ISAC

Experimentation with OpenAirInterface

24 March 2026

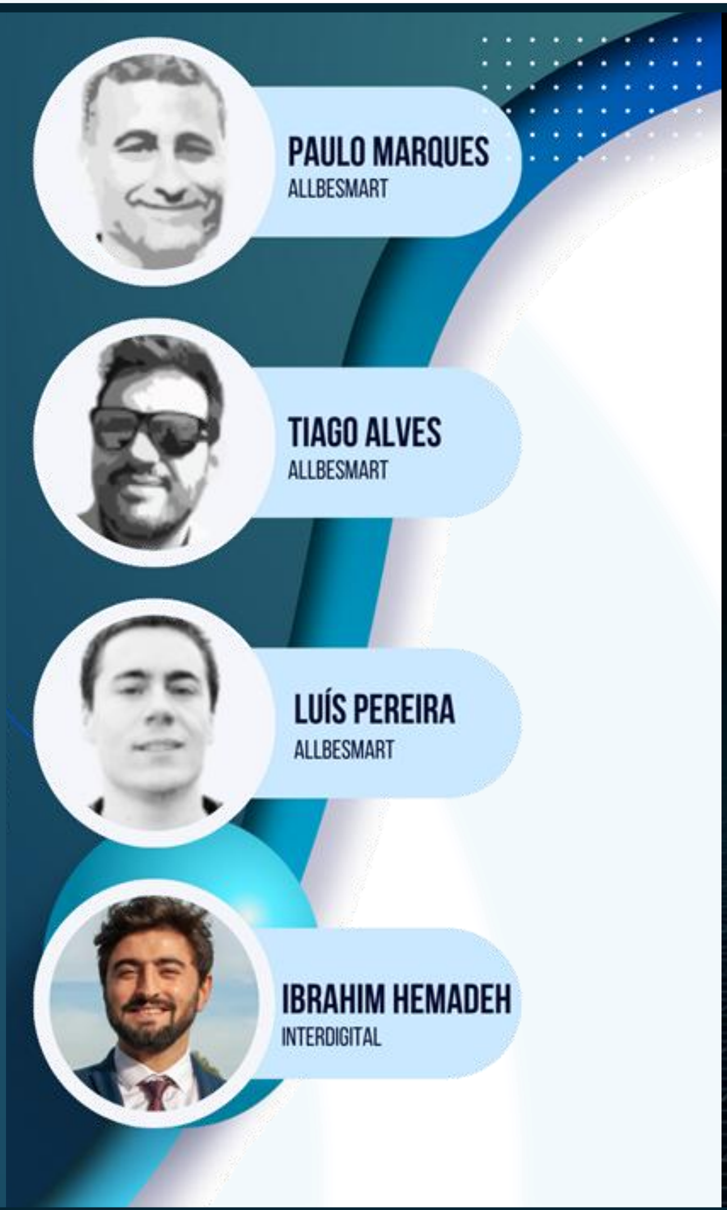
CONVERGE
view-to-communicate and communicate-to-view

Co-funded by the European Union

The CONVERGE project has received funding under the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101094831, including top-up funding by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee.

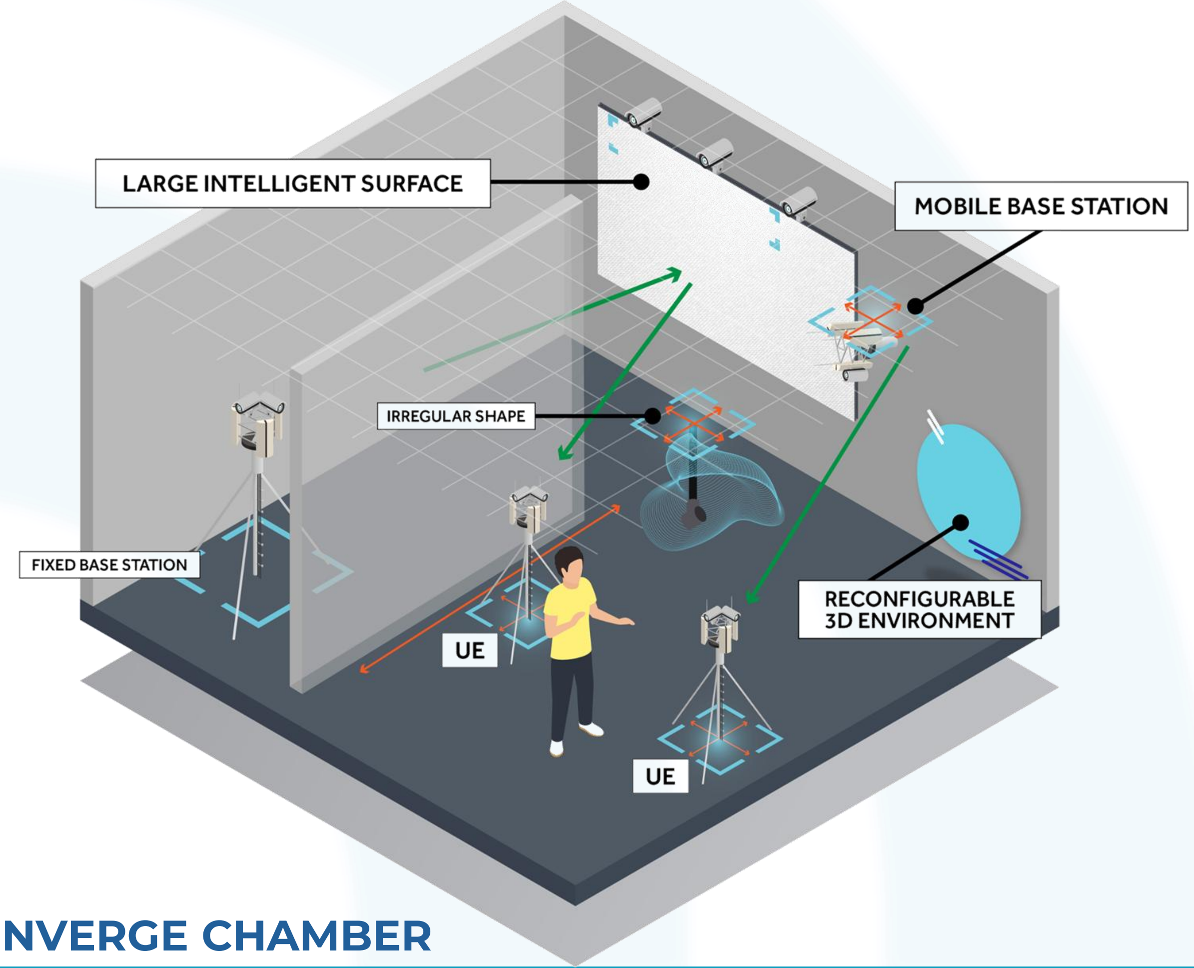
OPEN AIR INTERFACE

Today's speakers



Horizon Europe CONVERGE project

- The CONVERGE project develops a research infrastructure that combines radio, vision, and sensing technologies to enable new research areas based on the motto "view-to communicate and communicate-to-view".



CONVERGE CHAMBER

https://converge-project.eu/

CONVERGE
view-to-communicate and communicate-to-view

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Webinar agenda

- ISAC motivation, use cases and applications
- Industry perspectives and standardisation in ISAC
- 3GPP 5G reference signals applicable to ISAC
- Live demo: Counting people in a corridor using 5G ISAC
- Extracting 5G channel estimate from the OAI stack for ISAC
- Q&A session

Webinar material

- Slides will be available
- Code available in the OAI repository for experiment replication
  - https://gitlab.eurecom.fr/oai/openairinterface5g/-/tree/srs-ttracer
- Contact us
  - www.oaibox.com
  - pmarques@allbesmart.pt

ISAC motivation, use cases and applications

ISAC background

- Integrated Sensing and Communication (ISAC) is emerging as a key capability for 6G, enabling the joint use of radio spectrum and network infrastructure for both environmental sensing and data transmission.
- ISAC can detect passive objects not connected to the network, like radar technology.
- With ISAC Mobile Network Operators can reuse their cellular infrastructure as a sensing network, enabling detection without the privacy concerns associated with cameras and reaching areas where video surveillance cannot operate – new monetization opportunity.

Source: Huawei

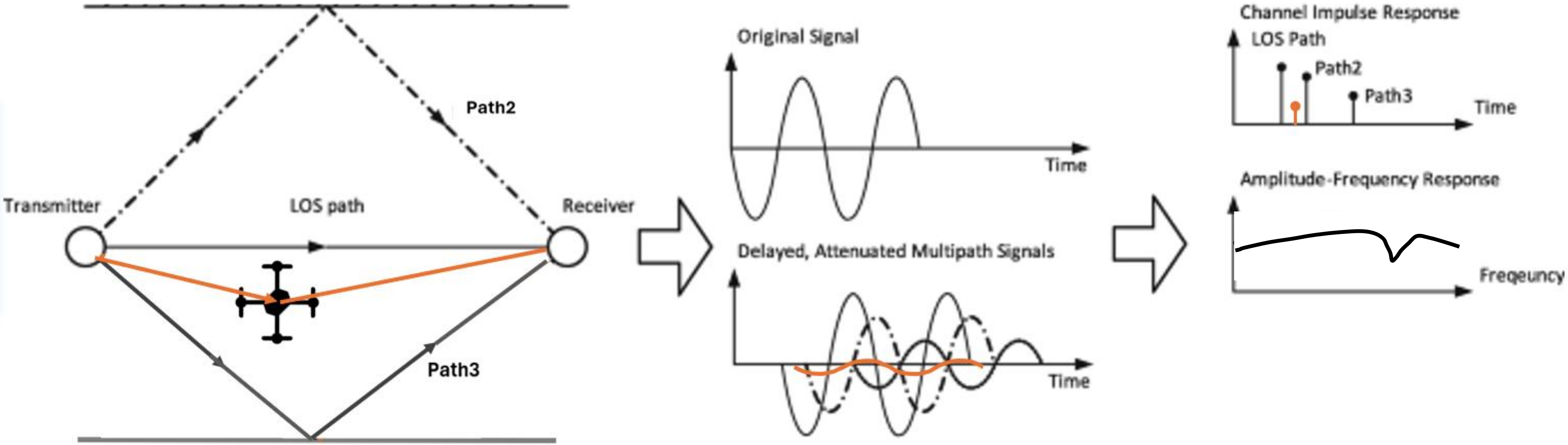
Examples of ISAC use cases included in 3GPP TR 22.837

- Intruder detection
  - Detecting human movement inside homes or restricted areas.
- Object detection and tracking
  - Detection of vehicles, pedestrians.
- UAV sensing
  - UAV trajectory tracking and collision avoidance.
- Smart infrastructure monitoring
  - Monitoring structural deformation or infrastructure collapse.
- Industrial sensing
  - Monitoring robots, production flows, or hazardous situations in factories.
- Environmental sensing
  - Weather monitoring, rainfall, flooding detection.
- Automotive and road safety
  - Detecting vehicles or pedestrians at intersections

How ISAC works ?

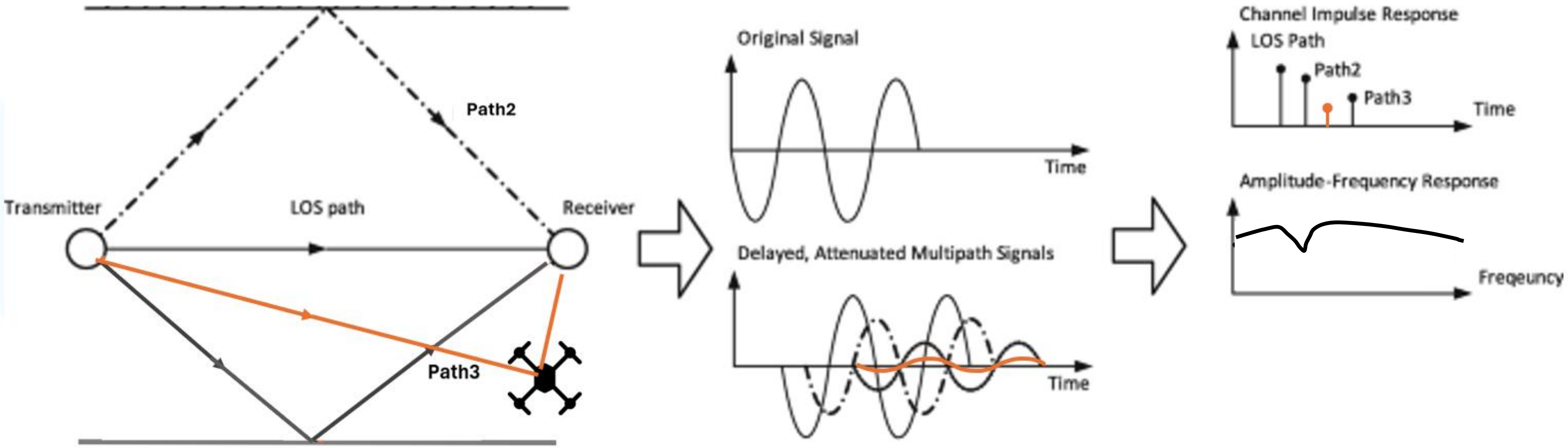
- By estimating the radio Channel Impulse Response / Channel Frequency Response an ISAC node detects week changes in the radio propagation channel which correspond to the human/object’s presence, and trajectory.
- AI/ML models can learn these complex patterns for reliable detection.
- No need of dedicated radio spectrum for environment sensing.

