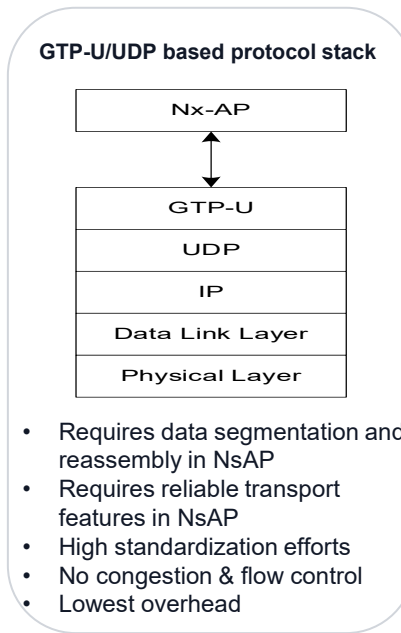
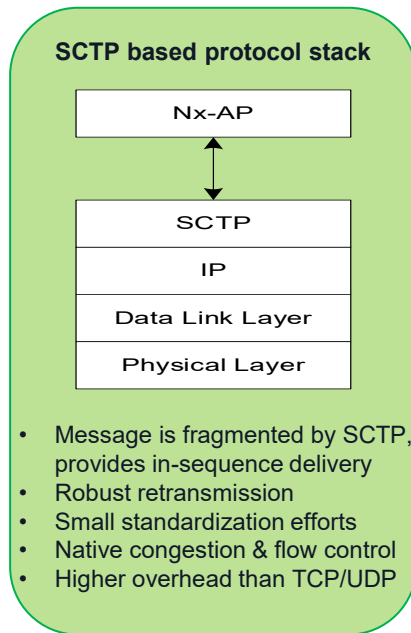
The **Sensing Function (SenF)** is a new logical network element, responsible for managing the end-to-end sensing service from request to result delivery. It contains **sensing control functionality (SenF-C)** and **sensing processing functionality (SenF-P)**.



Conclusions:

- The **Ns** is the new direct interface between the gNB and the SenF, without AMF involvement.
- The **SenF selects gNB(s) for sensing** based on at least the supported sensing area of the gNB.
- The gNB information can be provided to the SenF via OAM and/or via signalling. The **gNB decides TRP(s)** and sensing resources for sensing.

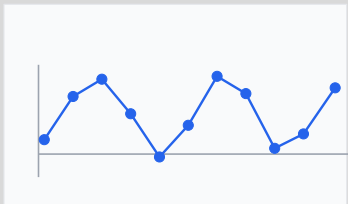
Three types of protocol stacks for signalling transmission and sensing data reporting have been studied.



- **A dedicated application protocol (NsAP)** between gNB and SenF should be adopted in a potential future normative phase.
- Ns interface adopts **SCTP Protocol Stack** for signalling transmission and sensing data report due to its good reliability and small standardization impacts.

Four types of sensing measurement reporting are studied, from raw data to objects.

A Raw data



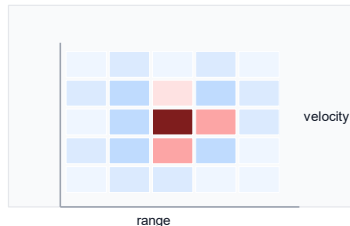
Payload: x10Gb ~ x100 Gb per TRP

gNB: transmit IQ data

SenF: IQ data → sensing result

Fusion: SenF performs full fusion
(based on raw data)

B Profile data



Payload: x10 Mb ~ x100 Gb per TRP

gNB: raw data → profile data

SenF: profile data → sensing result

Fusion: SenF performs cross-gNB
data fusion

C Path / point



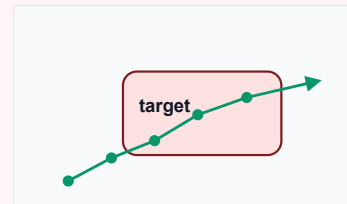
Payload: x1 Kb ~ x10 Kb per TRP

gNB: raw data → point/path data

SenF: point/path data → sensing result

Fusion: SenF performs cross-gNB
data fusion

D Object / target



Payload: x1 Kb per gNB

gNB: raw data → object position/velocity

SenF: object-level aggregation

Fusion: SenF performs object-level
aggregation across multiple gNBs.

