

Integrated Sensing and Communication in 6G:

e&'s Perspective on Strategic Applications, Monetization
Potential, and Global Roadmap

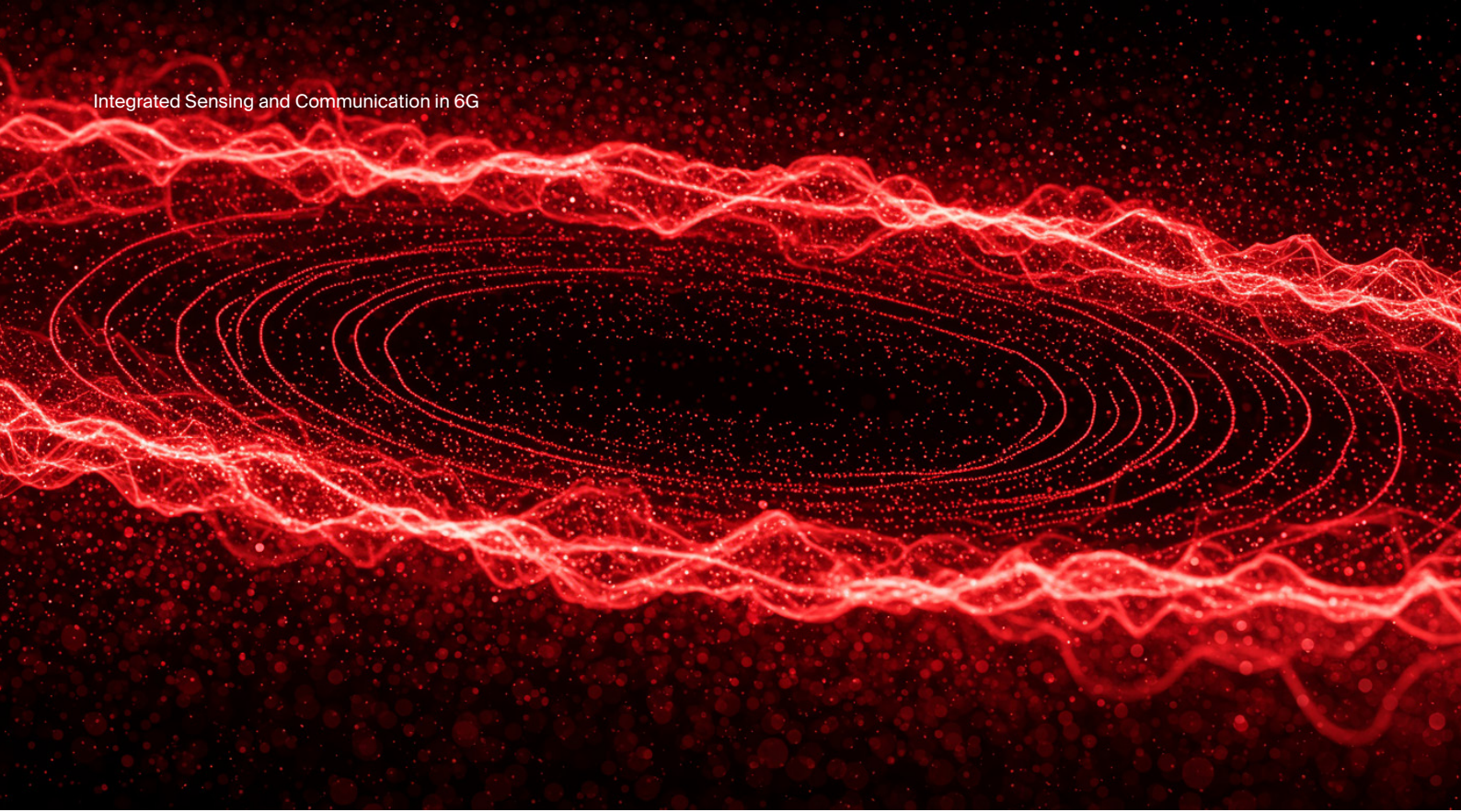
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1. Abstract

Integrated Sensing and Communication (ISAC) is poised to be a defining feature of 6G networks, enabling wireless infrastructure to simultaneously transmit data and perceive its physical environment. This whitepaper offers a comprehensive, industry-focused exploration of ISAC's strategic value, business models, and monetizable use cases across key verticals including transportation, smart cities, industrial automation, public safety, healthcare, immersive media, and network self-optimization. Drawing on global research, recent 3GPP developments, vendor roadmaps, and pilot deployments, the paper highlights how ISAC transforms traditional networks into real-time sensing platforms. It also outlines enabling technologies, deployment challenges, and the monetization funnel for Communication Service Providers (CSPs), with quantified addressable market estimates and a roadmap toward commercial viability in the 6G era. Designed for business leaders, strategists, and technology decision-makers, this whitepaper aims to guide the transition from theoretical promise to scalable, revenue-generating ISAC solutions.





2. Introduction

The next generation of wireless technology, 6G, is expected to not only advance communications but also introduce new capabilities that transform networks into intelligent sensing platforms. One such paradigm is **Integrated Sensing and Communication (ISAC)** – a concept where communication networks double as radar-like sensors for environmental awareness. In essence, ISAC merges traditional wireless connectivity with sensing functions, enabling mobile networks to **detect objects and changes in their surroundings in real time** [1]. This represents a significant evolution beyond 5G’s early positioning services, promising to unlock new levels of situational awareness and efficiency for many industries.

Crucially, ISAC is **poised to be a cornerstone of 6G standards**, with industry bodies already embracing it in their 6G vision. For example, 3GPP (the global cellular standards group) has **identified ISAC as a key feature for 6G**, laying groundwork in current 5G-Advanced (Release 19) and beyond [2]. In fact, initial study items on ISAC began in Release 19 and will progress through Releases 20 and 21, paving the way for 6G deployments around 2030 [3]. The appeal is clear: by sharing infrastructure and spectrum for dual purposes, ISAC can deliver **new services and revenue streams “on top” of existing networks while improving spectrum efficiency** [3], [4]. Telecom operators and vendors see this as an opportunity to expand the role of the mobile network and create a foundation for innovative applications. Advanced markets are already validating the concept on 5G networks today as a stepping-stone to 6G [2].

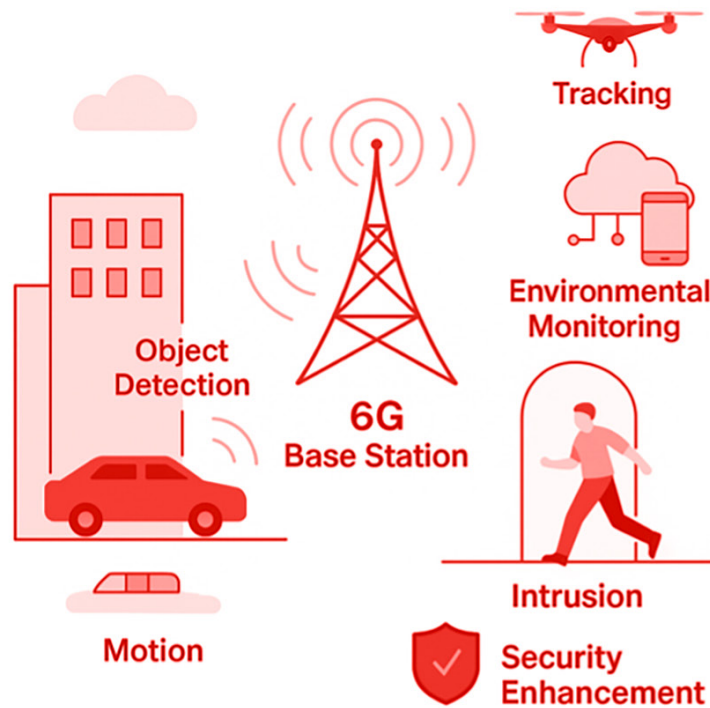


Figure 1: 6G networks are envisioned to function as distributed sensors throughout the environment.