Leveraging the rich multipath channel state information for ISAC



The drone appears as extra multipath in the CIR
Movement create Doppler shift
Object detection

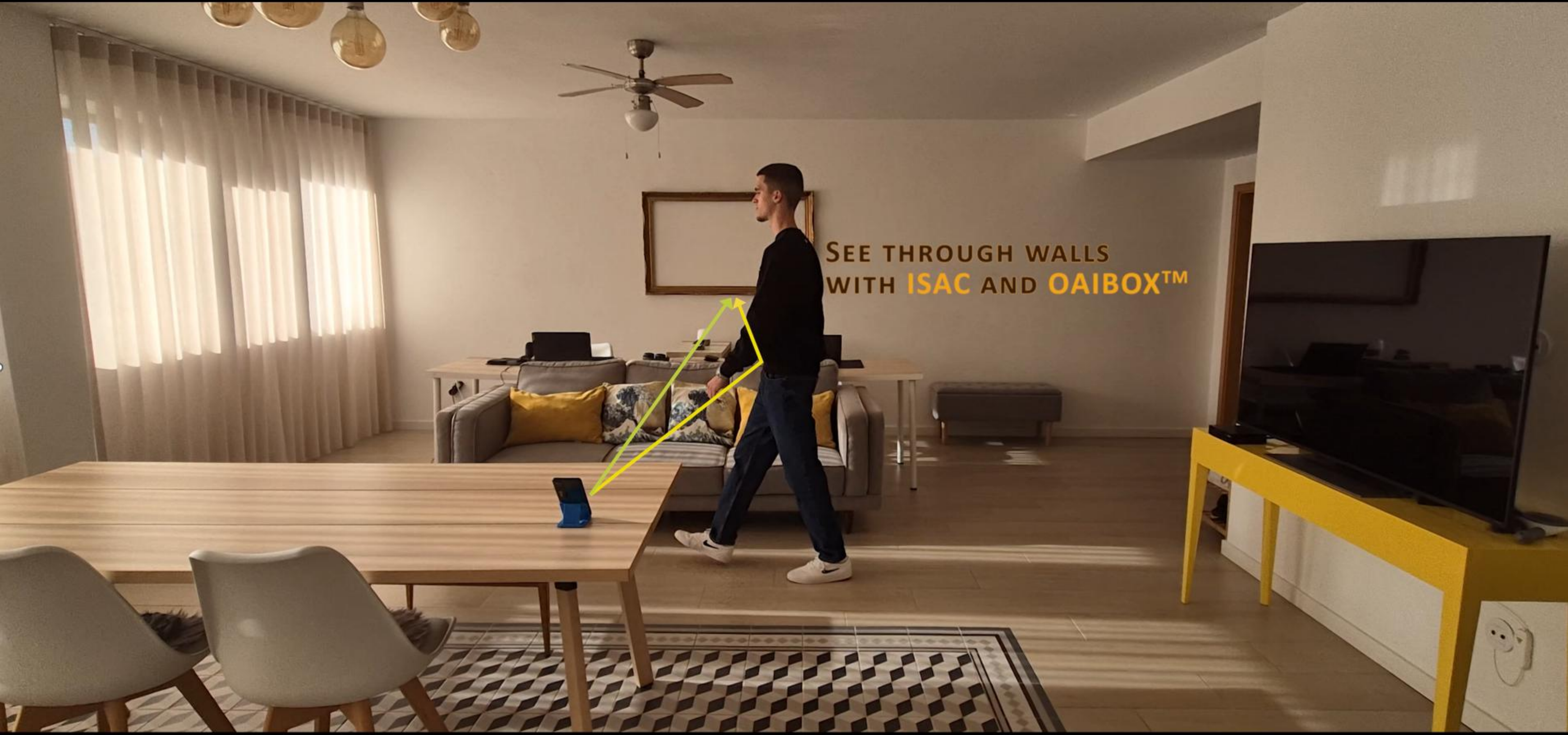
Leveraging the rich multipath channel state information for ISAC



The drone appears as extra multipath in the CIR
Movement create Doppler shift
Object detection


SEE THROUGH WALLS
WITH ISAC AND OAIBOX™
UE
iPhone


HUMAN MOVEMENT CHANGES
THE MULTIPATH RADIO CHANNEL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SEE THROUGH WALLS
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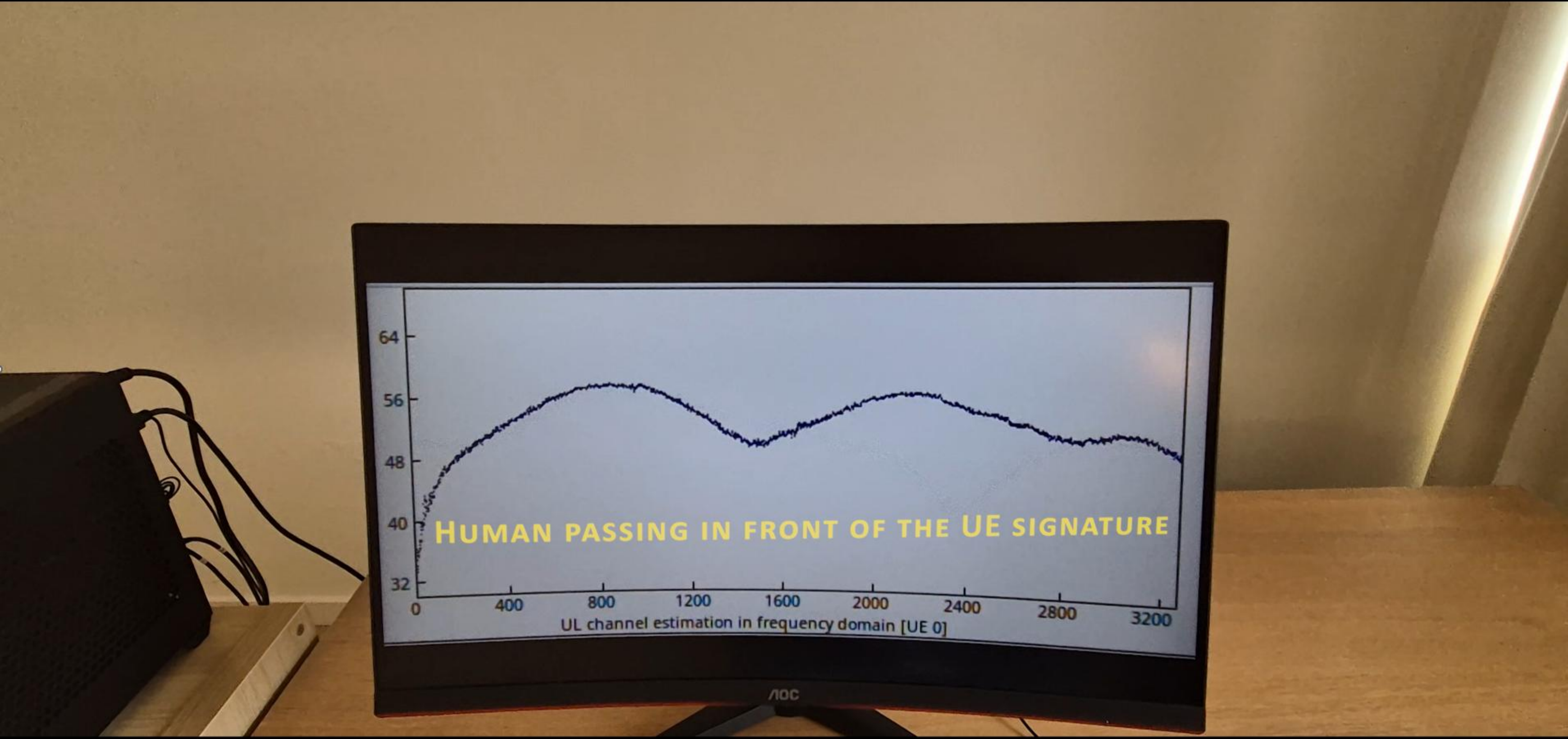
SEE THROUGH WALLS
WITH ISAC AND OAIBOX™


SURVEILLANCE ROOM
Deep fading
OAIBOX
MAX
USRP X410
EMERSON
5G gNB
Real time 100 MHz radio channel
(estimated based on SRS)


OAIBOX
MAX
allbesmart
64
56
48
40
32
0
400
800
1200
1600
2000
2400
2800
3200
UL channel estimation in frequency domain [UE 0]



64
56
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UL channel estimation in frequency domain [UE 0]
HUMAN PASSING IN FRONT OF THE UE SIGNATURE

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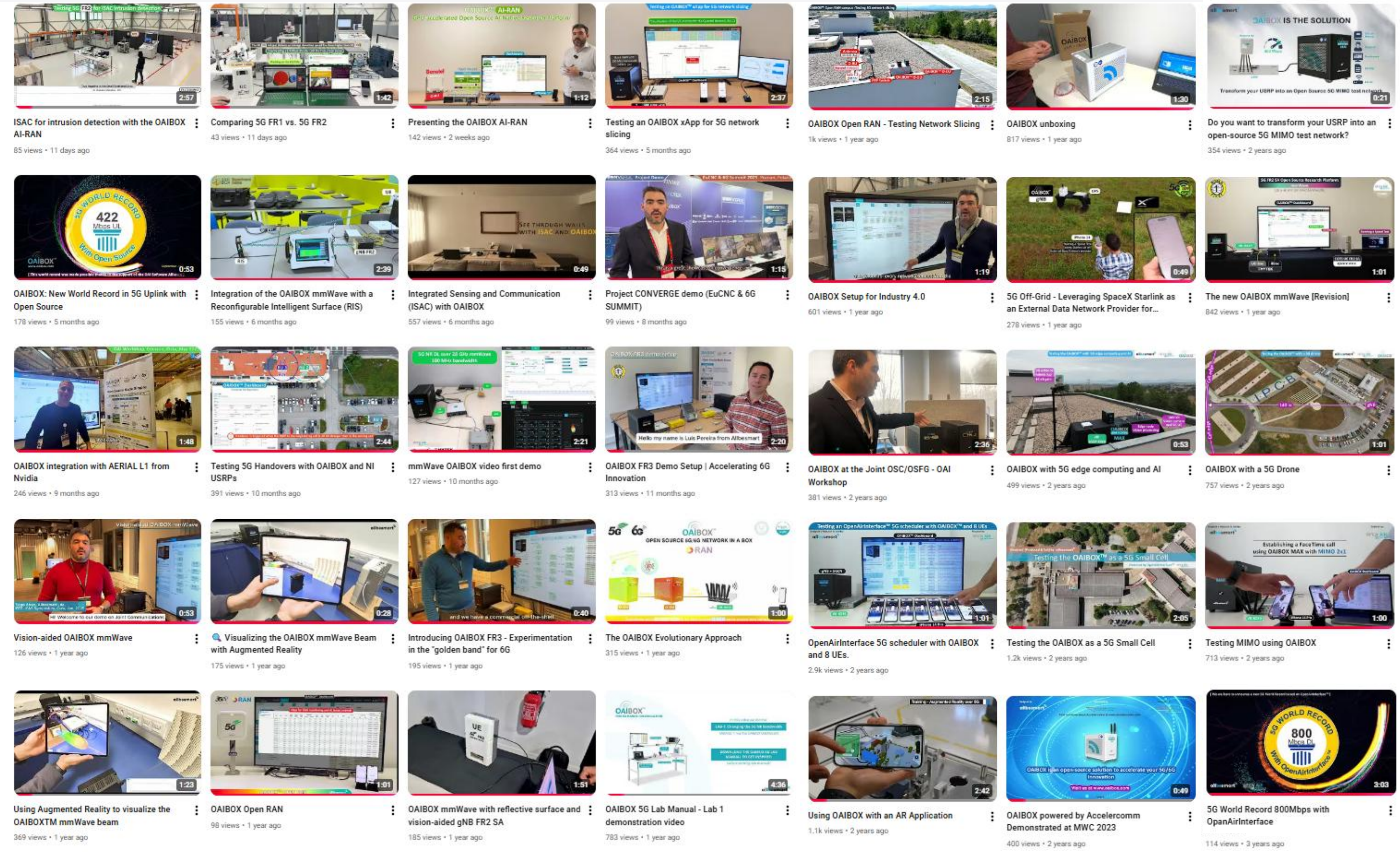
CHECK OUR USE CASE DEMOS ON YOUTUBE