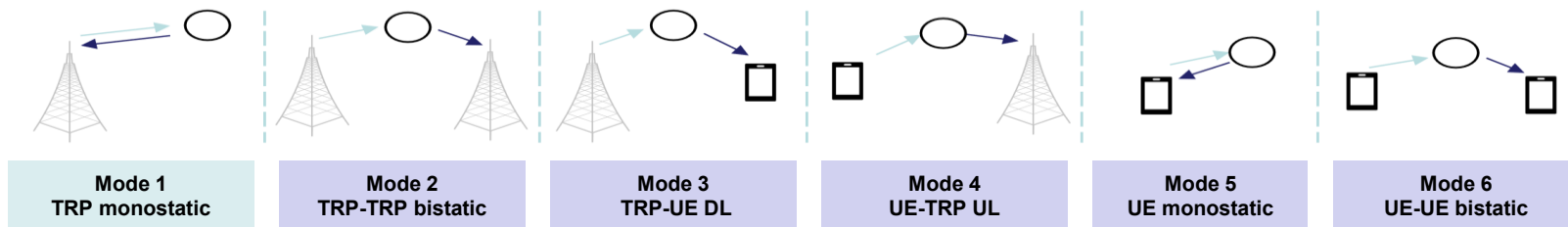
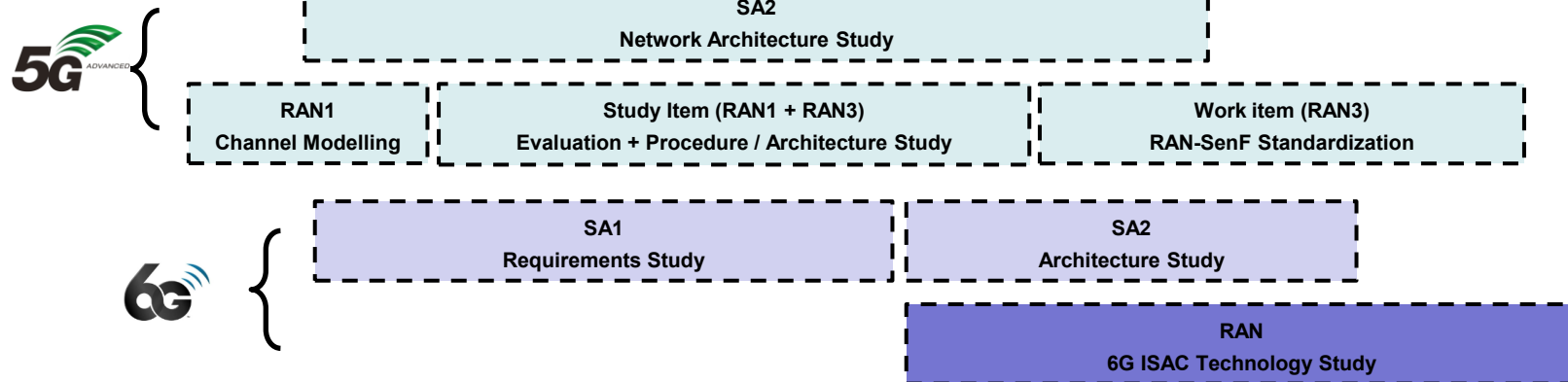
Conclusions:

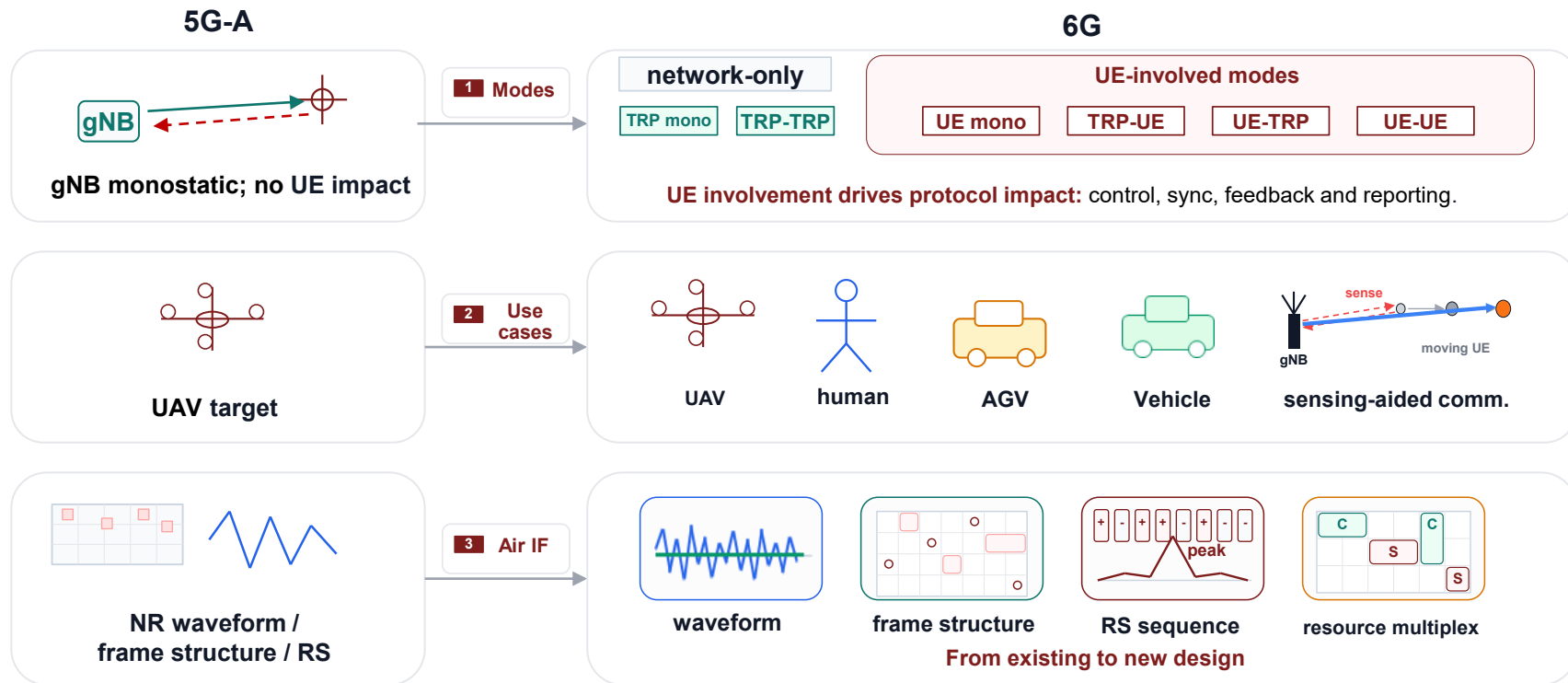
- **Level A** is not supported due to its higher transport capacity requirement.
- **Level C** is agreed for specification in a potential future normative phase.
- Whether also support **Level D** depends on the resolution of potential privacy and security issues by the appropriate WG(s).

- The objective of this Work Item is to specify **gNB-based mono-static sensing for UAV sensing target** use cases, building upon the conclusions of the ISAC Study Item as documented in TR 38.765. There will be **no UE impacts**.
- Specification of **network architecture and protocol stack** between gNB and SenF [RAN3];
 - » Applicability to intra-gNB bistatic sensing may be considered as part of this network architecture without additional architecture impacts.
- Specification of the **sensing procedures and signalling** between gNB and SenF [RAN3].
- Support for **measurement Level C and Level D**, and relevant measurement quantization for UAV use case per TR 38.765, if **security/privacy aspects** (if identified) are resolved in cooperation with SA3 [RAN3].
 - » NOTE1: It is expected that only **a subset of the measurement sub-levels** are supported.
 - » NOTE2: Coordination with RAN1 as necessary.

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6G ISAC scope: UE-involved modes + richer scenarios + new air-interface design.