Overall, ISAC marks a strategic shift in network design – moving from “connectivity-only” infrastructure to **multi-function systems that sense the physical world**. The remainder of this paper explores the progress toward ISAC in 6G, potential use cases ranked by business impact, the enabling technologies, and the monetization opportunities for Communication Service Providers (CSPs).

3. The Evolution Toward 6G and ISAC

The road to 6G is already being mapped out by global standards and industry initiatives, with ISAC at the forefront of new capabilities. In 2023–2025, **3GPP and ITU** workshops on “IMT-2030” (the framework for 6G) highlighted integrated sensing as a priority use case for 6G. Early consensus from industry stakeholders has been that 6G should support not just faster connectivity, but also entirely new services – including “**sensing-as-a-service**” – to drive revenue growth and new use cases [4], [3]. This motivation is evident in the first official 3GPP 6G workshop (March 2025), where **support for new services and revenue monetization** was cited among the common drivers for 6G technologies [4]. In line with this vision, integrated sensing and communication features have begun moving through the 3GPP work plan. Release 19 (a 5G-Advanced release in 2025) includes study items on ISAC, and **further advancements are anticipated in Release 20 and 21**, which will feed into the 6G standard around 2028–2030 [3]. By the time 6G arrives, ISAC will likely be a native function of the network architecture rather than an afterthought.

Globally, various organizations are contributing to ISAC research and pre-standardization. In **Europe**, **ETSI** launched an Industry Specification Group on ISAC and in April 2025 published a comprehensive report detailing 18 advanced ISAC use cases – ranging from human motion recognition and emergency rescue to autonomous vehicle navigation and industrial robotics [5]. The report also proposes integration levels (tight/intermediate/loose coupling of sensing and communication) and new performance metrics (e.g. Fine Motion Accuracy, Sensing Service Range) to guide 6G requirements [5]. This work is feeding into 3GPP’s requirements stage (SA1) for 6G. In North America, the **Next G Alliance (NGA)** – a consortium of industry and academia – has identified ISAC as a strategic priority for 6G and is developing white papers and technical recommendations. The U.S. National Institute of Standards and Technology (NIST), for instance, participates in the NGA ISAC group and is conducting research on channel models and interoperability to support ISAC standardization [1]. NIST has even contributed to related standards like IEEE 802.11bf (Wi-Fi sensing), which was approved in May 2025 to allow Wi-Fi devices to measure distance and motion using communication signals [1]. The activity in IEEE underscores that **integrated sensing is a cross-industry trend**, not limited to cellular networks alone.

Locally in the Middle East, 6G planning has also begun with ISAC in focus. The UAE's Telecom Regulatory Authority (TDRA) released a 6G roadmap targeting 2030 for launch, emphasizing use cases like autonomous transport and smart cities. The UAE-based operator e& UAE recently published its 6G vision which highlights ISAC as a core pillar of future networks [6]. In e&'s view, 6G base stations will act as **distributed sensors embedded with AI**, giving the network the ability to “sense” the environment and enabling capabilities like motion detection, terrain mapping, and infrastructure monitoring in real time [6]. This reflects a regional understanding that integrating sensing will be key for national digital initiatives (e.g. safer autonomous vehicles, smart city services, etc.). Similar 6G visions in other countries (e.g. Japan, South Korea, China) also prominently feature joint communication-sensing as a way to enable futuristic services like holographic telepresence and ultra-precise localization. All of these global and local efforts point to a common expectation: **by the 2030s, mobile networks will not only connect us but also constantly observe and interpret the world around us.**



4. Key ISAC Use Cases in 6G (Ranked by Market Opportunity)

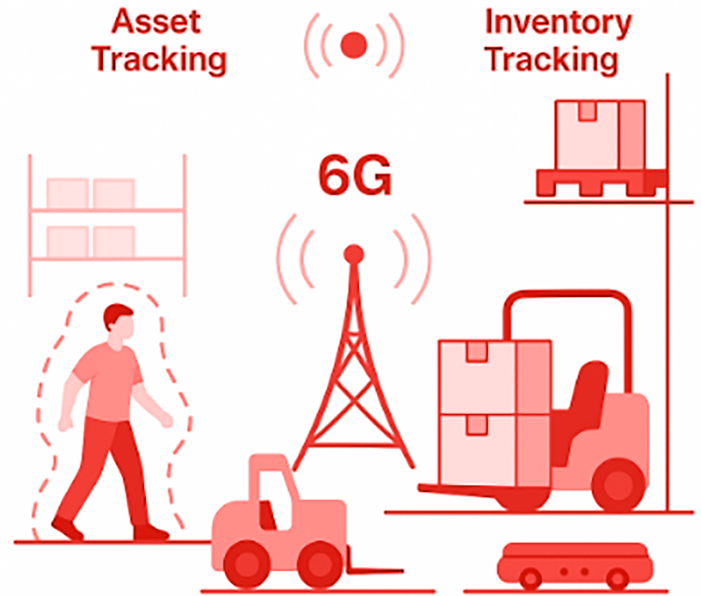
Integrated sensing and communication open a broad landscape of applications across numerous sectors. This section surveys the most promising ISAC use cases, with an emphasis on those expected to deliver high monetization value and large deployment volume. These use cases are grouped by sector and ranked roughly in order of their anticipated commercial impact (combining potential revenue and ubiquity). Notably, ISAC use cases span **indoor and outdoor environments and address both consumer and industrial needs**. For example, an industry study identified use cases as diverse as **estimating foot traffic in malls, monitoring factory robots, detecting falls in healthcare, enabling autonomous vehicles, and tracking drones in the sky** [3]. Such breadth illustrates how ISAC could touch nearly every domain. Below, we discuss major categories in detail:

4.1 Industrial Automation and Logistics

One of the highest-impact domains for ISAC is **Industry 4.0 – smart factories, warehouses, and industrial sites**. These environments are increasingly filled with Autonomous Guided Vehicles (AGVs), mobile robots, and sensor-equipped machines. ISAC can significantly enhance safety and efficiency in these settings. For instance, a 6G network with sensing capability can track the **real-time locations of AGVs, forklifts, and robots on the factory floor** to prevent collisions with workers or other equipment [3]. Today's industrial robots often rely on on-board sensors with limited range; a network-based sensor could provide an over-the-air “visibility” of obstacles beyond line-of-sight of the machine. ISAC-enabled collision avoidance could allow robots and humans to work in much closer proximity without physical safety cages [2], potentially improving workflow and productivity.