www.youtube.com/@allbesmart



Industry Perspectives on ISAC

Updates from ITU, 3GPP and ETSI

By: Ibrahim Hemadeh

24-March-2026

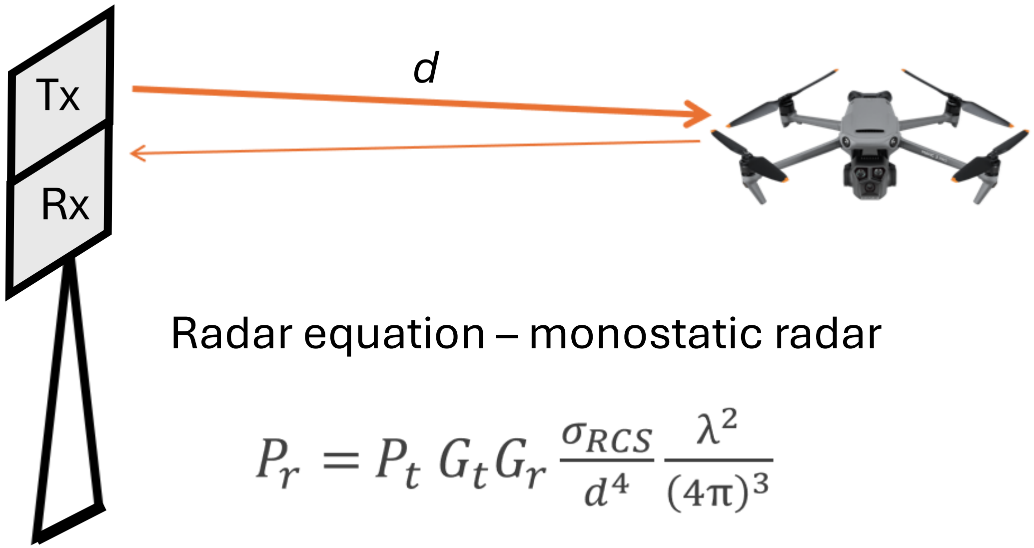
3GPP 5G reference signals applicable to ISAC

ISAC with 5G

- We don’t not need to wait for full 6G standardization to start benefiting from ISAC use cases. Many applications can already leverage existing 5G infrastructure and available radio spectrum.
- OpenAirInterface, through its open-source gNB and UE stacks, provides access to 5G reference signals that can already be used for ISAC experimentation using today’s 5G waveforms.

Radar signal bandwidth versus range resolution

- Distance estimate: $d = c.\frac{\Delta\tau}{2}$
- Time resolution: $\Delta\tau = \frac{1}{BW}$
- Range resolution: $\Delta R = c.\frac{\Delta\tau}{2} = \frac{c}{2BW}\ [m]$



Radar equation – monostatic radar

$$P_r = P_t\, G_t G_r \frac{\sigma_{RCS}}{d^4} \frac{\lambda^2}{(4\pi)^3}$$

- Minimum separation between two targets that allows the radar to resolve them as distinct objects (Physics limit).

3GPP is working on ISAC channel models

Bandwidth	Range resolution
20 MHz	7.5 m
100 MHz	1.5 m
400 MHz	37.5 cm
1 GHz	15 cm

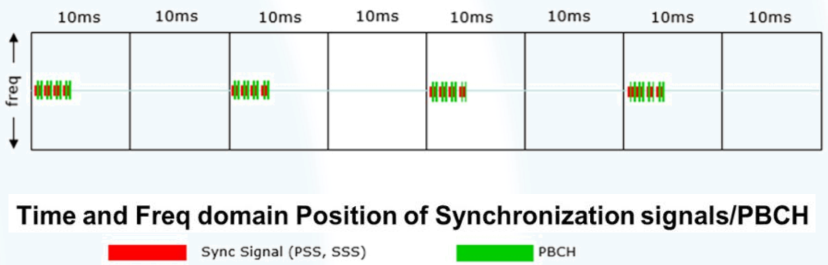
ISAC using 5G reference signals

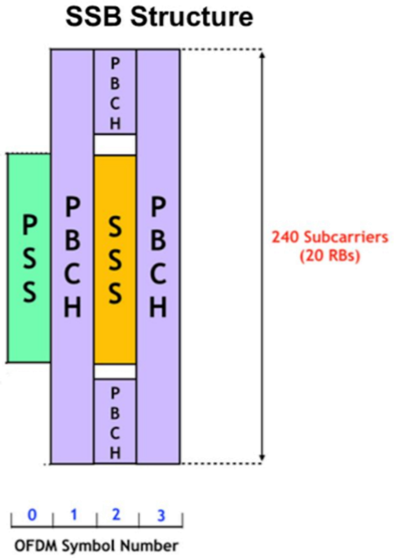
1. ISAC using **5G downlink reference signals**, sensing is done in the UE side
   - SSB
   - CSI-RS
2. ISAC using **5G uplink reference signals,** sensing is done in the gNB side
   - SRS

ISAC using 5G downlink SSB – sensing is done in the UE side

ISAC using 5G downlink SSB

- Synchronization Signal Block (SSB) is a broadcast signal, transmitted periodically by the gNB and is received by all UEs in the cell without any prior connection
- In 5G, SSB includes :
  - PSS (Primary Synchronization Signal)
  - SSS (Secondary Synchronization Signal)
  - PBCH (Physical Broadcast Channel)
- ISAC doesn't require prior access to the network's configurations
- Sensing is done on the UE (ISAC node) side
- SSB BW = 240 x SCS, for SCS=30 kHz → 7.2 MHz
- Range resolution: $\Delta R = \frac{c}{2BW} = 20.8\ m$





Source: 5G | ShareTechnote

ISAC using 5G downlink CSI-RS – sensing is done in the UE side

ISAC using 5G downlink CSI-RS

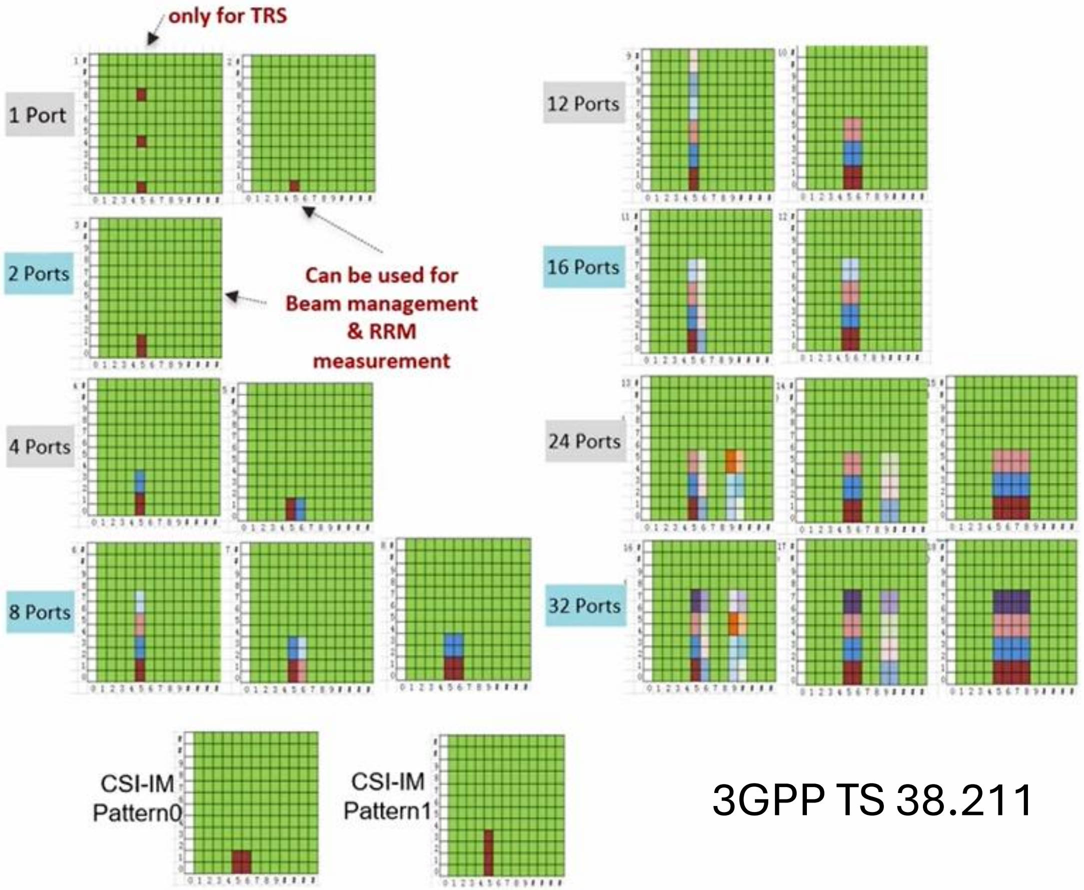
- Channel State Information Reference Signals (CSI-RS) enables downlink channel estimation by the UE
- The combination of wide bandwidth, beamforming, and configurable transmission patterns allows CSI-RS based sensing to achieve high spatial and temporal resolution
- ISAC requires prior access to the network's CSI-RS configurations
- 5G CSI-RS maximum BW = 100 MHz
- Range resolution: $\Delta R = \frac{c}{2BW} = 1.5\ m$
- 3GPP TS 38.211, 38.214 and 38.212

ISAC using 5G downlink CSI-RS

FREQUENCY & Time DOMAIN STRUCTURE OF CSI-RS CONFIGURATIONS(1)

Table 7.4.1.5.3-1: CSI-RS locations within a slot.

Row	Ports X	Density ρ	*cdm-Type*	$(\bar{k},\bar{l})$	CDM group index j	k'	l'
1	1	3	noCDM	$(k_0,l_0),(k_0+4,l_0),(k_0+8,l_0)$	0,0,0	0	0
2	1	1, 0.5	noCDM	(k_0,l_0),	0	0	0
3	2	1, 0.5	fd-CDM2	(k_0,l_0),	0	0, 1	0
4	4	1	fd-CDM2	$(k_0,l_0),(k_0+2,l_0)$	0,1	0, 1	0
5	4	1	fd-CDM2	$(k_0,l_0),(k_0,l_0+1)$	0,1	0, 1	0
6	8	1	fd-CDM2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0)$	0,1,2,3	0, 1	0
7	8	1	fd-CDM2	$(k_0,l_0),(k_1,l_0),(k_0,l_0+1),(k_1,l_0+1)$	0,1,2,3	0, 1	0
8	8	1	cdm4-FD2-TD2	$(k_0,l_0),(k_1,l_0)$	0,1	0, 1	0, 1
9	12	1	fd-CDM2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0),(k_4,l_0),(k_5,l_0)$	0,1,2,3,4,5	0, 1	0
10	12	1	cdm4-FD2-TD2	$(k_0,l_0),(k_1,l_0),(k_2,l_0)$	0,1,2	0, 1	0, 1
11	16	1, 0.5	fd-CDM2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0),(k_0,l_0+1),(k_1,l_0+1),(k_2,l_0+1),(k_3,l_0+1)$	0,1,2,3, 4,5,6,7	0, 1	0
12	16	1, 0.5	cdm4-FD2-TD2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0)$	0,1,2,3	0, 1	0, 1
13	24	1, 0.5	fd-CDM2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_0,l_0+1),(k_1,l_0+1),(k_2,l_0+1),(k_0,l_1),(k_1,l_1),(k_2,l_1),(k_0,l_1+1),(k_1,l_1+1),(k_2,l_1+1)$	0,1,2,3,4,5, 6,7,8,9,10,11	0, 1	0
14	24	1, 0.5	cdm4-FD2-TD2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_0,l_1),(k_1,l_1),(k_2,l_1)$	0,1,2,3,4,5	0, 1	0, 1
15	24	1, 0.5	cdm8-FD2-TD4	$(k_0,l_0),(k_1,l_0),(k_2,l_0)$	0,1,2	0, 1	0, 1, 2, 3
16	32	1, 0.5	fd-CDM2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0),(k_0,l_0+1),(k_1,l_0+1),(k_2,l_0+1),(k_3,l_0+1),(k_0,l_1),(k_1,l_1),(k_2,l_1),(k_3,l_1),(k_0,l_1+1),(k_1,l_1+1),(k_2,l_1+1),(k_3,l_1+1)$	0,1,2,3, 4,5,6,7, 8,9,10,11, 12,13,14,15	0, 1	0
17	32	1, 0.5	cdm4-FD2-TD2	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0),(k_0,l_1),(k_1,l_1),(k_2,l_1),(k_3,l_1)$	0,1,2,3,4,5,6,7	0, 1	0, 1
18	32	1, 0.5	cdm8-FD2-TD4	$(k_0,l_0),(k_1,l_0),(k_2,l_0),(k_3,l_0)$	0,1,2,3	0,1	0,1, 2, 3



