

# 6G Sensing

Integrated sensing and communications (ISAC) brings new capabilities to mobile networks.

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# Integrated sensing and communications

Integrated sensing and communications (ISAC) natively integrates communication and sensing into a common network architecture that can simultaneously transfer data and act as a large-scale RF sensor.

Wireless sensing works by detecting and analyzing changes in RF signals as they travel from a transmitter to a receiver to gather information about the surrounding environment. Typically, for wide area sensing, dedicated radar systems are used. In local area networks, Wi-Fi sensing is also an option.

By integrating radar-like sensing capability into mobile networks, a wide range of consumer, business, public safety, and national security applications becomes commercially viable.

The International Telecommunication Union Radiocommunication Sector (ITU-R), a global telecommunications standards body, has designated ISAC as one of the major new usage scenarios for 6G.

6G further strengthens the ISAC framework by enabling the fusion of RF-based sensing data with inputs from external sensors (e.g., cameras and imaging systems), unlocking deeper, multi-modal environmental awareness.

## ISAC use cases

ISAC provides high fidelity spatial information about unconnected and connected devices, tracking their movements and environmental surroundings. Operators can expose sensing information to application developers via network APIs to create new forms of value.

The following is a non-exhaustive list of example ISAC use cases:

- **Drone airspace management:** A wide range of applications, from drone detection in no-fly zones through to navigation and monitoring.
- **Smart transportation:** Diverse scenarios from traffic monitoring to network-assisted autonomous driving, railway monitoring, shipping and maritime, and more.
- **Industrial operations:** Map facilities, coordinate robotic and human operations, and maintain digital twins.
- **Sensing-assisted communications:** Leveraging real-time environmental awareness obtained through wireless sensing of objects, user positions, and channel conditions to dynamically optimize communications, including precise beamforming, seamless mobility management, and enhanced link reliability.

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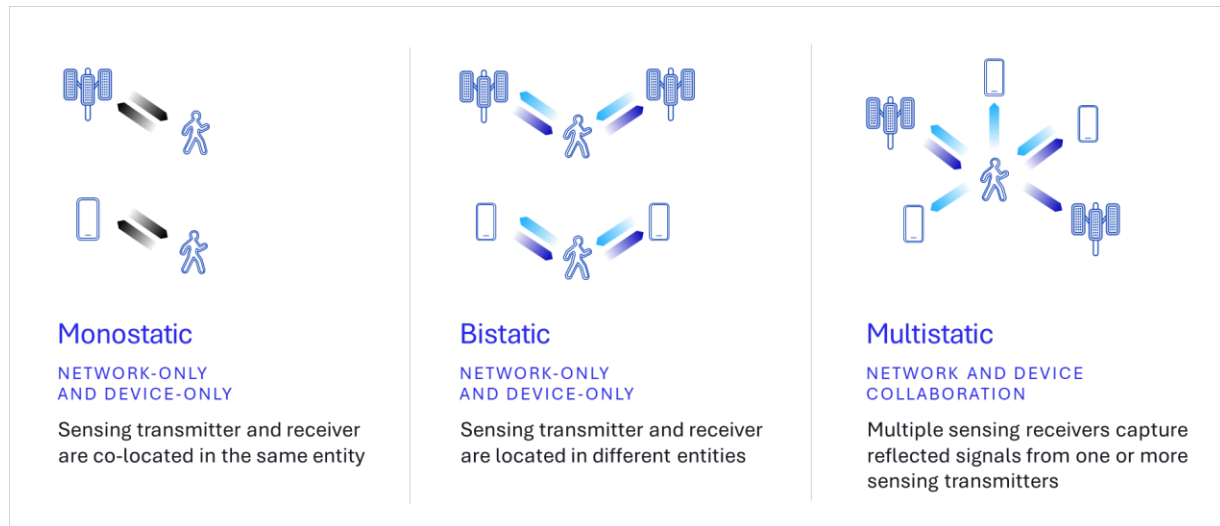
- **Public safety and disaster response:** For example, to locate persons in need of rescue.
- **Supplemental RF data:** To identify objects beyond a camera’s field of view and in low light or nighttime conditions; to augment satellite imagery for mapping.

## ISAC modes and deployment scenarios

Network-based 6G sensing can be deployed in diverse environments, including dense urban areas, industrial settings, high mobility scenarios, and non-terrestrial networks (NTN). It is being specified for both private networks and wide area public networks.

Various sensing modes are proposed for standardization, as shown in **Figure 1**.

Figure 1: Network and device sensing modes



Source: Qualcomm

- **Monostatic sensing:** Because the transmitter and receiver are at the same physical location and share a single synchronized clock, range and velocity estimation are more straightforward. This mode generally offers greater accuracy in line-of-sight scenarios and is ideal for localized deployments.
- **Bistatic sensing:** Useful in high mobility scenarios where multiple 6G base stations can cooperate to offer sensing across a wide area. This mode is useful, for example, to track drones or vehicles over multi-kilometer distances.
- **Multistatic sensing (device-assisted):** When higher accuracy is required or if the target moves beyond network line-of-sight (e.g., at ground-level blind spots). This is the most complex sensing mode because it requires a higher level of coordination and technical sophistication.

# Spectrum impact on sensing accuracy

Sensing accuracy and resolution are directly related to the underlying channel bandwidth and frequency band. **Table 1** illustrates how different frequency bands can be used for a given sensing application. Clearly, it will be advantageous for regulators to allocate wide channel bandwidths for 6G.

Table 1: Sensing accuracy and resolution by frequency range

Frequency range	Channel bandwidth	Range resolution	ISAC use case
Sub-6GHz	20MHz	7.5m	Coarse macro tracking
6-7GHz	100MHz	1.5m	Vehicle detection; large object tracking
cmWave (FR3)	400MHz	37.5cm	Drone identification and distance tracking; urban traffic

Source: Omdia

The higher the sensing frequency, the greater the possible velocity resolution. For example, mmWave is 3x more sensitive to velocity changes than cmWave.

Therefore, the mmWave band may be better suited for an ISAC system that needs to track small objects, such as pedestrians, bicycles, microdrones, and industrial mobile robots, over distances of less than 500 meters. Sensing in cmWave would be better for tracking road vehicles, trains, and aircraft in bad weather, heavy rain, or tree foliage over distances of 1-5km.

## Conclusion

Integrated sensing and communications (ISAC) brings new capabilities to mobile networks. The addressable market for 6G ISAC will scale from long-range cmWave sensing in the macro network to high precision sensing in local area and small cell networks. By leveraging spectrum appropriately, mobile operators can unlock sensing as a service revenue streams.

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