Another use case is **asset and inventory tracking**. Integrated sensing can keep tabs on tools, parts, and products in a facility by sensing their presence or movement if they reflect radio signals. Unlike RFID tags that require a tag on each item, the network could passively detect objects (for example, pallets or containers) as they move, as long as they cause some disturbance in the radio environment. This capability, combined with connectivity, enables a real-time digital twin of the warehouse or factory inventory. The business benefit is better inventory management, loss prevention, and automated logistics.

From a monetization perspective, **CSPs could offer ISAC-powered services to industrial clients** (as part of private 5G/6G network solutions). This might be sold as a premium safety package or operational intelligence service. **The value proposition is strong: reduce accidents (avoiding costly downtime and liability), optimize asset utilization, and enable new automation.** In terms of market volume, there are thousands of large factories and warehouses globally that could adopt such solutions, each willing to invest in technologies that boost throughput and safety. Because the **business potential is high and immediately tangible (productivity and safety gains)**, industrial ISAC use cases rank near the top for 6G monetization opportunities [3]. Several telecom vendors are already trialing basic versions of this. For example, **AGV tracking in factories and remote robot teleoperation via 5G** have been demonstrated, and 6G ISAC will take it further with network-based sensing resolution down to a few centimeters' accuracy.



Industrial Automation and Logistics

Figure 2: ISAC in Industrial Automation and Logistics.

e& UAE is actively building the foundation for Industry 4.0 and smart manufacturing use cases by partnering with leading automation and digital transformation providers. For example, e& has entered into a strategic MoU with Exeed Industries to co develop smart factory roadmaps that integrate connected sensors, IIoT, AI powered analytics and digital twin frameworks across its plants. Through these engagements, e& is positioning its network infrastructure and enterprise capabilities as the sensing backbone for logistics, asset tracking and real time process optimisation in factories and warehouses.

4.2 Transportation and Automotive

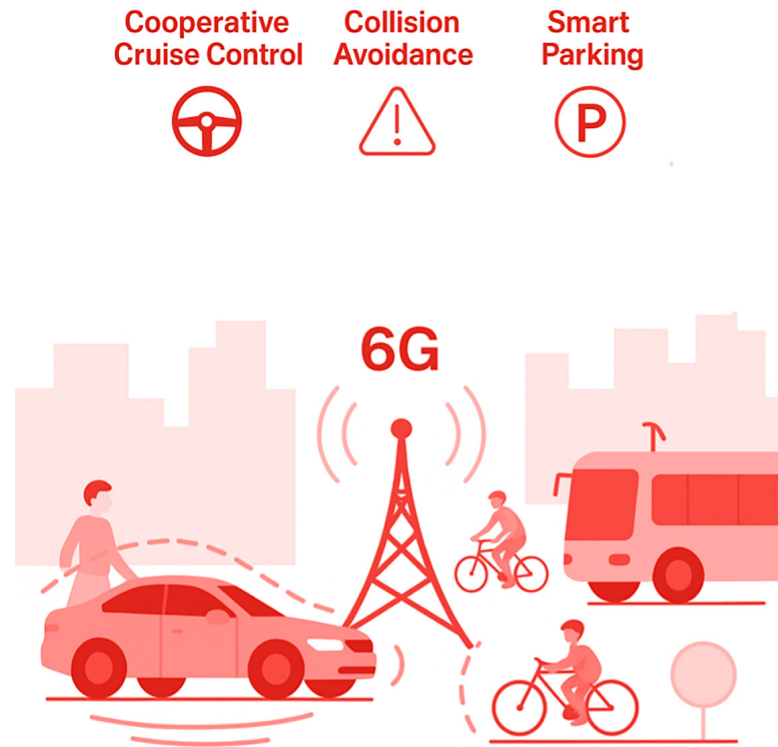
The transportation sector – particularly connected and autonomous vehicles – is expected to be a major beneficiary of ISAC. **Autonomous cars, trucks, and even trains or ships** will need ultra-reliable awareness of their environment to navigate safely. They already use on-board sensors (lidar, radar, cameras), but these have limitations in range and line-of-sight. A 6G network with integrated sensing can act as an additional, **cooperative sensor extending the vehicle’s perception** beyond what its own sensors see [2]. For example, a roadside 6G base station could detect a pedestrian or bicycle approaching an intersection obscured by a building and warn an approaching autonomous car, even if the car’s cameras haven’t seen the person yet. In Ericsson’s vision, **ISAC at busy city crossroads can alert vehicles (and even human drivers) to hidden hazards**, such as a child running between parked cars or an accident around a blind corner [2]. This network assistance could dramatically improve road safety in urban areas.

Another use case is **cooperative adaptive cruise control and collision avoidance**. With ISAC, the mobile network can track many vehicles’ positions and velocities simultaneously in a coverage area. It can effectively create a dynamic map of traffic. This enables new services like network-guided collision avoidance – for instance, warning two connected cars on a collision course at a blind intersection. Even for unconnected vehicles, the network sensing could detect an impending crash and signal connected vehicles nearby to take defensive action. Regulators and insurance companies would highly value such capabilities for safety improvements.

In more everyday convenience terms, **ISAC could help find parking spaces**. A network that senses the environment might detect open parking spots on a street or in a lot (by recognizing the absence of a vehicle where one usually is, or by sensing voids), and then communicate that to nearby drivers or autonomous vehicles [2]. This “smart parking” service could save time and reduce congestion – drivers might pay a small fee for such real-time data, or municipalities might deploy it to manage parking efficiency.



For CSPs, the monetization model around automotive ISAC might involve partnerships with car manufacturers or city transport authorities. **Premium safety services** enabled by 6G (similar to today's connected car subscription packages) could include network-assisted sensing. Given the massive scale of the automotive market and the high value placed on safety and efficiency, the volume and revenue potential here are substantial. By 2030+, autonomous and connected vehicles will likely number in the hundreds of millions worldwide, representing a huge addressable market for ISAC services. Many analysts see **vehicular sensing services as one of the first mass-market offerings to emerge from 6G**. Even Qualcomm has indicated that **drone and vehicle geofencing could be among the earliest 6G use cases**, highlighting industry expectation that transportation-related applications will drive 6G adoption [7].



Transportation and Automotive

Figure 3: ISAC in Transportation and Automotive

e& UAE is advancing connected and autonomous mobility by forming alliances aimed at enabling Vehicle to Everything (V2X), edge compute and smart infrastructure services. A recent MoU with Space42 saw e& leveraging its advanced 5.5G/edge compute network to deploy testbeds for V2X infrastructure, robotaxi fleets and mobility services – laying the groundwork for a transition to 6G enabled sensing in transport. By enabling vehicles, roads and cities to share environmental and positional awareness, e& is establishing itself as a key player in autonomous mobility ecosystems.

4.3 Unmanned Aerial Vehicles (Drones) and Airspace Management

The skies are getting busier with **drones and unmanned aerial vehicles (UAVs)** being used for everything from deliveries to inspections – and this will accelerate into the 6G era. Managing this low-altitude air traffic and ensuring safety is a significant challenge (drones can collide with each other or with buildings, and rogue drones pose security risks). ISAC provides a unique solution: **the mobile network can act as a “radar network” to monitor drones** in its coverage area. Unlike current drone tracking systems that rely on the drone’s cooperation (e.g. ADS-B signals or network registration), ISAC can passively detect any drone by its radar reflection, even if the drone isn’t connected to the network or is “RF-silent.”