3GPP TS 38.211

CDM type: The grid number of each color represent the port number

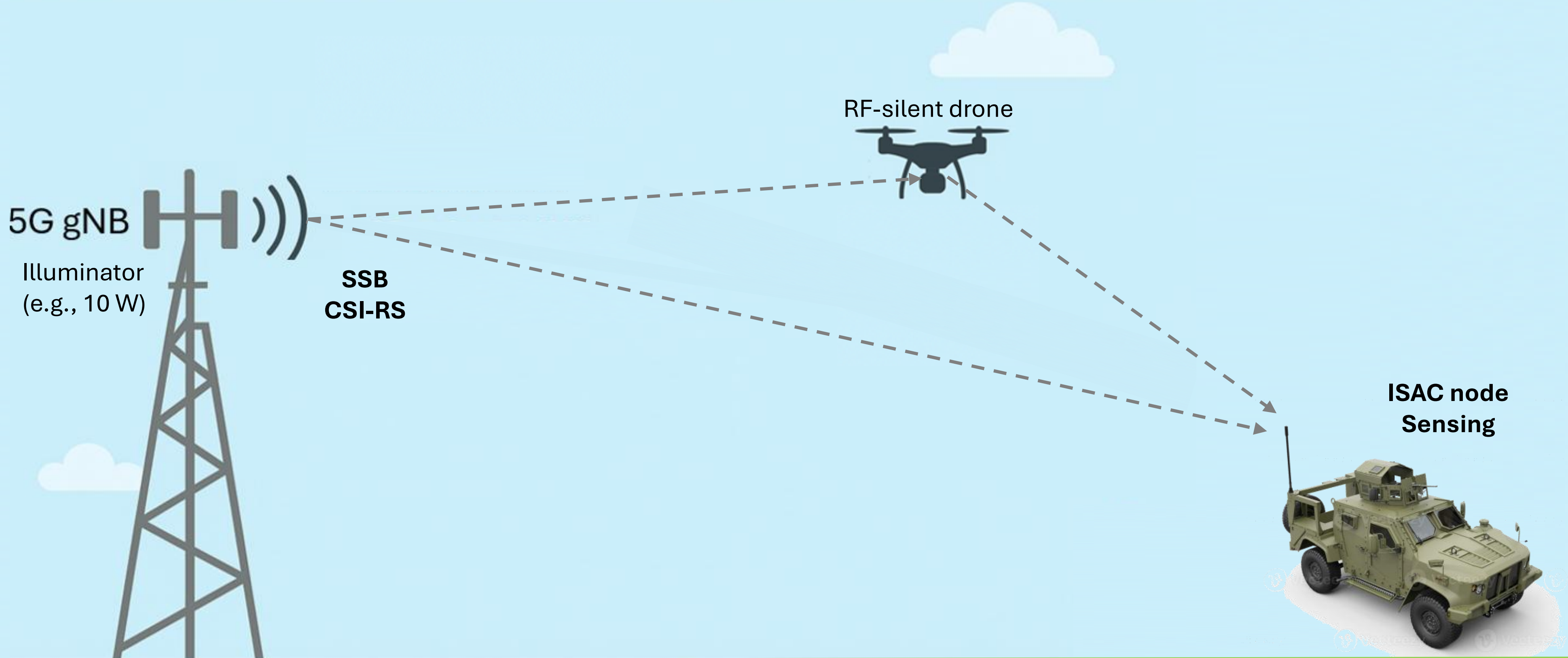
Source: https://www.youtube.com/watch?v=ofnnTSBX2IQ

Application on passive radar with downlink SSB or CSI-RS

- Passive radar reuses existing RF signals from external illuminators (e.g., 5G gNBs) instead of transmitting its own waveform.
- This enables target detection in contested RF environments without emitting additional signals.
- RF scanners cannot detect RF-silent (“dark”) drones, which do not transmit control or telemetry radio signals.

Passive radar with downlink SSB or CSI-RS

- Example of a bi-static passive radar.
- By estimating the radio channel, the ISAC node detects week changes in the radio channel which correspond to the drone's presence, and trajectory.



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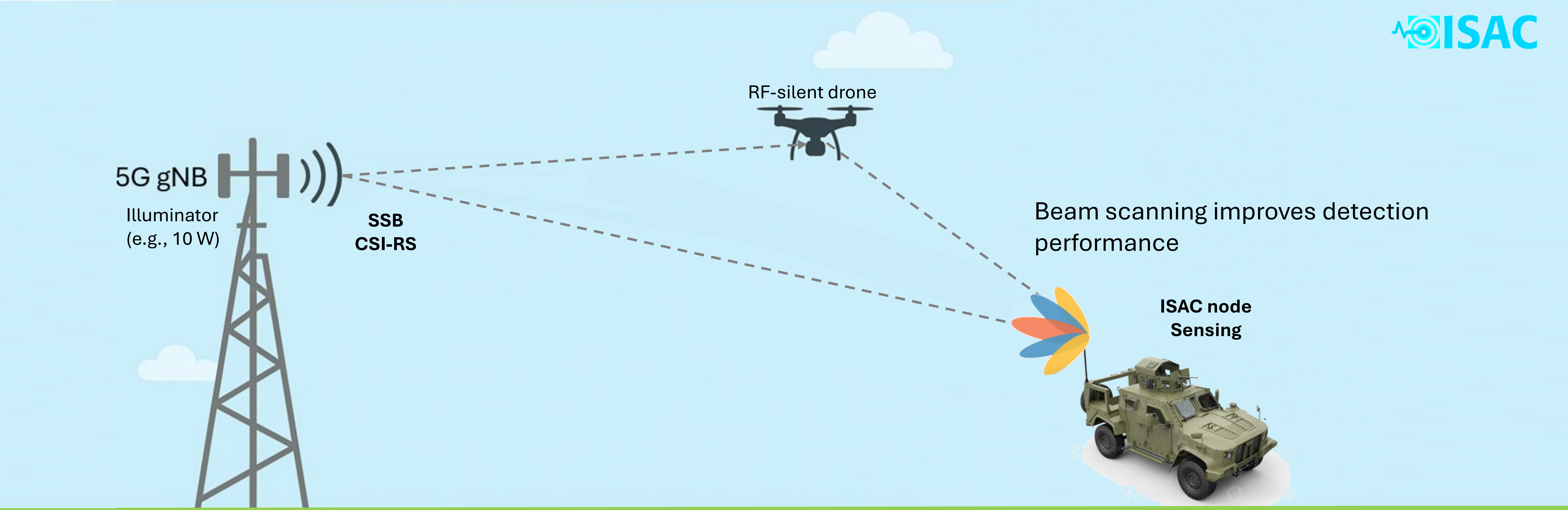
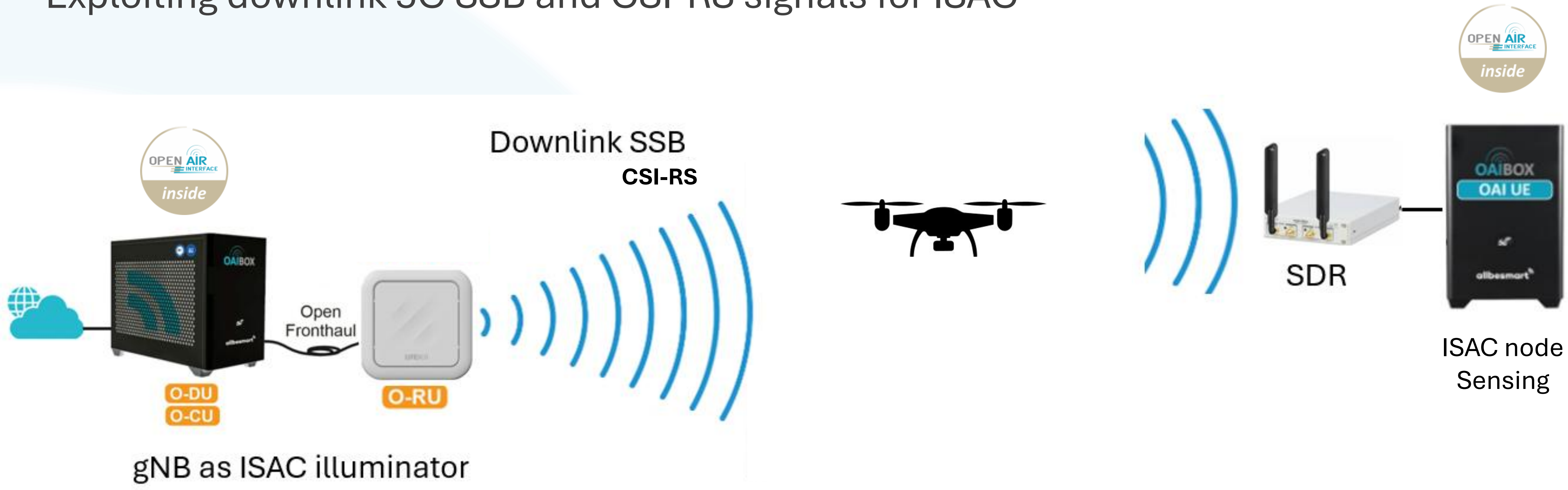


Testbed for 5G ISAC experimentation with SSB and CSI-RS

- Exploiting downlink 5G SSB and CSI-RS signals for ISAC



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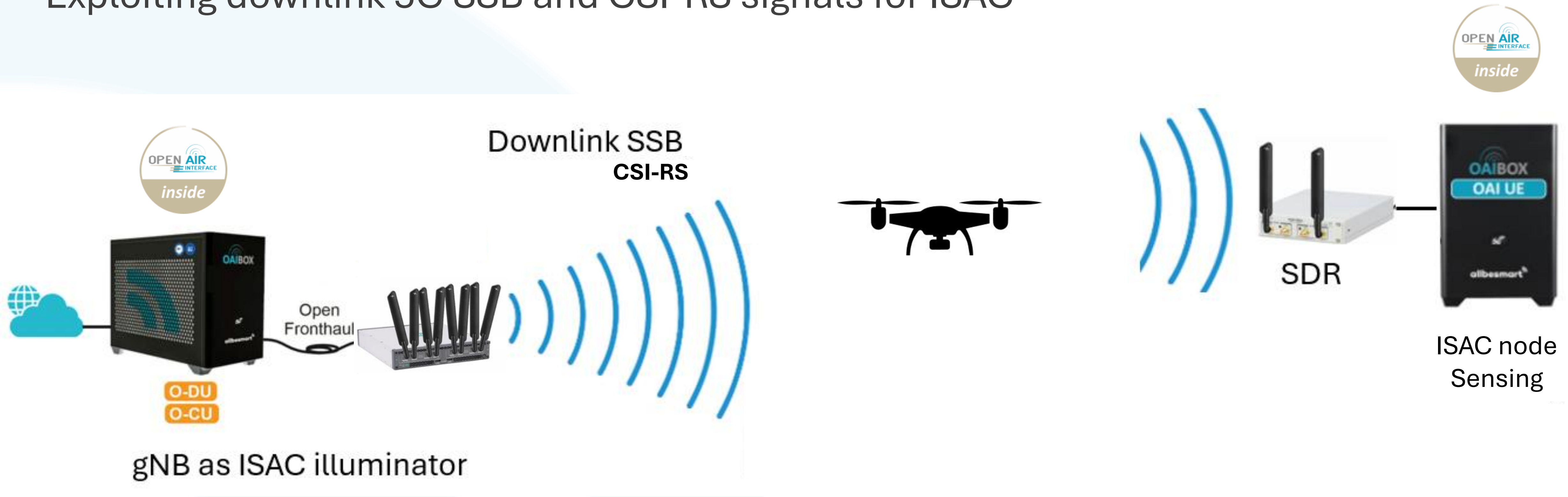
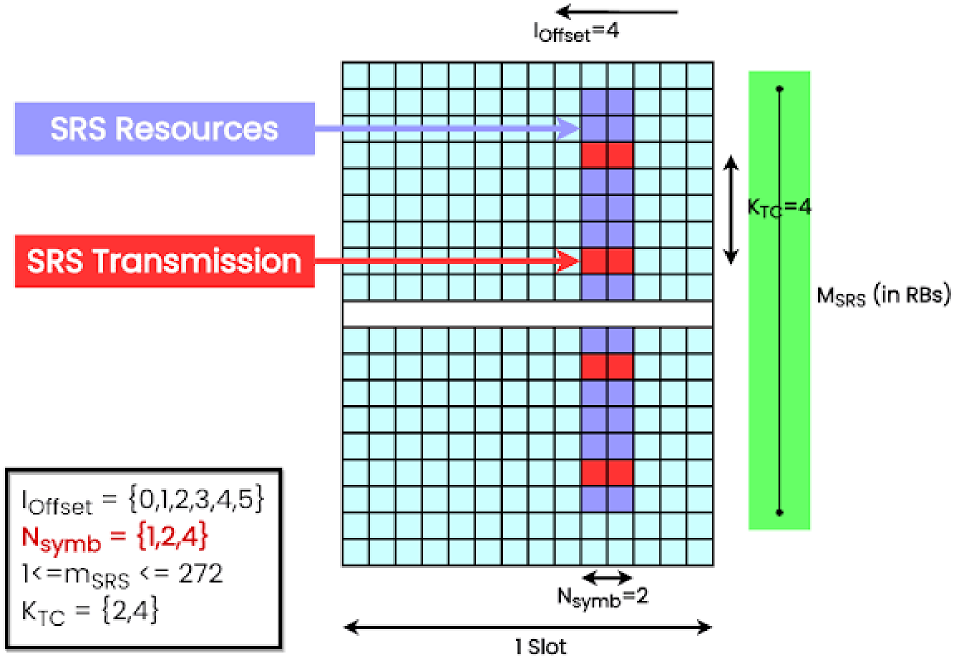


