Towards 6G: Integrated Sensing and Communications (ISAC)

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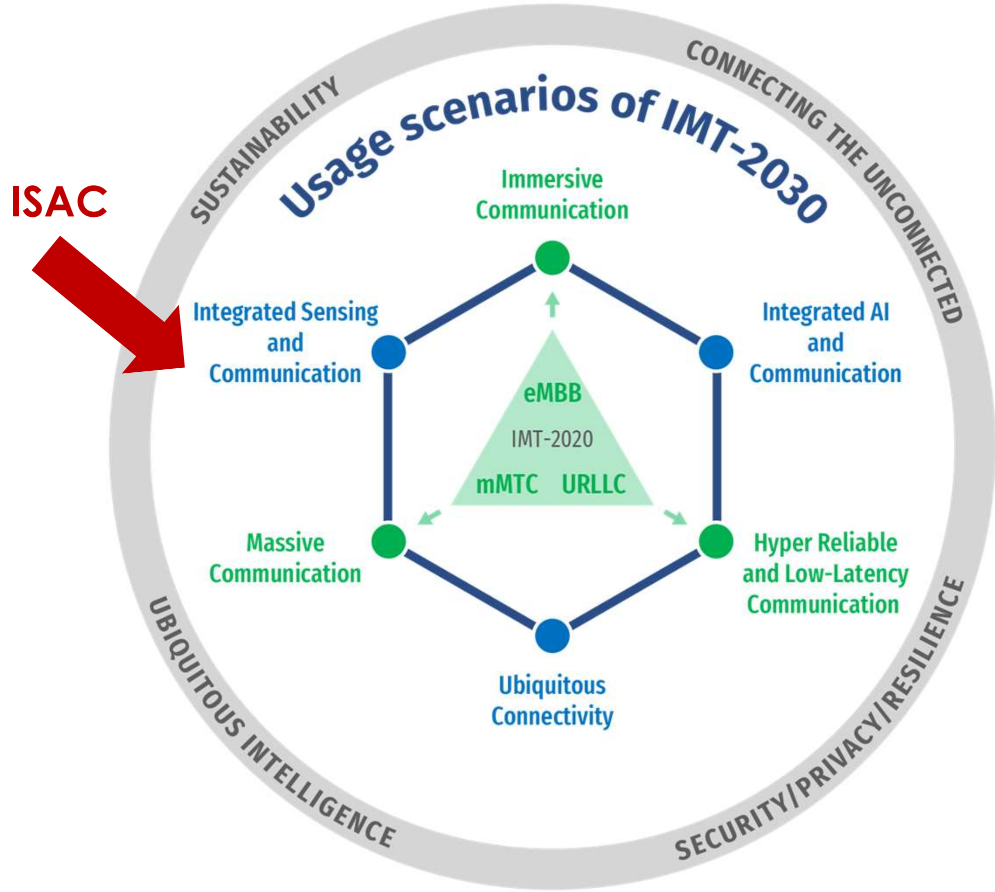
WE INVENT THE TECHNOLOGIES THAT MAKE LIFE BOUNDLESS

Setting the scene

1) Like AI, integration of sensing and communication is emerging as a **pillar usage scenario for IMT-2030 and beyond**

2) Like AI, we don't have to wait until 6G to benefit from sensing into the network. This is **already with us today to an extent**!

3) The 6G challenge is to **integrate** sensing into the communication system design.