Several use cases arise from this capability. First, **drone collision avoidance and traffic coordination**: As swarms of delivery drones and air taxis emerge, network sensing could help keep them safely separated. A 6G network could track dozens of UAVs in a city sector and feed trajectory data to an air traffic management system or directly to the drones. This would augment onboard anti-collision sensors, especially in poor visibility conditions. In fact, network-based **flight trajectory tracking enables UAV operation in all weather and lighting conditions** by compensating when cameras or lidar fail [2].

Second, **no-fly zone enforcement and intruder detection**: ISAC can detect unauthorized drones entering protected airspace (e.g. around airports, critical infrastructure, or private property) and alert authorities [2]. This has strong security and public safety value. For example, a 6G network around an airport could continuously scan for any drones in the vicinity of runways. Trials have already shown this is feasible – in one case, a 5G-based ISAC prototype was installed at a U.S. airport and successfully demonstrated **drone detection out to over 100 feet** in restricted zones. The system, provided by Tiami Networks [8], used passive radar techniques with 5G signals and achieved detection accuracy comparable to dedicated radar systems – highlighting how ISAC can offer a cost-effective alternative for drone surveillance.

Third, beyond safety, there is **commercial drone traffic management**. Companies operating drone delivery fleets might subscribe to a network-based sensing service that provides situational awareness of other objects in the airspace (birds, other drones, etc.), to optimize routes and avoid incidents. Telecom operators could partner with aviation authorities to provide a **UAV tracking feed as a service**. Monetization could involve government contracts for securing public airspace or subscription fees from private drone operators for enhanced navigation data.

The volume of drones is expected to grow exponentially (millions of UAVs by 2030 globally), which means a large potential market for such services. Given the critical safety aspect, stakeholders are likely willing to invest in solutions – making drones/UAV ISAC use cases a high-value opportunity. Notably, 3GPP is already considering **UAV-specific ISAC scenarios**; for example, integrating ISAC in 6G was proposed to support UAV use cases in the 3GPP Release 20 timeframe [4]. This indicates strong interest in making drone sensing an early capability of next-gen networks.



Figure 4: ISAC in Drones and Airspace Management



e& UAE, through its collaboration with Tiami Networks, has demonstrated the first live ISAC demonstration in the MENA region during GITEX 2025 – marking a strategic step toward realizing 6G-powered sensing and connectivity. Moreover, e&'s broader technology roadmap emphasises ultra high bandwidth, sensing capable networks (including terahertz trials in the region) which are essential for future drone and airspace management use cases. This positions e& to support air space monitoring, no-fly-zone detection and drone fleet coordination as part of the ISAC capabilities of its next generation infrastructure.

4.4 Smart Cities and Public Safety

ISAC can play a transformative role in **smart city infrastructure and public safety services**, which represent a broad category of use cases with significant community benefits (and associated economic value). Urban areas are filled with activity – pedestrians, vehicles, infrastructure – and currently rely on a patchwork of cameras, inductive loop sensors, and other devices to monitor conditions. A 6G network with built-in sensing could provide a more cohesive, city-wide sensing layer.

One application is **traffic monitoring and management**. While we discussed individual vehicles earlier, at a city scale the network could sense overall traffic flow on roads (by detecting movement and density of vehicles) and even identify anomalies like accidents or traffic jams as they form. This could feed into city traffic control systems in real time. It's similar data to what cameras or road sensors provide today, but potentially at much lower cost and with broader coverage (every cell site becomes a sensor). Cities might pay for a “smart traffic” service from operators, or operators could partner to provide the data in exchange for access to municipal infrastructure.

Another use: **pedestrian footfall analysis and crowd management**. ISAC can estimate crowd sizes and movements in public spaces by analyzing how wireless signals bounce off human bodies. For example, a 6G network could measure how many people are moving through a park, or queueing at an event, without needing cameras. This has value for city planners (to understand usage patterns), for retail (estimating foot traffic on shopping streets), and for safety (detecting overcrowding or unusual gatherings). In indoor public venues like shopping malls or stadiums, ISAC could similarly monitor occupancy in real time, helping with crowd control and emergency response. Importantly, these methods can be designed to **avoid capturing personal**

identifiable information – they detect presence and motion, not identity, which is a boon for privacy. This privacy-preserving nature of passive sensing makes it attractive for public deployments compared to CCTV. In the airport pilot mentioned earlier, the **5G ISAC system achieved over 91% accuracy in passenger movement detection** without any cameras, demonstrating how such solutions can augment or replace video surveillance in certain scenarios [8].

Public safety and disaster response are other critical angles. ISAC can assist in scenarios like **emergency search and rescue** – for instance, after a building collapse or in a fire, 6G signals could help locate people inside by sensing movements or breathing. Likewise, ISAC could monitor environmental conditions: detecting rising water levels in flood-prone areas (radio signals reflecting off water surfaces), or sensing structural vibrations in bridges and buildings to warn of failures. In fact, researchers have noted that **wireless signals can be used to detect floods or rainfall intensity** by measuring signal attenuation [3]. A 6G network could thus double as a distributed weather sensor network across a city. These capabilities, while perhaps less directly monetizable, carry societal value and could be part of government-funded smart city initiatives. CSPs might monetize them indirectly via contracts or by enhancing the overall value proposition of 6G networks for cities.

Security and perimeter protection is another smart city use. ISAC can secure the perimeters of sensitive facilities (power plants, data centers, campuses) by detecting intrusions. For example, if someone approaches a restricted area, their presence could be picked up by the network's sensing function (as a moving reflection) and trigger an alert, even in darkness or through foliage where cameras might fail. This extends to border security or critical infrastructure monitoring in remote areas using network towers as silent sentries.

In terms of ordering by value: Smart city use cases can generate revenue for operators through solution sales and ongoing services to municipalities or enterprises. The volume of deployment (number of sites, cities adopting) could be large, though budgets vary. Arguably, traffic and crowd monitoring have clear economic benefits (improving transportation efficiency, tourism experiences, etc.), making them likely early adopters. Public safety-related uses might rely on government funding but address high-value problems (safety of citizens). Overall, as cities worldwide strive to become “smarter,” the ability for the mobile network to provide **pervasive, privacy-conscious sensing data** is a compelling offering that operators can monetize through smart city platforms and partnerships.

e& UAE has publicly articulated a vision for 6G as a platform for “intelligent infrastructure that underpins everything from XR and self driving mobility to ... smart cities”. The company’s network and transformation strategies align with national smart city frameworks, and its collaborations (e.g., with technology firms on critical infrastructure automation) indicate the deployment of sensing enabled connectivity for urban intelligence, crowd flows and public safety services.