ISAC using 5G uplink SRS – sensing is done in the gNB side

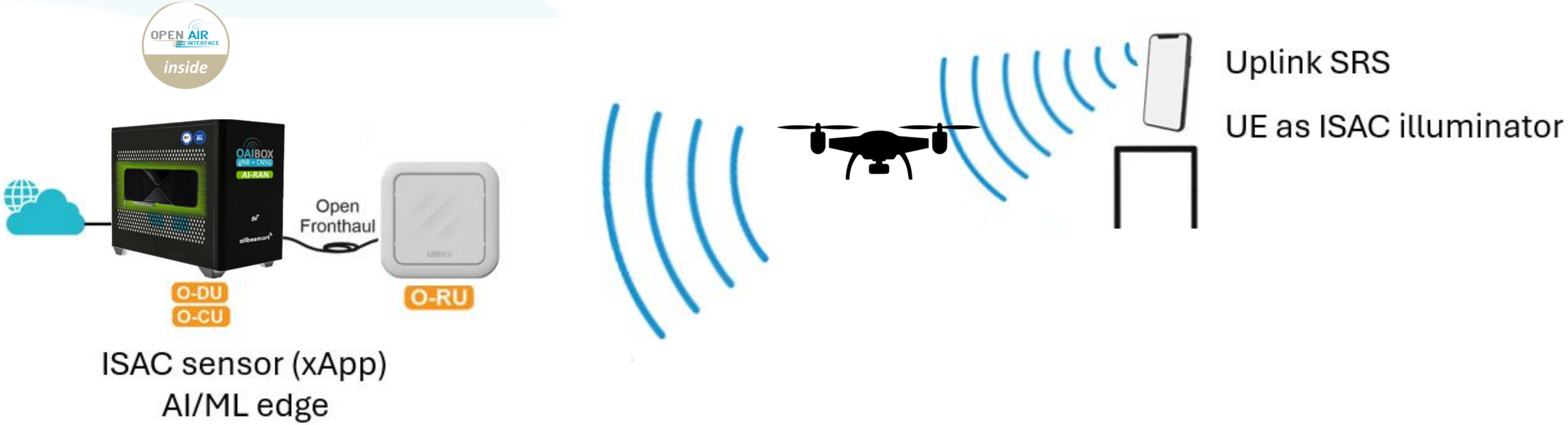
ISAC using 5G uplink SRS

- Sounding Reference Signal (SRS) is a signal transmitted by the UE which is used by the gNB to estimate the uplink radio channel
- ISAC requires prior access to the network's SRS configurations
- The ISAC illuminator can be a commercial UE
- Sensing is done on the gNB
  - Different UEs have different SRS → collaborative sensing
- 5G SRS maximum BW = 100 MHz
- Range resolution: $\Delta R = \frac{c}{2BW} = 1.5\ m$
- Typical SRS configuration in OAI
  - Nsymb=1 and KTC=2



Testbed for 5G ISAC experimentation with SRS

- Exploiting uplink 5G SRS signals for ISAC



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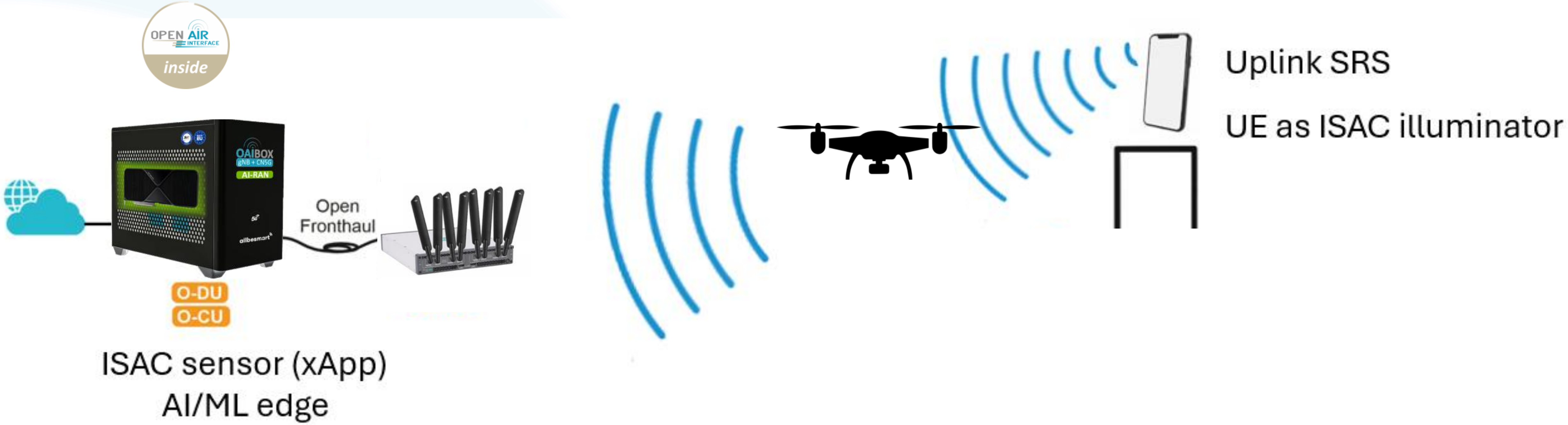
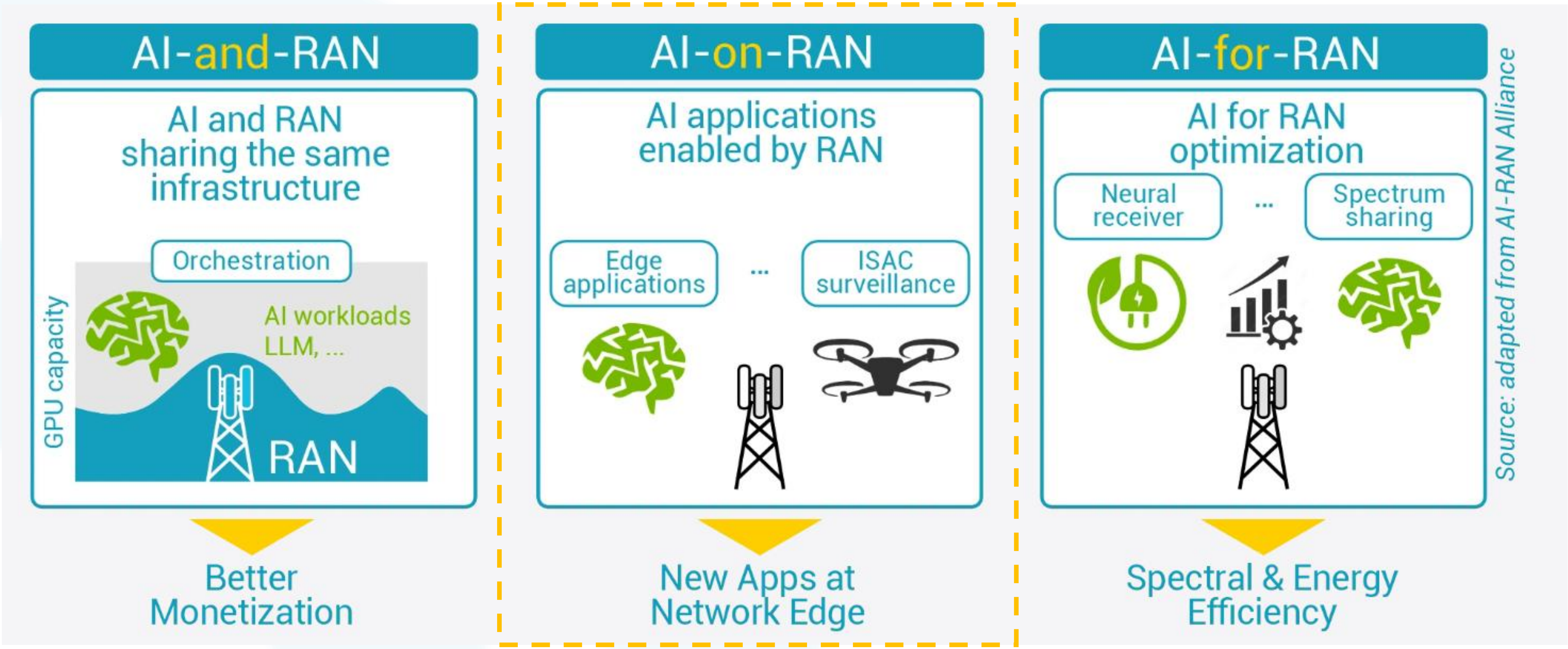


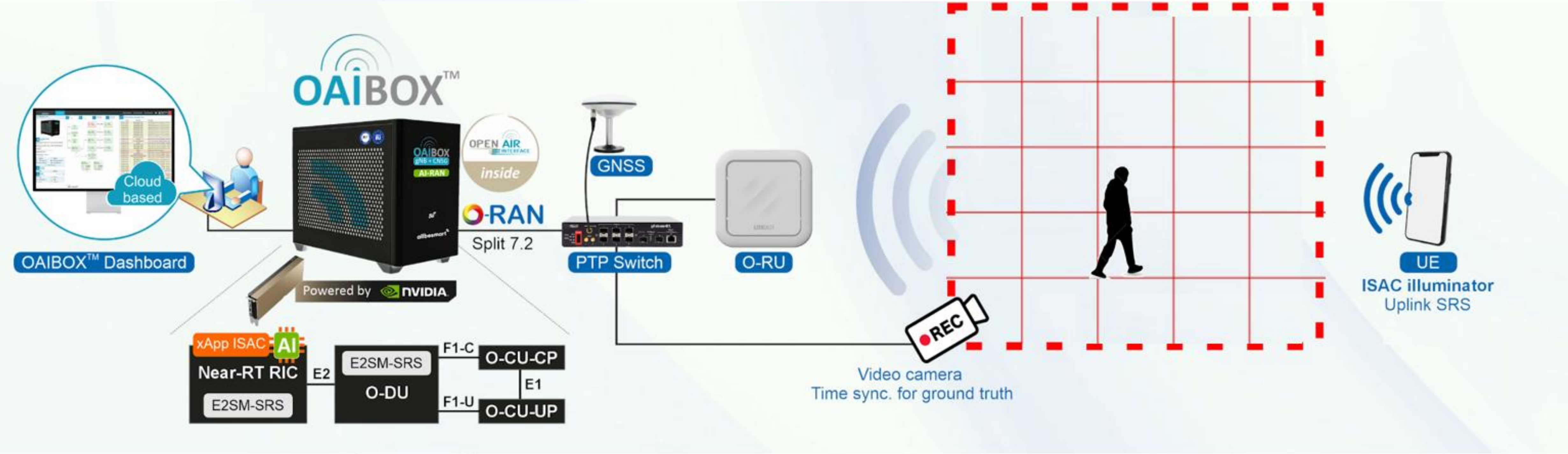
AI/ML for ISAC

ISAC is an AI-on-RAN use case



Training an AI/ML model for ISAC

- Time-sync. video cameras provide ground-truth positioning for AI model training
- Supervised learning with labels from ground truth