Definition and use cases

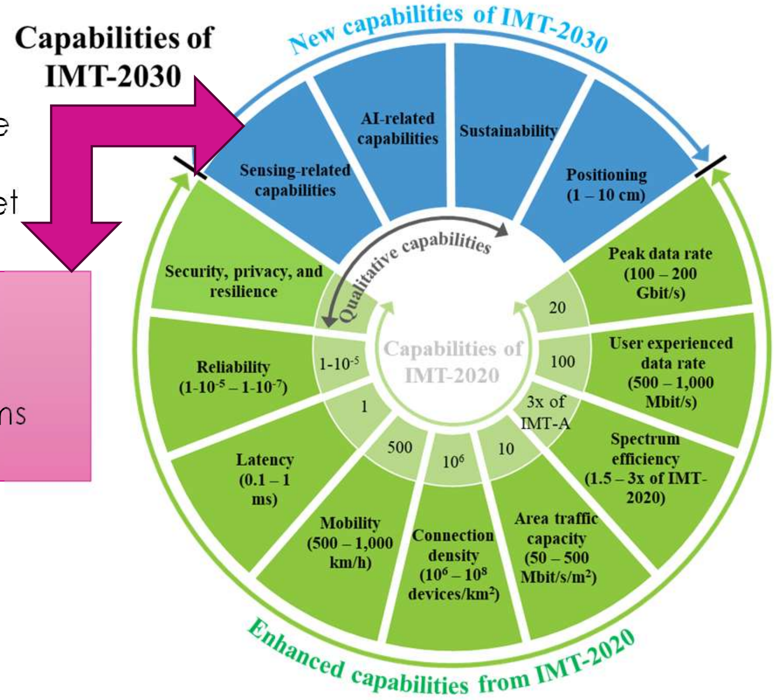
- Sensing refers to the **use of radio signals to sense objects** in the environment that may be connected or not to the network
- This adds a **new capability** to the wireless network for detection, estimation, localization, tracking, navigation, monitoring, imaging, etc.
- The sensing data collected can be leveraged to **enhance the network operations and the services running on top**

Several use cases defined [e.g. 3GPP TR22.837]

- Object and intruder detection
- Collision avoidance and trajectory tracking
- Automotive manoeuvring and Navigation
- Monitoring (Environment, Health, Sports)
- Sensing provisioning for seamless XR, AI and digital twin apps

Target capabilities

- ITU-R started defining IMT-2030 capabilities and this will continue over the next few years …
  - Positioning: Positioning is the ability to calculate the approximate position of connected devices. Positioning accuracy is defined as the difference between the calculated horizontal/vertical position and the actual horizontal/vertical position of a device. The research target of the positioning accuracy could be 1-10 cm .
  - Sensing-related capabilities: Sensing-related capabilities refer to the ability to provide functionalities in the radio interface including range/velocity/angle estimation, object detection, localization, imaging, mapping, etc. These capabilities could be measured in terms of accuracy, resolution, detection rate, false alarm rate, etc.
- A first set of metrics has been defined and used to formulate potential requirements of the use cases studied in the 3GPP SA1 [TR22.837]
  - Confidence level [%], Accuracy of positioning estimate by sensing [m], Accuracy of velocity estimate by sensing [m/s], Range resolution [m], Velocity resolution (horizontal/ vertical) [m/s x m/s], Max sensing service latency [ms], Refreshing rate [s], Missed detection [%], False alarm [%]



Mono-static sensing

Monostatic Sensing

- Reflected signal received by transmitting node
- Receiver has knowledge of transmitted signal
- Full duplex operation and self-interference cancellation is needed

Distributed multi-node monostatic Sensing

- Enables multi-view sensing
- Combination of two or more mono-static sensing nodes
- Time synchronization between TX and RX between the nodes is not required
- Centralized fusion is needed to combine inputs from the different receivers
- Different Tx nodes can operate at different frequency bands, including non-RF (i.e. lidar, camera, etc.) and non-5G/ 6G bands. Utilization of multiple frequency bands.

Note: Tx / Rx sensing node can be a gNB, TRP, UE (for DL, UL, SL or cross link (CL) sensing), or it can be a non-5G/6G device.

Multi-static sensing

Bi/Multi-Static Sensing

- Tx / Rx nodes can be changed to do multi-view sensing
- Reflected signal received at different node(s)
- Time synchronization between TX and RX nodes between the nodes is required
- Centralized fusion is needed to combine inputs from the different receivers

Multi-static + Mono-Static

- Some Tx nodes may be full duplex capable, so reflected signals can be received by the same node and also at different node(s)
- Time synchronization between different TX and RX nodes is required
- Centralized fusion is needed to combine inputs from the different receivers
- Different Tx nodes can operate at different frequency bands, including non-RF and non 5G / 6G bands. Utilization of multiple frequency bands.