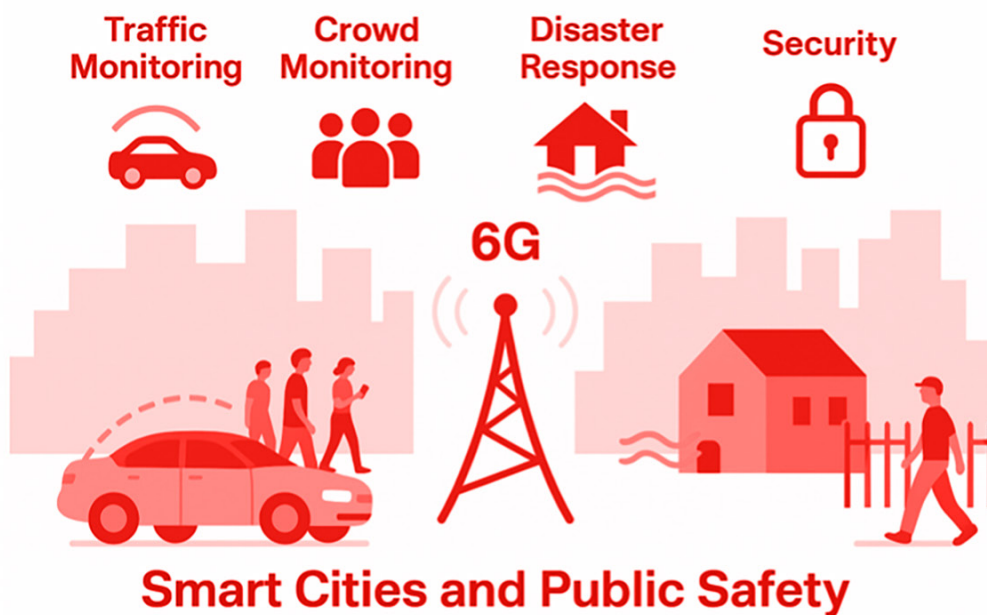


Figure 5: ISAC in Smart City and Public Safety

4.5 Smart Buildings and Retail Analytics

Stepping down to a more local scale, ISAC use cases within buildings are also important – and potentially widely deployed. **Smart buildings, shopping centers, offices, and homes** could utilize network sensing for various convenience and analytics purposes. One example is **occupancy sensing and space utilization**: By analyzing wireless signal patterns indoors, a 6G access point could determine which rooms or areas are occupied and even roughly how many people are present, without using cameras. This can drive intelligent HVAC (heating/cooling only occupied areas to save energy), automatic lighting control, and optimized cleaning schedules, etc. Commercial real estate managers value such insights for improving building efficiency and reducing costs.

In retail, **customer footfall and behavior analytics** can be derived from sensing data. Instead of or in addition to surveillance cameras, a store might use ISAC via its in-store small cells or WiFi-6G access points to track how customers move through aisles (e.g., detecting dwell times in front of displays via changes in signal propagation). This can inform store layout decisions and targeted marketing, much like modern online retailers track clicks. Some of this is already done with Wi-Fi and Bluetooth signals, but ISAC can enhance it by detecting even those not carrying a detectable device (by their physical presence). Operators or solution providers could offer this as a packaged analytics service to retail chains – effectively “**anonymous shopper analytics**” powered by radio sensing.



Another building use case is **security and intrusion detection** for home or office. Using the RF signals from Wi-Fi/6G router, motion can be detected in a room (like an unseen intruder). Standards like IEEE 802.11bf are enabling exactly this for Wi-Fi [1]. In a 6G context, the mobile network (or a femtocell) in a building could act as a motion sensor after hours to alert owners of any movement. This is attractive because it doesn't require special motion detector hardware – it repurposes the communication system. CSPs might partner with security companies or offer value-added services in this domain (for example, a telecom company bundling a home security monitoring service that uses the home 6G hub to detect movement, on top of providing broadband).

The monetization here might be more incremental per site, but the volume is huge – millions of buildings, enterprises, and homes. The **business case for energy savings and security** can drive adoption. Telcos could sell IoT or enterprise solutions that include these sensing features as differentiators. Notably, in the **case of the Gerald Ford Airport pilot**, one of the goals was exactly this kind of occupancy monitoring: the 5G-based ISAC system provided **camera-free passenger counting in airport lounges and gates** to gauge crowding, while respecting privacy. The result was actionable insights on passenger flow that the airport could use for operations (e.g., opening additional screening lines when certain areas got too crowded), achieved without installing a single camera. This example is equally applicable to malls or office lobbies – anywhere you want to understand presence without invasive surveillance. The successful pilot underscores the commercial readiness of such solutions.

In summary, smart building and retail use cases for ISAC rank high in volume (ubiquitous potential deployment), though each deployment might yield moderate revenue. Still, collectively they represent a significant opportunity for CSPs to offer **enterprise analytics and automation services**. These services can often be layered on top of existing connectivity contracts, increasing ARPU (average revenue per user) in the enterprise segment.

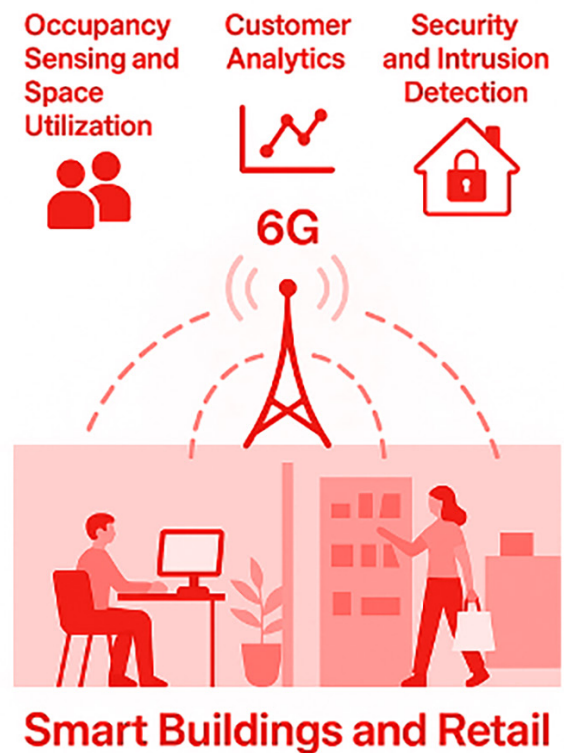


Figure 6: ISAC in Smart Building and Retail

e&'s engagement in industrial and manufacturing automation implicates adjacent capability for building scale sensing, occupancy analytics and smart facility services. The enterprise digital transformation offerings hint at how its connectivity platforms can be extended inward to retail zones, office campuses and commercial property portfolios.

4.6 Healthcare and Wellness Monitoring

Healthcare applications of ISAC, while still emerging, could become quite valuable given global trends in aging populations and telehealth. With integrated sensing, networks can perform tasks like **remote patient monitoring in homes or hospitals**. For example, a 6G router in an elderly person's home might monitor their breathing and movement patterns through wall reflections – detecting abnormalities like a fall or a lack of movement indicating a possible health issue. Research has shown that Wi-Fi signals can detect breathing and small motions; 6G's higher frequencies and greater bandwidth could do so with even finer granularity. **Fall detection** is specifically highlighted as a use case where network sensing could allow caregivers to be alerted immediately if an elderly resident falls, without requiring the person to wear any device [3]. This type of passive health monitoring can enable safer independent living for seniors and reduce the need for constant in-person checks.

Another aspect is **in-hospital patient monitoring**: ISAC could track patient mobility (has someone left their bed?) or monitor vital signs in a less obtrusive way. In emergency scenarios, like someone becoming unconscious, the network might pick up on the lack of usual movement or breathing patterns and trigger an alarm.