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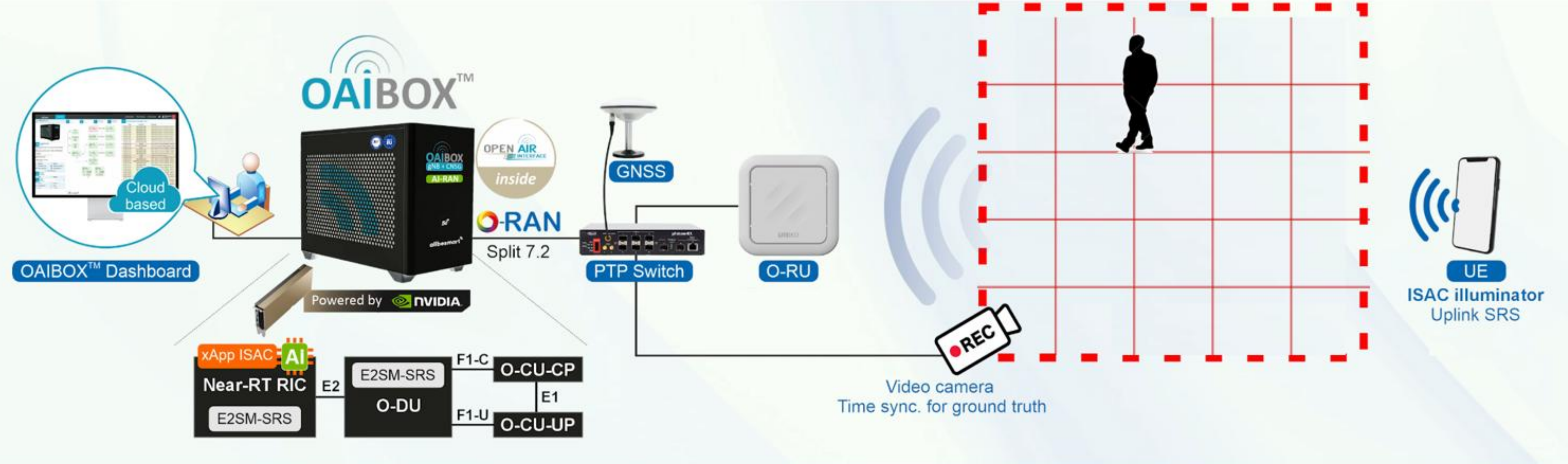

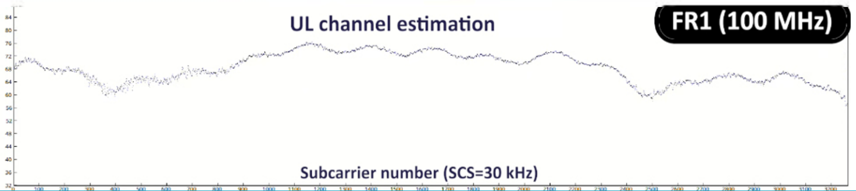

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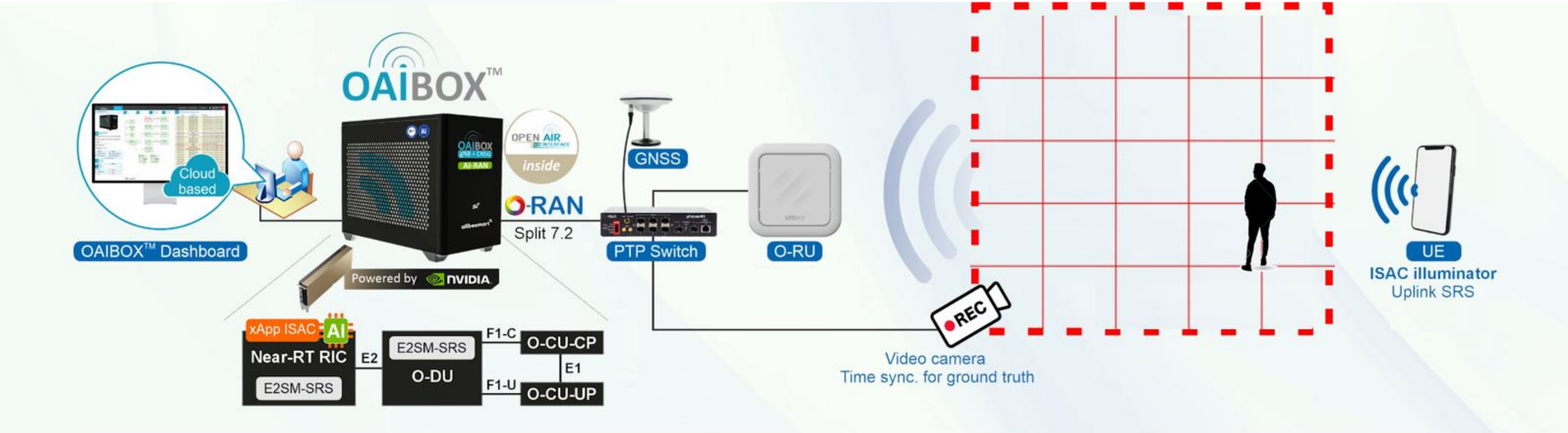
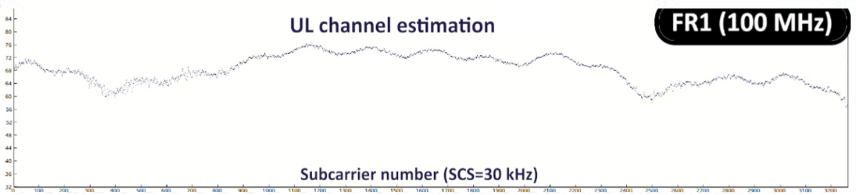
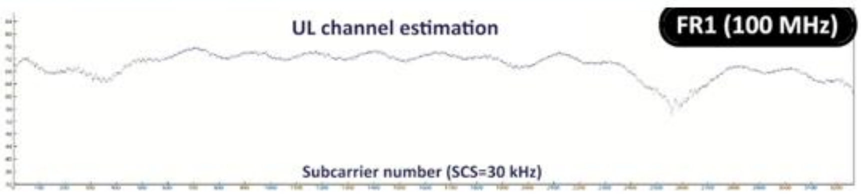
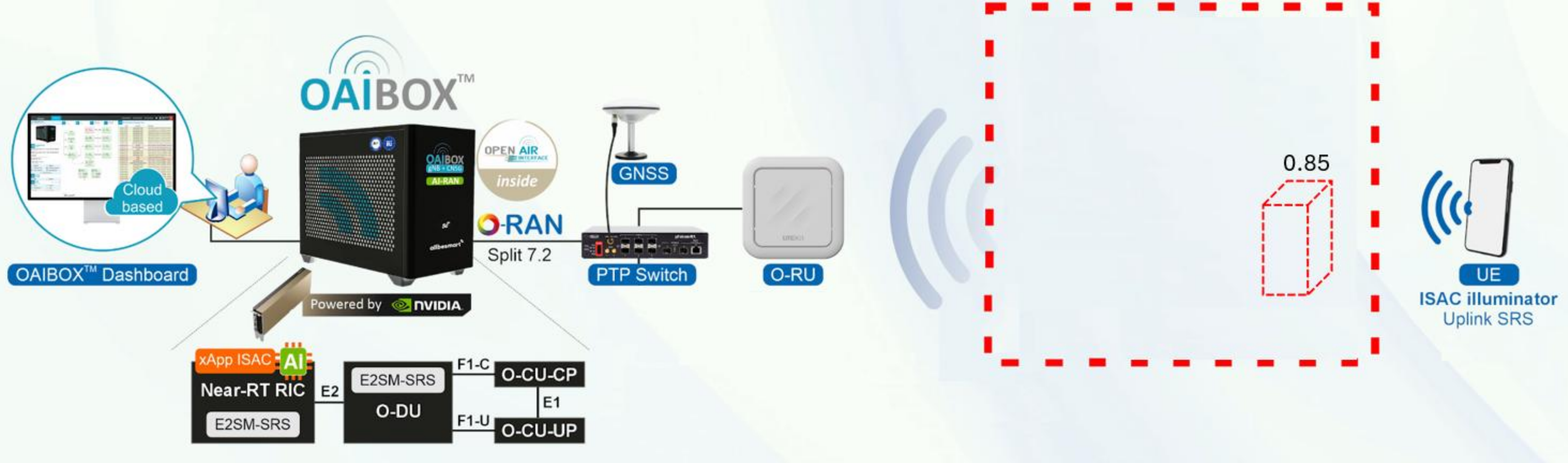


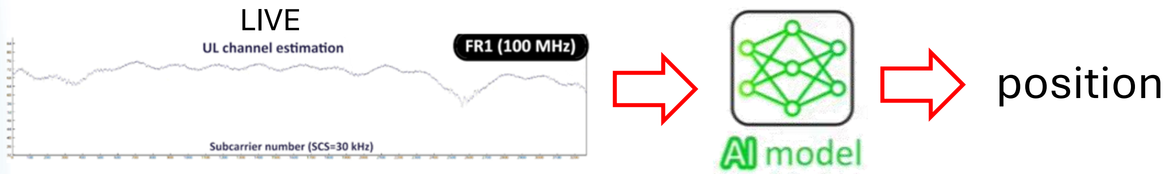




Training an AI/ML model for ISAC

- Inference based on the live 5G UL channel estimate



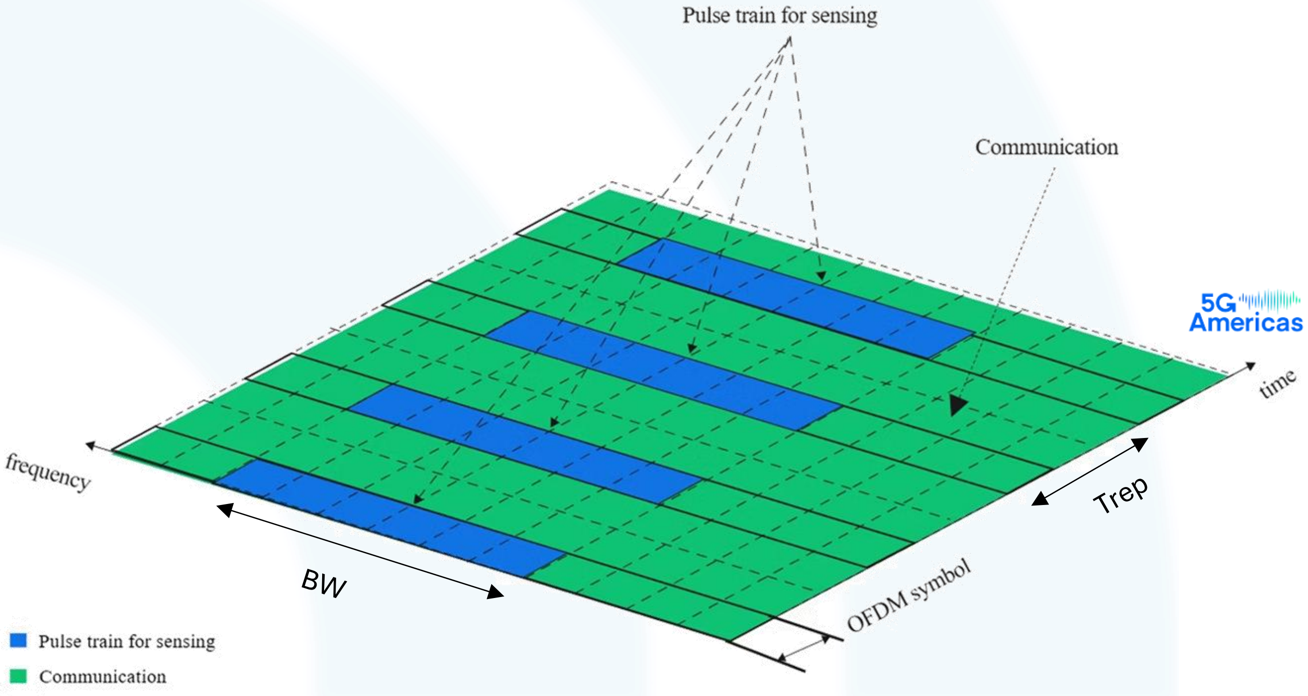


Why OpenAirInterface is important for ISAC research ?

- Commercial gNBs and UEs don't expose the required low-level radio channel parameters required for ISAC operation.
- OpenAirInterface, through its unique open-source gNB and UE stacks, provides full access to 5G reference signals required for ISAC **over-the-air experimentation**.
- ML model accuracy in ISAC depends heavily on dataset quantity, quality, and diversity.
- Open-source testbeds and open datasets are essential for ISAC research, where achieving robust AI/ML **model generalization** remains a key challenge.

Why OpenAirInterface is important for ISAC research ?