Note: Tx / Rx sensing node can be a gNB, TRP, UE (for DL, UL, SL or cross link (CL) sensing), or it can be a non-5G/6G device.

ISAC Projects and Initiatives

- ISAC in scope of several 6G European research projects
  - HEU 6G-SHINE
  - HEU 6G-XR
  - HEU CENTRIC
  - HEU CONVERGE
  - HEU HEXA-X II
  - HEU ISLANDS
  - HEU TIMES
  - HEU TERRAMETA
  - BMBF KOMSENS-6G
  - BMBF 6G-ICAS4MOBILITY
  - UK DSIT TUDOR

- ISAC also in scope of pre-standards and standards
  - ITU-R IMT-2030
  - 3GPP (Rel.19)
  - IEEE 802.11bf (WLAN sensing)
  - IEEE 802.15 (UWB sensing)
  - (new) ETSI ISAC ISG

Early Prototypes

Source	Comment	Link to the PoC/demo
Hexa-X	Hexa-X Project demo	https://youtu.be/OMqRZjrZJyI
Huawei	Huawei's ISAC PoC demos	https://www.youtube.com/watch?v=ZbmADVE0TAw&t=3820s https://www.huawei.com/en/huaweitech/future-technologies/6g-isac-thz
MWC 2023	6G sensing highlighted in various demos at MWC 2023 (Nokia, Keysight, R&S)	NA
Qualcomm	Precise positioning and RF sensing	https://www.youtube.com/watch?v=k3hpgBzD3xk
UCL	UCL ISAC Proof-of-Concept	An Experimental Proof of Concept for Integrated Sensing and Communications Waveform Design
ZTE	ZTE ISAC PoC and field trials in outdoor practical 5G networks	https://arxiv.org/abs/2305.13924 https://ieeexplore.ieee.org/abstract/document/10182512

(New) ETSI ISAC ISG

- Approved by ETSI Director General at ETSI Board(23)144 meeting (19-20 Sep'23)
- Kick off due in Nov'23 for a first 2 years period
- Co-founded by 22 ETSI members and supported by an additional 4 members
- **Open to new members to join following the issue of the Collective Letter (due by mid Oct'23)**
- Convenor: Alain Mourad (InterDigital)

Founding Members

No	Organization	Country	Category
1	Anritsu EMEA Ltd	Sweden	Manufacturers
2	Apple GmbH	Germany	Manufacturers
3	Robert Bosch GmbH	Germany	Manufacturers
4	China Telecommunications	China	Network Operators
5	CNRS	France	Research Bodies
6	Huawei TECH. GmbH	DE	Manufacturers
7	IMEC	Belgium	Research Bodies
8	InterDigital Europe Ltd	UK	Manufacturers
9	Mitsubishi Electric RCE	France	Manufacturers
10	NEC Europe Ltd	DE	Manufacturers
11	NPL	UK	Research Bodies
12	Samsung R&D Institute UK	UK	Manufacturers
13	Telenor ASA	Norway	Network Operators
14	University of Athens	GR	Universities
15	BJTU - University Beijing Jiaotong	China	Universities
16	University Chalmers	Sweden	Universities
17	University College London	UK	Universities
18	UofG - University Glasgow	UK	Universities
19	Queen Mary University of London	UK	Universities
20	University of Oulu	Finland	Universities
21	ICS - University of Surrey	UK	Universities
22	ZTE Corporation	China	Manufacturers
23	AT&T	USA	Network Operators
24	BT Plc	UK	Network Operators
25	Orange	France	Network Operators
26	Siemens AG	DE	Manufacturer
27	University Politecnico di Milano	Italy	Universities

(New) ETSI ISAC ISG – Mission

- Provide an opportunity for ETSI members to coordinate their **pre-standards** 6G research efforts on **integrated sensing and communication technology** across various **European/National funded collaborative projects**, extended with relevant **global initiatives**, towards paving the way for **6G standardization** of the technology.
- Prepare **systematic output on 6G** use cases, sensing types, channel models, architectures and deployment considerations, KPIs and evaluation assumptions, for subsequent **evaluation by standards organizations such as future 3GPP 6G releases (R20+) and ITU-R IMT-2030 deliverables*.**