These healthcare use cases have an obvious social value and tie into the concept of “**preventive healthcare**” and telemedicine. Monetization might come via healthcare providers or insurers who pay for such monitoring services as part of care programs. Telecom operators might partner with healthcare tech companies to offer integrated solutions (for example, a “6G wellness hub” for smart assisted-living homes). While the user base might be smaller than broad consumer markets, the willingness to pay in healthcare can be relatively high per user due to the critical nature of the service. Privacy is of utmost importance here, and ISAC has an edge because it can be designed to collect minimal personal data (only movement/vital metrics, no audio or video). Regulators would likely support such technologies if proven effective and safe. Given these factors, healthcare ISAC use cases might not be the first to roll out (due to required validations and regulatory approvals), but they hold strong monetization potential in the long run through subscription-based health monitoring services and potentially reduced healthcare costs (a major economic driver for governments and insurers).

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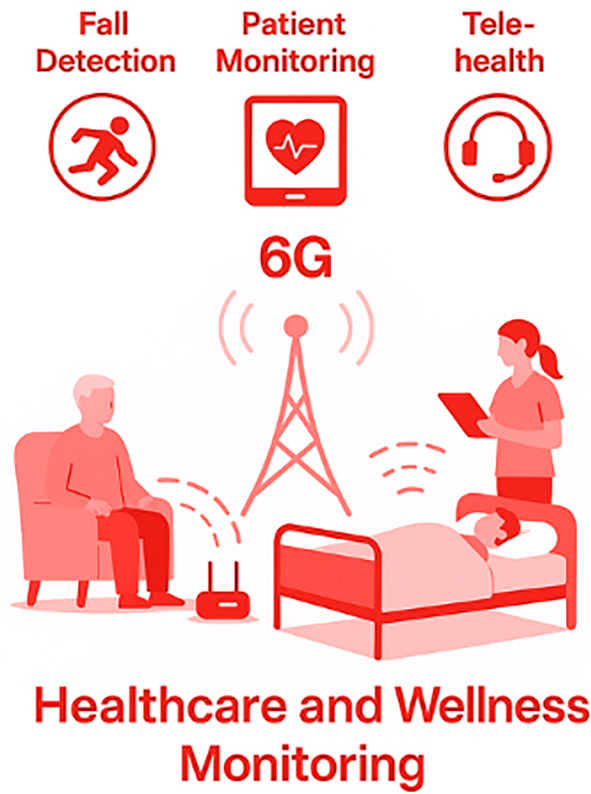


Figure 7: ISAC in Healthcare and Wellness Monitoring

e& UAE's documented focus on connectivity, AI and vertical industry solutions suggests it is well placed to support passive sensing and monitoring use cases in assisted living or healthcare settings. Although specific ISAC healthcare announcements are not prominent, the company's 6G roadmap explicitly mentions sensing, environmental perception and real time infrastructure monitoring – capabilities which can translate into in home wellness and remote patient monitoring services.

4.7 Immersive Media and Consumer Experiences

Toward the lower end of immediate monetization (but still exciting) are use cases around **immersive experiences, augmented reality (AR), virtual reality (VR), and gaming**. In the 6G era, we expect far more pervasive use of AR glasses, mixed reality experiences blending digital content with the physical world, and location-based entertainment. ISAC can enhance these experiences by providing **contextual sensing data to applications**. For instance, an AR application could query the network's sensing data to understand the user's surroundings – are there walls, furniture, other people nearby? – and then tailor the virtual content to that environment [2]. This could make holographic or AR content more realistic and interactive with the physical space. Imagine an AR game that knows where obstacles in the room are because the network “sees” them via radio, so virtual characters can hide behind real objects, etc. The improvement in immersion could be a selling point for 6G over Wi-Fi or offline experiences.

Another example is **adaptive XR streaming**: if the network senses that a user has moved from a large open area into a small room, it could adjust the field of view or content of an AR/VR stream to avoid causing motion sickness or simply to focus on relevant augmentations. This dynamic context awareness might differentiate high-end 6G-powered XR services.

Monetization for operators here is less direct – it may come from enabling a richer ecosystem that drives data usage (thus revenue) or through partnerships with content providers. For instance, a telecom operator could offer a premium AR package for sports events where the network's sensing is used in the stadium to create live AR overlays for attendees, enhancing their experience (and the operator could charge for this value-added service).



Furthermore, **digital twins** and simulations – creating a live virtual model of a physical space – are anticipated 6G use cases. ISAC is what allows the continuous updating of these digital twins with real-world changes. Industries might pay for digital twin services of factories or cities (tying back to earlier use cases), but even consumers might have personal digital twins of their home for IoT management or entertainment. ISAC provides the data to populate these models. A Nokia researcher described ISAC development as “a cornerstone for enabling context-aware services and digital twin technologies in 6G”, underlining the importance of sensing for these future applications [3].

In summary, immersive and consumer applications might not generate the highest direct revenue initially, but they will enrich the overall 6G value proposition and create new usage scenarios (which indirectly drives data subscriptions and ecosystem growth). They are likely to follow once the more mission-critical uses (like those above) establish the ISAC capabilities in networks.

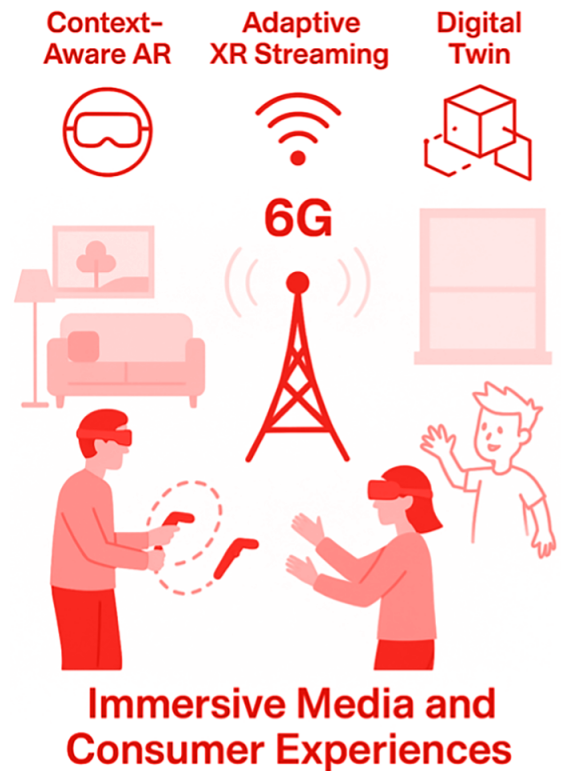


Figure 8: ISAC in Immersive Media and Customer Experience

e& UAE’s vision of 6G emphasises immersive experiences, ultra low latency and high capacity links – all enablers of next gen AR/VR and mixed reality services. While the company hasn’t yet focused publicly on ISAC driven XR features, its broader connectivity strategy places it in a strong position to commercialise network sensing driven consumer experiences once ISAC capable infrastructure becomes available.