- OpenAirInterface provides the foundation for 6G waveform design with an open-source PHY layer
- OAI enables the exploration of trade-offs between communication requirements (throughput, latency) and sensing performance (localization accuracy, detection probability), at gNB and UE sides.

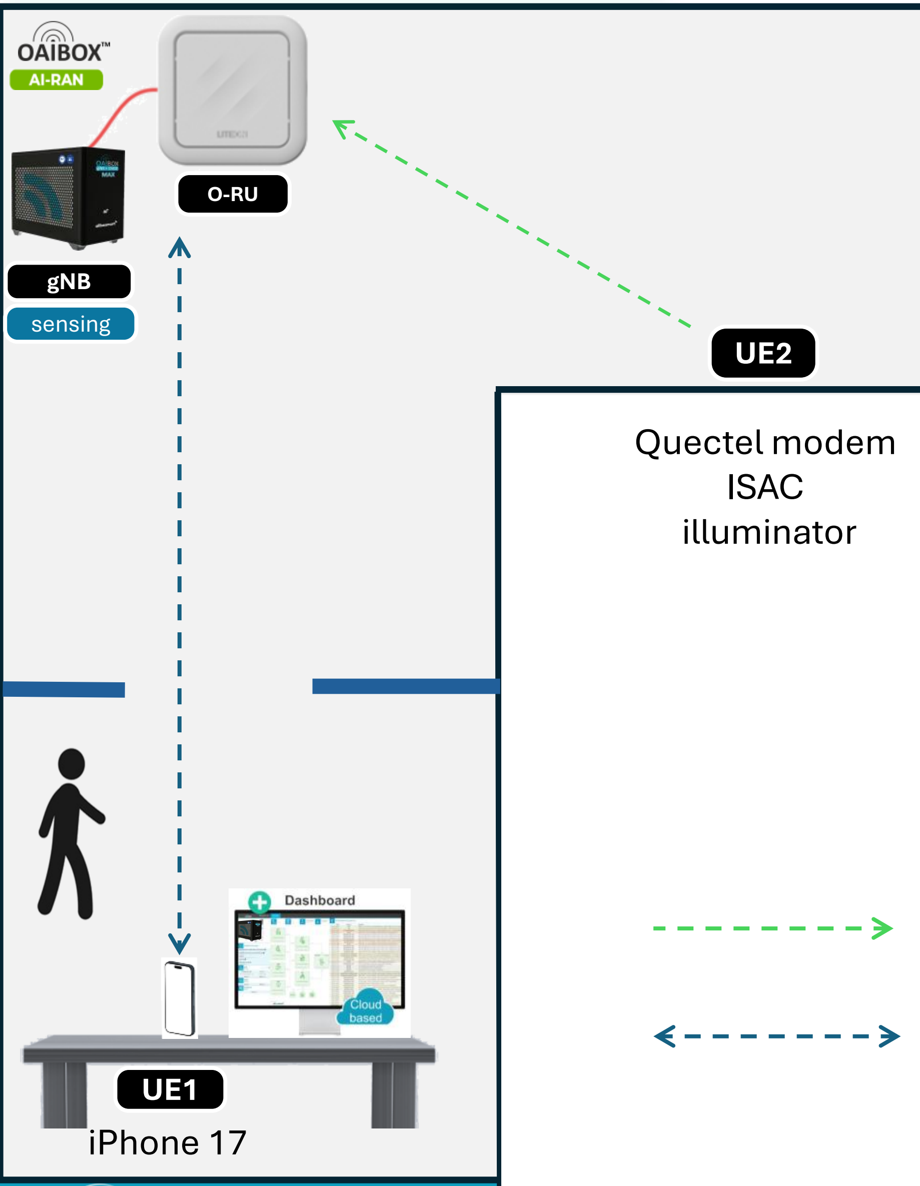


5G Americas

OPEN AIR INTERFACE

Live demo: Counting people in a corridor using 5G ISAC

Today's experiment: 5G bi-static radar to counting people



Sensing link (uplink SRS)

5G communication link

Frequency band	n77/n78
Bandwidth	100 MHz
Subcarrier spacing (SCS)	30 kHz
TDD pattern (5 ms)	DDDDDFUUUU
SRS periodicity	40 ms (SCS 30 kHz)

O-RU	LITEON FlexFi
gNB (O-CU/O-DU)	OAIBOX AI-RAN
CN	OAI
Edge GPU	RTX PRO 6000
PTP switch	Fibrolan FalconRX

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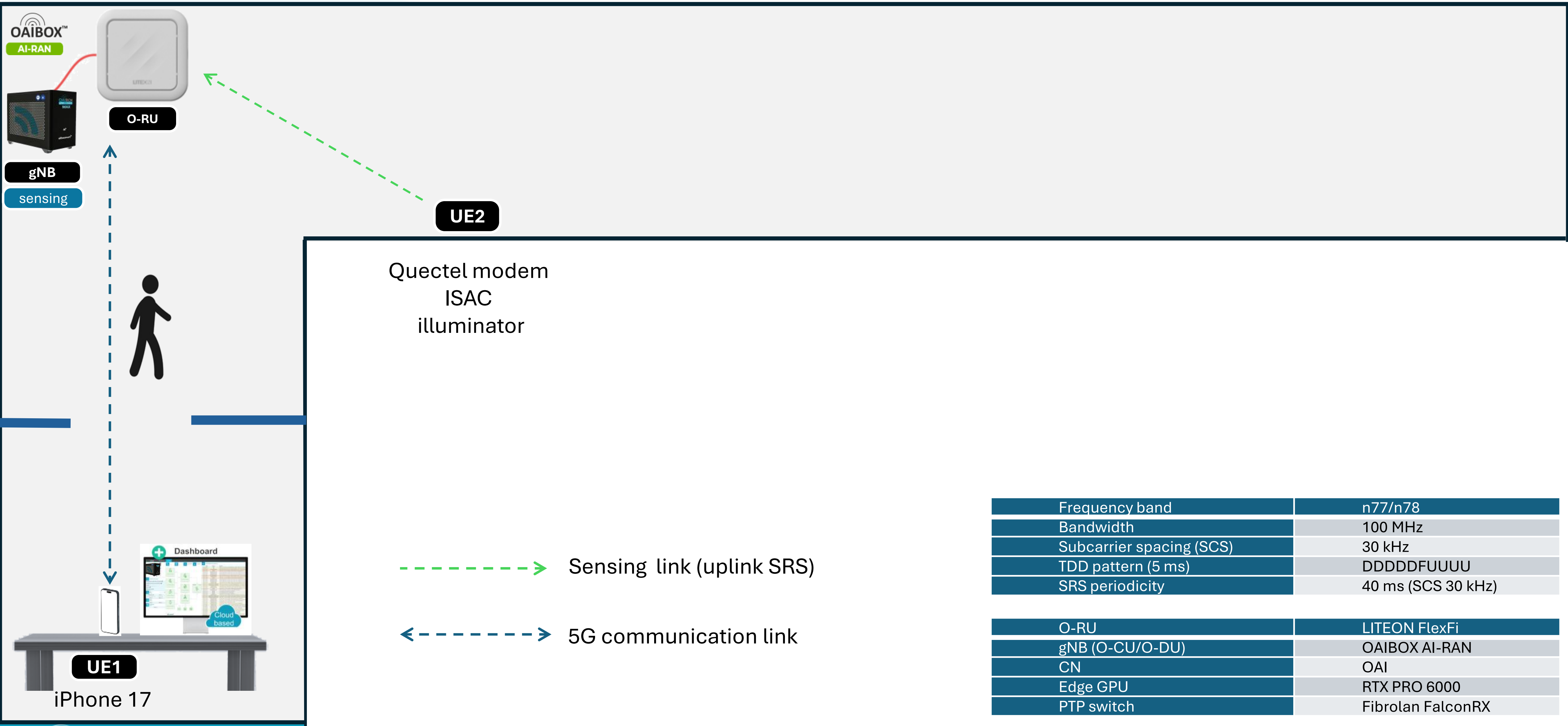

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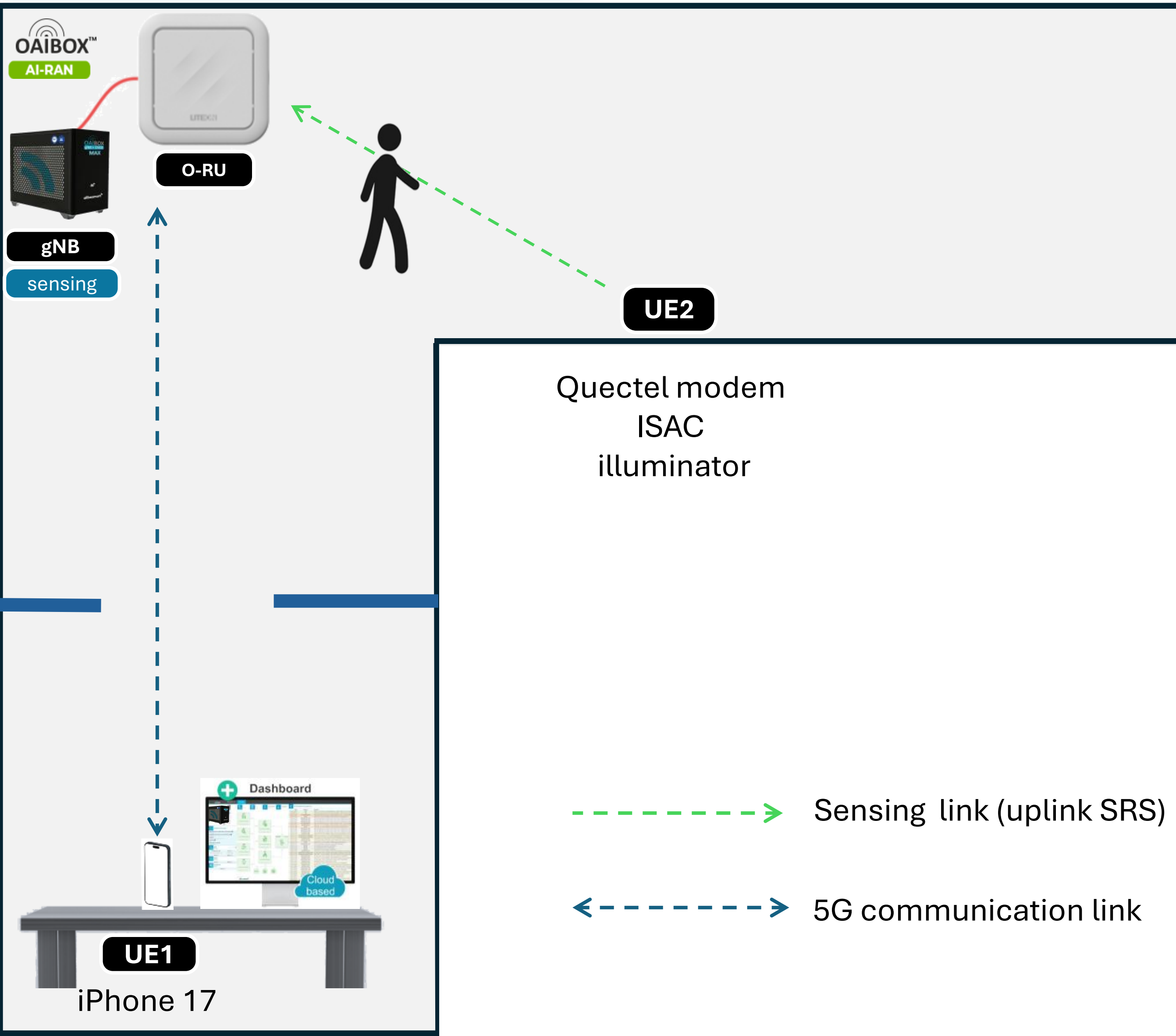