Candidate Waveform

1

Reuse 6GR comm. waveform

CP-OFDM as baseline
DFT-s-OFDM for UL sensing



2

Enhance CP-OFDM / DFT-s-OFDM

PAPR, AF/correlation properties
out-of-band characteristics



3

New waveform



LFM / FMCW
Radar-native chirp



OTFS / AFDM
Doppler-oriented

Sensing TRX modes



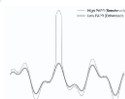
pulsed

listen

continuous



Evaluation metrics



PAPR

peak-to-average
power ratio



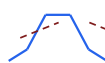
Ambiguity

main lobe width,



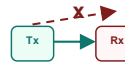
Correlation

auto / cross
property



Emission

OOBE / ACLR



Interference

self-interf.
inter-cell interf.



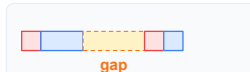
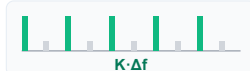
Tx power gain

PA model

Progress

- **CP-OFDM**: starting point for 6G ISAC waveform study.
- **CP-OFDM enhancement** includes PAPR/AF/correlation/out-of-band characteristics, etc.
- **Other waveforms**: not precluded.

1 Frame structure — CP extension



2 Reference signal — design principle

(time-freq pattern ⇌ sensing bounds)

Range resolution: ΔR

$$\Delta R = c / (2 \cdot B)$$



Velocity resolution: Δv

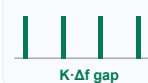
$$\Delta v = \lambda / (2 \cdot T_c)$$



longer coherent processing interval (CPI) $T_c \rightarrow$ finer velocity bins

Max unambiguous Range: R_{max}

$$R_{max} = c / (2 \cdot K \cdot \Delta f)$$



larger comb K $\rightarrow$ smaller R_{max} (overhead $\downarrow$)

Max unambiguous Velocity: v_{max}

$$v_{max} = \lambda / (4 \cdot T_{sym})$$



shorter symbol gap $T_{sym} \rightarrow$ larger v_{max}

3 Reference signal — Sequence candidates

$|S(f)|$ const



ZC / enhanced ZC

- + low PAPR; near-ideal AF; insensitive to frequency offset
- needs root-index option for cross-correlation

$\pi/2$ rot



$\pi/2$ -BPSK

- + ~2 dB PAPR; reuses DMRS chain
- loses const-amplitude in frequency

freq sweep



Chirp-like sequence

- + chirp-like AF; flexible duty cycle
- LFM challenges OFDM RX complexity

a+b flat



QCSS (complementary)

- + low PSLR via complementary set
- higher resource overhead

shaped



FDSS shaping

- + tunable AF main-lobe / PSLR
- needs matched RX shaping

pulse

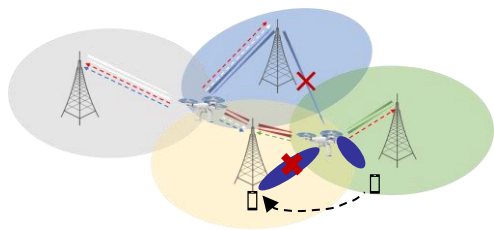


FMCW/LFM

- + ultra-low PAPR; radar-native
- Compatibility with OFDM; guard time needed

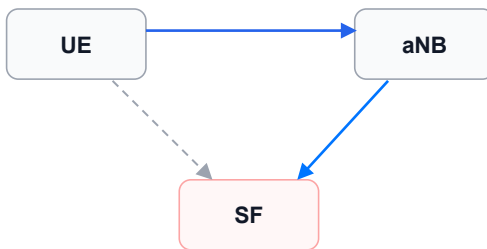
6G ISAC functions and signaling design shall consider **sensing entity selection, UE capability reporting, sensing measurement and reporting, sensing configuration, and data/control transport.**

Sensing Entity (Re-)Selection



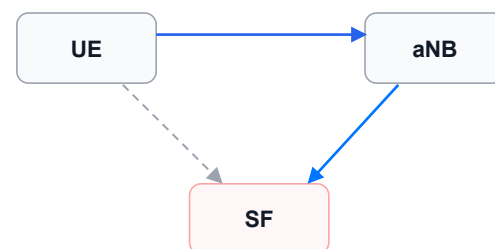
- **Sensing entity:** A physical node or logical network element within the network architecture that is **responsible for performing physical layer wireless sensing measurements.**
- Support **aNB/UE discovery** and **fast (re-)selection** for sensing continuity
 - The mobility of targets and sensing UEs may interrupt sensing services