4.8 Network Operations and Optimization

Finally, it's worth noting that ISAC can also be used **by the network itself, for its own optimization**, which, while not a sold service, has business benefits in cost savings and user experience. By sensing the environment, a 6G network can self-optimize in real time. For example, the network can detect if a usual line-of-sight path is blocked (say a new building went up or a truck is parked in the way) and proactively adjust beamforming or handover to another cell [2]. It could predict signal obstructions by sensing moving objects (like a large vehicle that might block mmWave signals) and switch an affected user's connection to an alternate path before the blockage causes an outage. Environmental sensing data can also improve **beam management** for high-frequency (mmWave/THz) signals by understanding reflecting surfaces and dynamic changes [2]

The network might also use ISAC to detect where users are concentrated (like a sudden crowd at a concert) and reallocate radio resources or deploy a drone base station to bolster capacity there. In 5G, some of this is done via indirect indicators; in 6G, direct sensing could make it far more responsive.

While these uses don't generate new revenue, they **reduce churn and improve quality** – which indirectly affect the bottom line by keeping customers satisfied and lowering operational costs (e.g., fewer truck rolls if the network can detect issues remotely). Operators will monetize 6G partly by offering superior reliability and performance, and ISAC contributes to that differentiation.

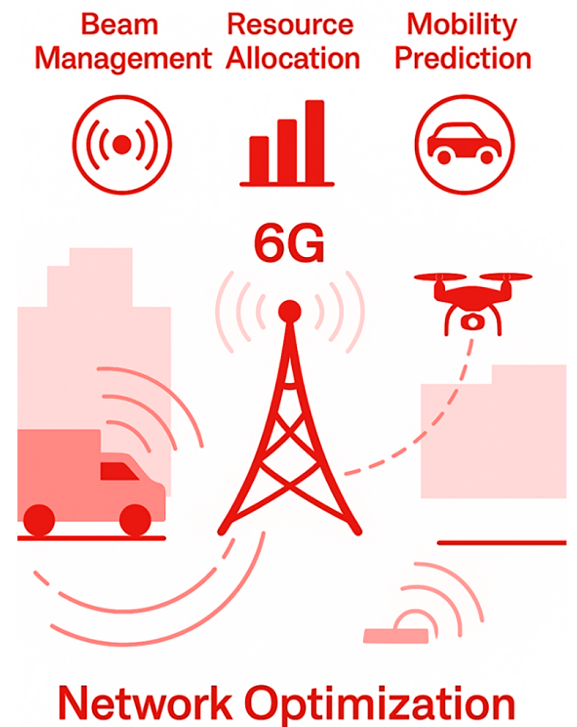


Figure 9: ISAC in Network Optimization

Overall, the **use cases for ISAC in 6G are extensive**, but those with the strongest business case appear to be in sectors like industrial automation, transportation, and smart cities where there are clear pain points and willingness to invest. In many analyses, use cases are prioritized by a combination of **commercial potential, societal benefit, and technical feasibility** [3]. Early indications from standards bodies (like 3GPP and ETSI) and industry groups (Next G Alliance, 5G Americas, etc.) align with the above categorization. For example, ETSI’s report highlights the versatility of ISAC across indoor, outdoor, and mixed scenarios and emphasizes that commercial potential is crucial for 6G success [3]. It’s notable that **many use cases require collaboration with other sensors or data sources (sensor fusion)** – for instance combining network sensing data with cameras or lidar for

autonomous driving – rather than ISAC working in isolation [5]. This means the 6G ecosystem will need to integrate communications, sensing, and AI across various platforms to fully realize these applications.

To guide strategic planning and investment in ISAC-enabled 6G services, we present a comprehensive comparison of key use cases based on monetization potential, market size, deployment timeline, and customer segmentation. This analysis helps prioritize where communication service providers (CSPs) and ecosystem players should focus to maximize both early impact and long-term value. The assessment reflects the alignment with 6G rollout phases and highlights the relative scale and revenue opportunities across industrial, public, and consumer domains. See Table 1 below for a detailed breakdown [9]-[27].

Use Case	Monetization Potential	Addressable Market Value (2031-2033)	Market Volume (Sites/Users)	6G-Aligned Timeline	Primary Customers	Revenue Model	Strategic Value
Industrial Automation & Logistics	High	\$7B-\$35B	Thousands of large factories and warehouses	2028 pilot → 2030 full launch	Enterprises, factories, warehouses	Private 6G SaaS, safety subscriptions	Safety, asset visibility, workflow efficiency
Transportation & Automotive	High	\$2B-\$10B	Hundreds of millions of vehicles globally	2029 pilot → 2030 full launch	Auto OEMs, transport authorities	V2X safety services, traffic APIs	Urban safety, smart mobility
Drone / Air-space Management	High	\$1B-\$5B	Millions of drones and UAVs by 2030	2028 pilot → 2030 full launch	Airports, defense, regulators	UAV tracking SaaS, airspace security contracts	Airspace control, security, delivery enablement
Smart Cities & Public Safety	Medium – High	\$1B-\$5B	Global urban population; 1000s of cities	2028-2029 trials → 2030 rollout	Municipalities, city planners	Data-as-a-service, analytics subscriptions	Urban intelligence, crowd management
Smart Buildings & Retail	Medium	\$1B-\$3.5B	Millions of commercial buildings and malls	2029 pilot → 2030 rollout	Facility managers, retail chains	Smart building analytics, IoT integrations	Energy savings, operational efficiency
Healthcare & Wellness Monitoring	Medium	\$0.5B-\$1.5B	Tens of millions of elderly / tele-health users	2029-2030 trials → 2031 rollout	Hospitals, insurers, elderly care providers	Wellness monitoring subscriptions	Aging population care, remote diagnostics
Immersive Media & Consumer XR	Low - Medium	\$0.5B-\$1.5B	Hundreds of millions of AR/VR/XR users	2029 trials → 2031+ rollout	Consumers, media/entertainment providers	Premium content bundles, data-driven experiences	XR realism, ecosystem differentiation
Network Self-Optimization	Indirect (Cost Savings)	Internal (non-revenue)	All base stations, every operator	2028-2029 integration	CSP internal operations	Reduced truck rolls, churn, improved QoS	Lower OPEX, predictive network management

5. Enabling Technologies and Challenges

Delivering the above capabilities will rely on a range of advanced technologies in 5G/6G, and it also raises significant technical challenges. Here we outline key enablers and hurdles on the path to ISAC in 6G:

- **High-Frequency & Ultra-Wideband Signals:**

6G is expected to utilize millimeter-wave and even sub-THz frequency bands. These higher frequencies come with huge available bandwidths, which directly translates to higher sensing resolution. Simply put, wider bandwidth allows the network to discern smaller objects and finer details in the environment (similar to how higher-frequency radar has better resolution). However, high frequencies also suffer more from propagation issues (blockage, absorption), so the network will need to be dense or use intelligent reflecting surfaces to ensure coverage. The challenge is to balance communication and sensing needs; wideband waveforms can be designed to carry data and still emit useful signal patterns for sensing, but careful **waveform design and signal processing** is required to avoid self-interference between the two functions [3].

- **Advanced Signal Processing and AI:**

ISAC will generate massive amounts of raw sensing data (echoes, reflections) that must be processed to extract meaningful information (like the location of an object). This is where advanced algorithms and AI come in. Edge computing nodes on the network might run machine learning models to interpret radar returns and identify objects or events. Real-time processing is critical, especially for fast-moving objects (e.g. vehicles). AI will also help in adapting the sensing strategy (for instance, focusing sensing beams on areas of interest). The challenge is ensuring this can all happen with low latency and in a scalable way. Additionally, algorithms must be robust to noise and multipath clutter in complex environments.