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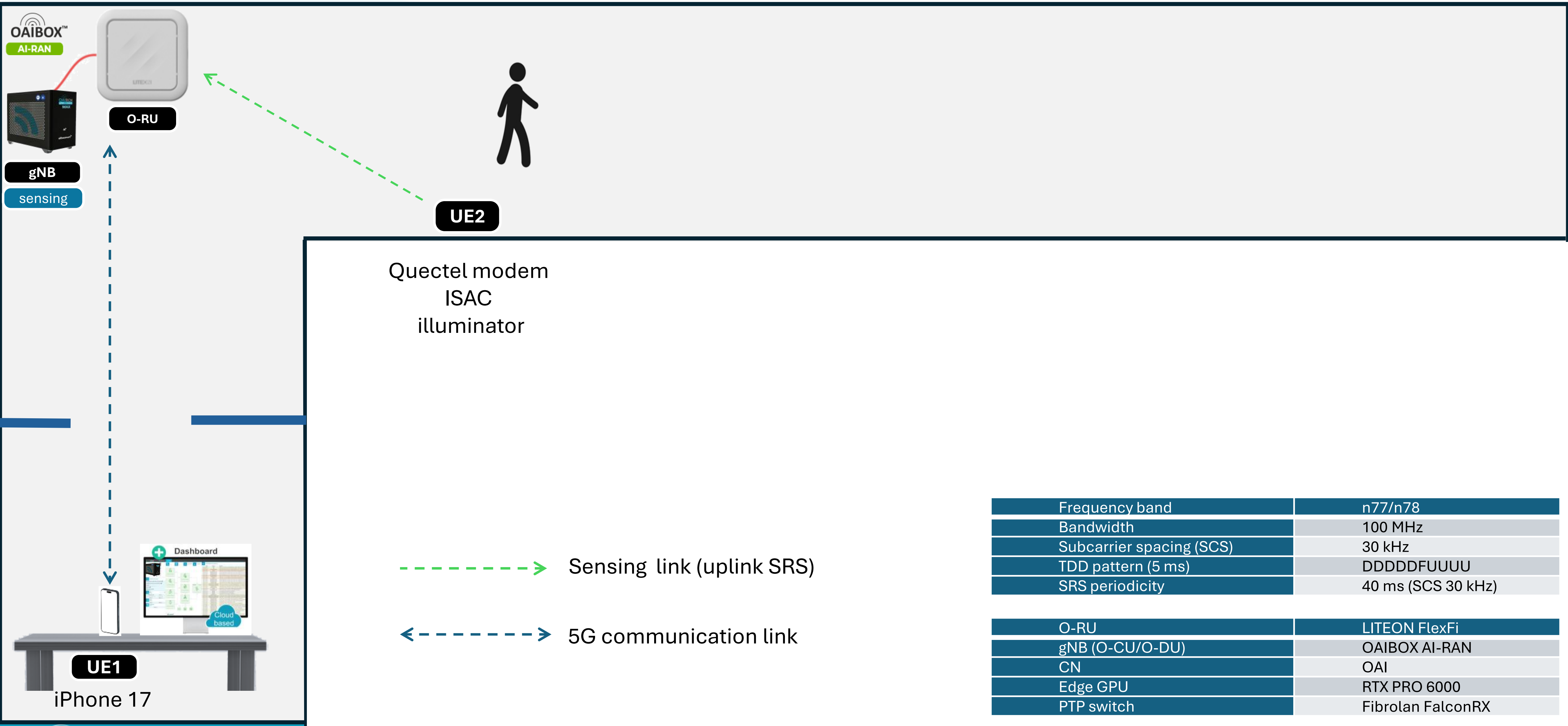
Today's experiment: 5G bi-static radar to counting people



Frequency band	n77/n78
Bandwidth	100 MHz
Subcarrier spacing (SCS)	30 kHz
TDD pattern (5 ms)	DDDDDFUUUU
SRS periodicity	40 ms (SCS 30 kHz)

O-RU	LITEON FlexFi
gNB (O-CU/O-DU)	OAIBOX AI-RAN
CN	OAI
Edge GPU	RTX PRO 6000
PTP switch	Fibrolan FalconRX

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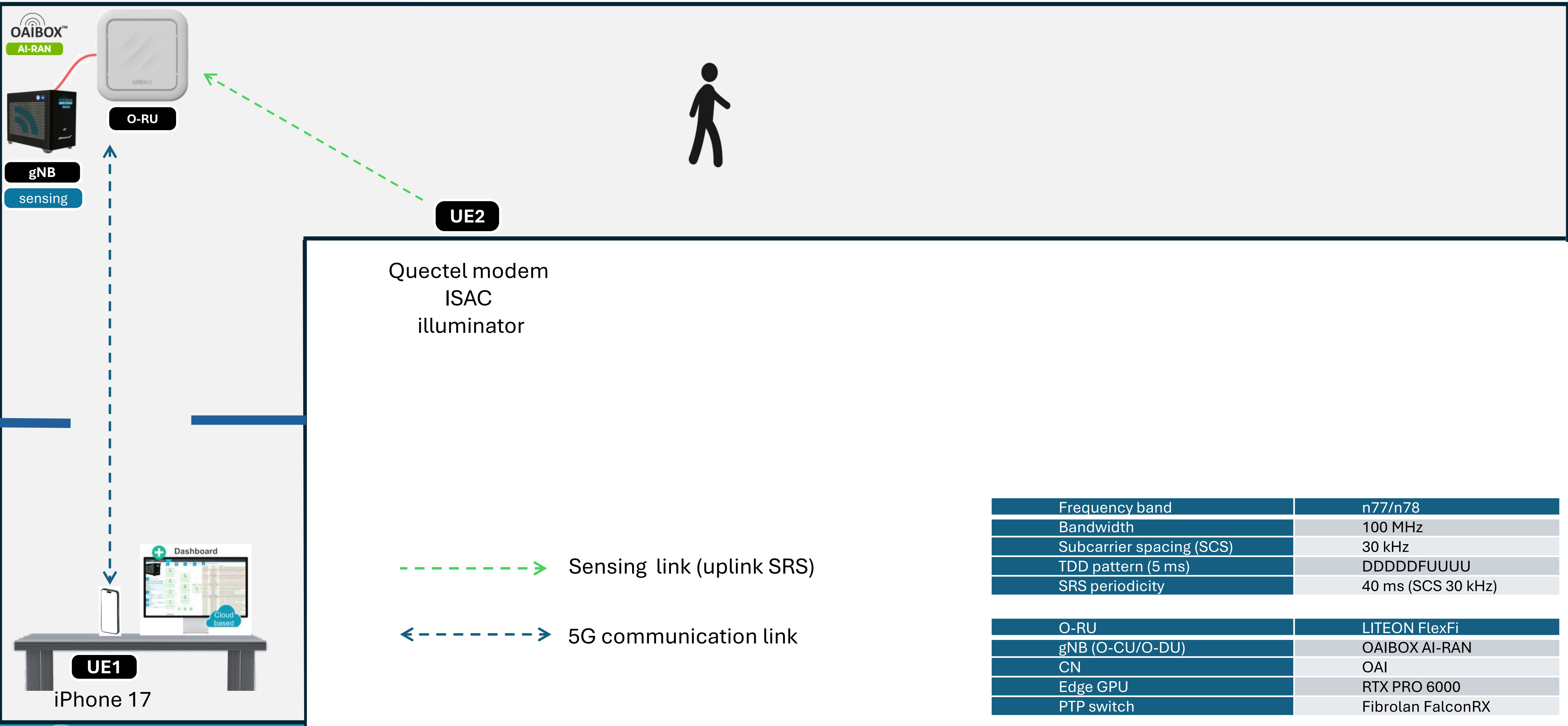

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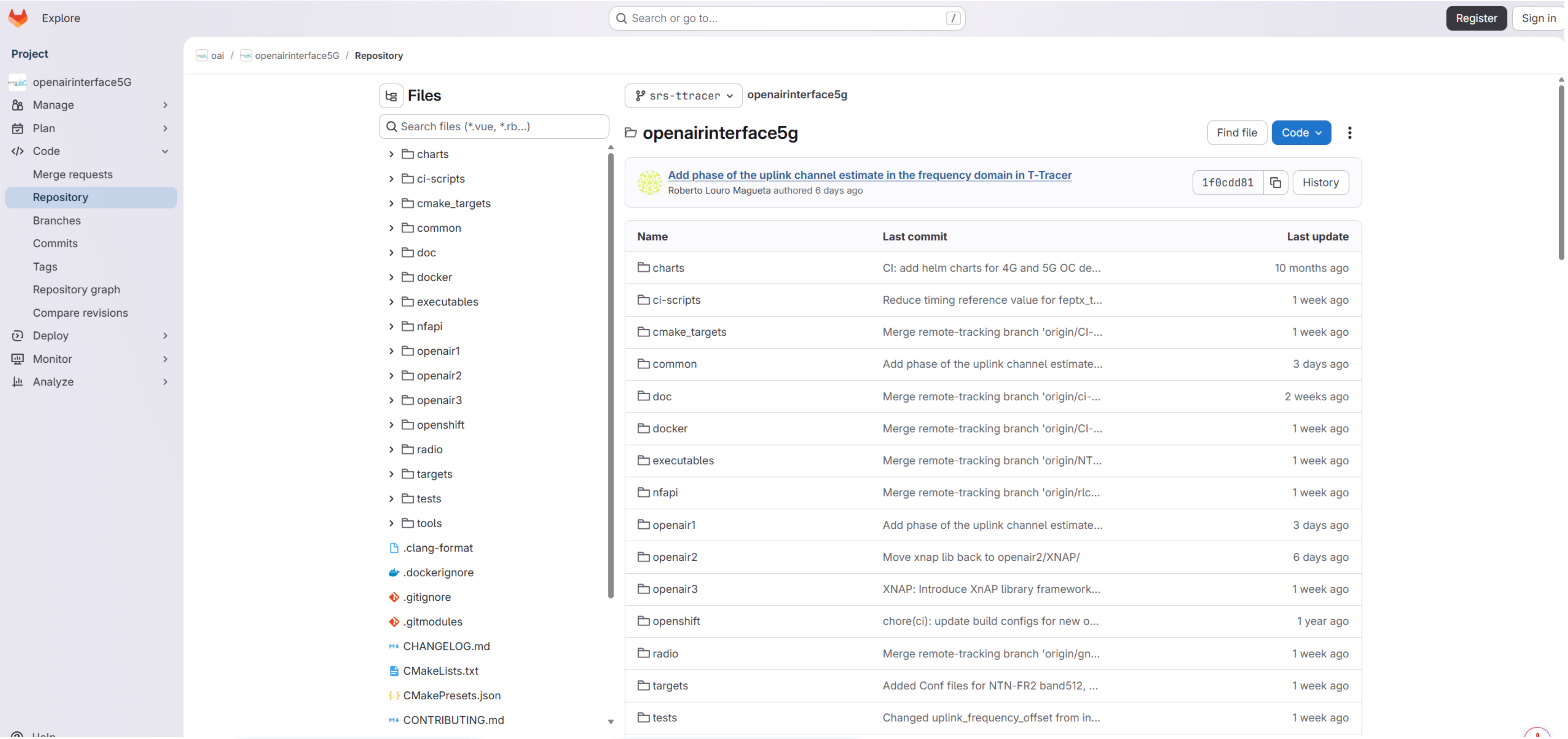
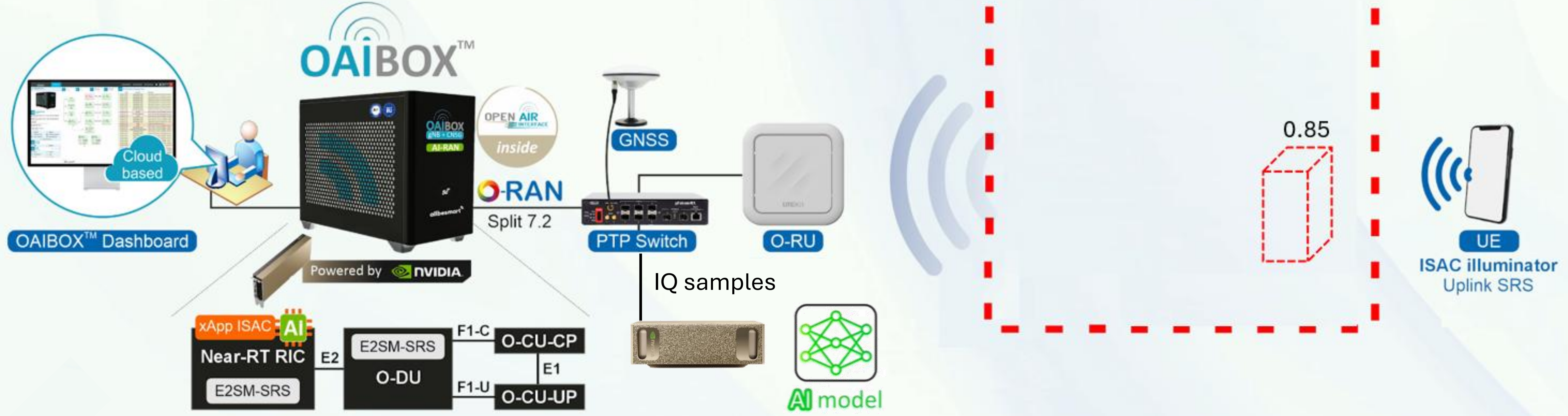
Live ISAC demo

Implementation available in OAI to replicate this experiment

- https://gitlab.eurecom.fr/oai/openairinterface5g/-/tree/srs-ttracer



IQ samples collection



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Thanks !

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Paulo Marques
Founder
pmarques@allbesmart.pt