UE Capability Reporting



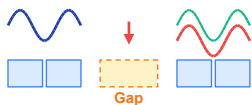
- Whether the aNB acquires **the UE's sensing capabilities** or not?
- **Static capabilities:** Supported sensing modes, Number of transceiver antenna panels ...
- **Dynamic capabilities:** Power, RRC state, CSI ...

Measurement and Reporting



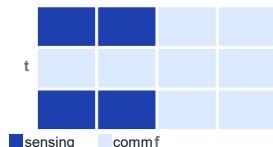
- Do the **sensing data measurement levels** need to be unified between the UE and the aNB?
- Whether the aNB acquires **the UE's sensing results** or not?
- Event-triggered / periodic / on-demand / location-based reporting?

Phase continuity



- **Impact factor:** U/D switch, TA frequency-hopping, etc
- **Maintain** within capability window
- **Recover** via RS cross-Gap stitching

Resource multiplexing



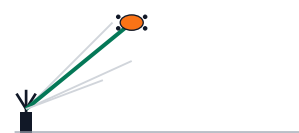
- **TDM / FDM** main directions (CDM/SDM minor)
- **Collision handling or signal sharing**

Interference handling



- **Intra-sensing** interference (e.g.: UAV LOS signal of other TRPs)
- **Sensing** ↔ **comm** coordination
- **Handling:** start from communication framework

Beam management for RS



- **Start from** communication beam management framework
- **Sensing beam** ≠ best comm beam

Power control / allocation

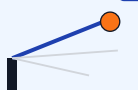


- **Pathloss reference:** STX-target-SRX path
- **Constant power** in CPI (← phase continuity)
- **May Independent** from communication Power control

★ Sensing-aided communication — 7 use cases (to identify ≥1 representative)

Beam mgmt.

High



CSI acquisition

High



Mobility

Medium



Power saving

Medium



Resource / Link Adaptation

Low



Channel estimation

Low



Power control

Low



Progress

- **Phase continuity:** study CPI definition, break causes, maintain/recover, impact on reporting, etc.
- **Resource multiplex:** study TDM/FDM/CDM/SDM/PDM within sensing & sensing-communication.
- **Beam / Power / Interference:** study necessity & spec impact; take communication framework as starting point.
- **Sensing-aided communication:** identify ≥1 representative use case.

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Challenges

1. Single-Band Limitations

Low-frequency lacks resolution, while high-frequency lacks wide coverage.

2. Scenario Diversity

Sensing targets in different scenarios exhibit different characteristics, requiring specific consideration.

3. Target Identification

Although RF sensing is capable of target detection, it faces difficulties in target identification.

Solutions

Multi-Band

FR1 & FR2

- sub-6GHz: e.g., 3.5GHz
- mmWave: Offers better precision
- Overcomes the single-band limitations, achieving simultaneous wide-area coverage and high-accuracy positioning

Multi-class targets

UAV & Vessel

- Targets include fast UAV and far vessel
- Verify Multi-Band cooperative system adaptability under maritime and low-altitude scenarios

Multi-Modal

RF + Optical Fusion

- Eliminates target identification ambiguity
- Successfully distinguish targets from interference like balloons

3.5GHz Maritime Vessel Sensing Test



China Telecom has conducted 3.5 GHz maritime vessel sensing test

- Long-range sensing, up to 1.6km
- Meter-level sensing precision
- Sensing and communication resources with frequency division multiplexing to achieve zero communication interruption

3.5GHz and mmWave Collaborative UAV Sensing Test



China Telecom has conducted 3.5GHz and mmWave collaborative low-altitude UAV sensing test

- 26GHz offers sub-meter sensing precision, 3.5GHz provides extensive coverage
- Verify the performance gain of multi-frequency collaboration
- Under rain and fog conditions

Thanks!