**Focus set on ITU-R IMT-2030 requirements and evaluation methodology*

(New) ETSI ISAC ISG – Scope

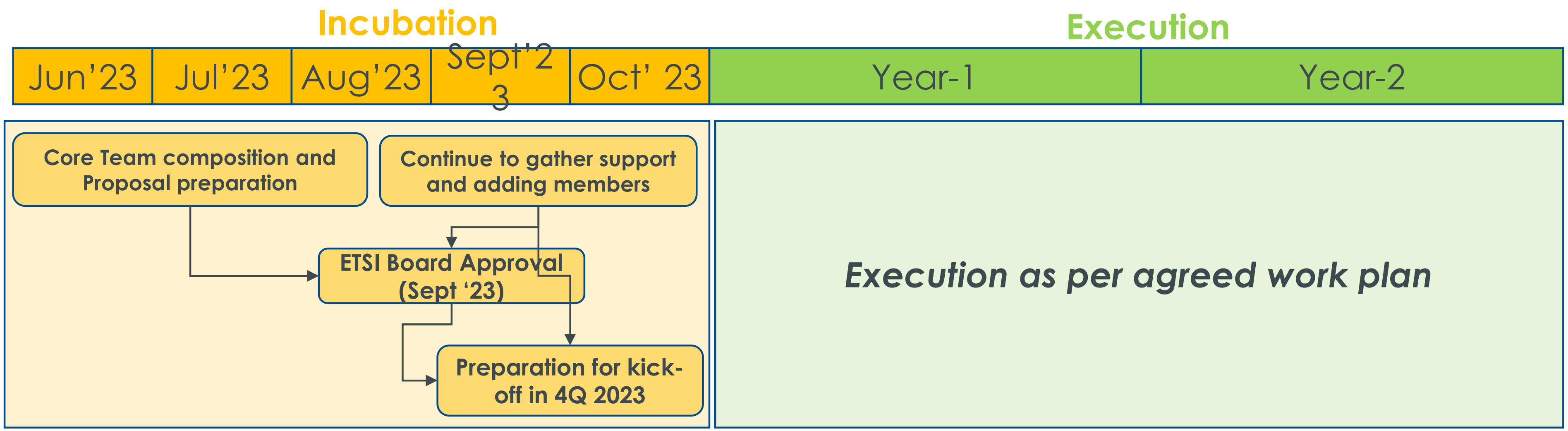
1. Definition of a prioritized set of **6G use cases and sensing types** with a roadmap for their study and evaluation.
2. Development of **advanced channel models** for the target 6G ISAC use cases and sensing types, and validation through **extensive measurement campaigns**, that can fill the gaps of existing communications-based channel models (e.g. 3GPP, IEEE 802. ITU-R)
3. Specification of **KPIs and evaluation methodology** building upon the channel modelling and measurements, simulations/POCs, and synergies with ETSI ISG RIS and ISG THz.
4. Study of a **System and RAN architecture framework** for 6G ISAC, including end-to-end deployment considerations.
5. Study of the **privacy and security aspects** of sensing data in the ISAC 6G framework.
6. Study of **impact of widespread deployment of ISAC on UN sustainability goals**.

(New) ETSI ISAC ISG – Timeline and Deliverables

Deliverables: Technical Reports (TR/GR), White Papers and Proof-of-Concepts

Examples (to be confirmed after ISG kick off in Nov'23):

1) GR#1: Use Cases, Sensing Types, Deployment Scenarios and Channel Models
2) GR#2: Metrics and Evaluation Methodologies
3) GR#3: Architectures, RAN deployment, and Security/Privacy Considerations



Conclusions

- ISAC is an important capability anticipated in 6G
- Design assumptions for ISAC need to be established
- Research infrastructures (such as SLICES-RI) are key to support ISAC design, verification and validation
- Newly created ETSI ISAC ISG open to all ISAC stakeholders to contribute their research towards standardization of the technology in 6G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