- **Network Architecture & Resource Management:**

Integrating sensing means the 6G network architecture needs new components and coordination mechanisms. For example, the network might have a **Sensor Data Plane** alongside the user data plane, to collect and distribute sensing information. 3GPP is studying what new network functions or interfaces are needed to support ISAC. One proposal is that base stations (gNodeBs in 5G terms) could share sensing data with a central analytics function or expose it via APIs to authorized applications [2]. Moreover, scheduling and resource management must account for sensing tasks – e.g., scheduling “quiet” moments for listening to echoes, or allocating time-frequency blocks for dual-use signals. A major challenge is optimizing the **co-design of communication and sensing waveforms** so that neither function unduly degrades the other [3]. Techniques like embedding radar-like pulses into communication signals or using MIMO beamforming for both data and sensing are being researched. The network also has to handle trade-offs dynamically: if traffic is heavy, sensing might need to be throttled or

vice versa. This requires intelligent resource allocation algorithms.

- **Interference and Coexistence:**

Sensing by its nature involves listening to reflections, which could be weak and easily masked by other transmissions. If the same frequencies are used simultaneously for communication and sensing, interference management is crucial. Some approaches include using guard intervals or separate signaling for sensing, or leveraging full-duplex radios that can transmit and receive simultaneously (with strong self-interference cancellation). **The challenge of interference** extends to when multiple base stations are sensing – their signals might interfere with each other’s echoes. Coordination among cells (possibly using different codes or schedules for sensing signals) will be needed. This is a new area for standardization to address so that large-scale networks can perform sensing collaboratively rather than chaotically.

- **Accuracy, Coverage and New Metrics:**

What metrics define a “good” sensing service in 6G? Traditional network KPIs (throughput, latency, etc.) are now supplemented by sensing KPIs. For instance, **positioning accuracy, object detection probability, and update rate** will matter. ETSI’s ISAC report introduced metrics like Fine Motion Accuracy (how precisely small movements can be detected) and Sensing Service Range [5]. Networks might need to guarantee a certain sensing accuracy in service level agreements (e.g., able to detect a human moving at 100 m distance with 95% probability). Achieving high accuracy means using multiple antennas, wide bandwidth, and possibly sensor fusion (combining data from multiple sites or frequencies). A challenge here is that lower-frequency bands (sub-6 GHz) have wide coverage but poor resolution, whereas mmWave has great resolution but small coverage.

6G will likely use a mix: e.g., use a lower band to first detect the presence of something over a wide area, then trigger a mmWave beam to scan it for details. Meeting stringent accuracy across conditions (urban clutter, indoor multipath, high-speed targets) remains an area of active research.

• **Privacy and Security Considerations:**

Turning networks into pervasive sensors raises new privacy questions. While ISAC can be designed to be less invasive than cameras, the network will still be collecting environmental data that could indirectly infer human activities. Clear policies and perhaps on-device processing (to ensure raw sensing data isn't misused) will be needed. On the security front, **sensing data could be sensitive** (e.g., positions of people or objects). It must be protected in transmission and storage. There's also the flip side: could an adversary spoof the network's sensors (e.g., by emitting fake echoes)? Techniques from radar countermeasures and secure communications will converge to address this. Encouragingly, industry groups are aware of this – ETSI emphasizes secure and **trusted ISAC implementations, especially for human-centric use cases** [5]. Standards will likely incorporate authentication of sensing signals and encryption of sensor outputs.

• **Device Capabilities:**

While much of ISAC is discussed from the network perspective, devices (UEs) could also play a role in sensing. For example, phones or cars might participate in a **distributed sensing mesh**, reporting their own observations or serving as additional receivers for network transmissions (bistatic sensing). 3GPP has considered UE-assisted sensing scenarios. This would require devices to have firmware and hardware support for processing and sharing sensing data. Battery life impact and computational load on devices are challenges to consider if UEs become part-time sensors.

Despite these challenges, progress is being made. Prototype ISAC systems (as cited earlier) have validated that basic passive and active sensing can be done with 4G/5G signals. Research testbeds (including those at NIST and various universities) are exploring joint communication-sensing waveform designs and algorithms. The **technical feasibility of ISAC is no longer in doubt; the focus now is on refining performance and integration**. As one industry report summarized, ISAC offers both technical and economic benefits, but realizing its full potential will require overcoming the above challenges through innovation and standards collaboration [3].

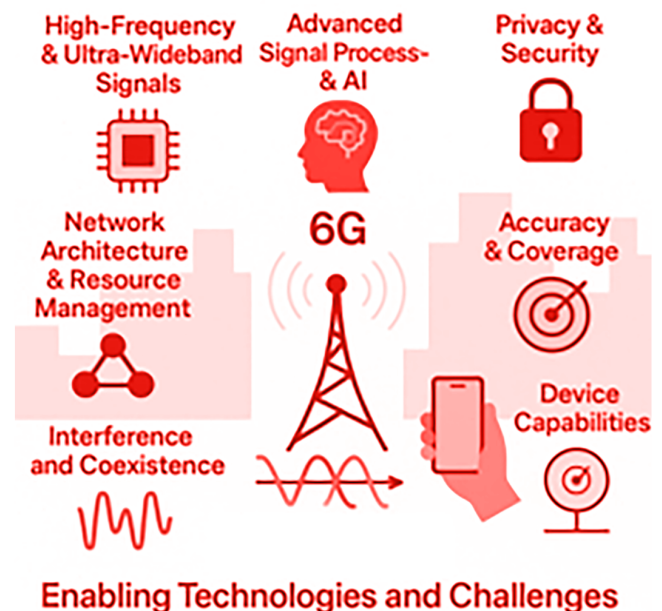


Figure 10: ISAC Enabling Technologies and Challenges

In its pursuit not only to adopt but to shape the 6G era, e& UAE has entered strategic research partnerships with leading academic institutions. Notably, e& UAE and NYU Abu Dhabi recently achieved the Middle East’s first 6G Terahertz (THz) pilot, reaching 145 Gbps throughput – a breakthrough that advances ultra high bandwidth, low latency capabilities crucial for next generation sensing and communication networks. Complementing this milestone are collaborations with Khalifa University (KU) and Zayed University (ZU) to establish a UAE 6G Innovation Hub and federated test bed ecosystem. Through these initiatives, e& UAE is positioning itself at the forefront of global standardisation, test lab development and commercial roll out pathways for ISAC enabled 6G—ensuring that the UAE is not merely a beneficiary of the next generation of networks, but an active co creator of them.

6. Monetization Opportunities for Telecom Operators

For Communication Service Providers, ISAC in 6G is not just about new technology – it is a potential new revenue frontier. The ability to offer “sensing as a service” on top of connectivity could differentiate operators and open business models beyond traditional data plans. Here are the key monetization pathways and strategic opportunities for CSPs: [9]-[26]

- **Sensing-as-a-Service Platforms:**

Operators can expose the rich sensor data collected by 6G networks to third parties via **API-based platforms** [2]. For example, an operator might provide a cloud API that gives real-time object detection or positioning data in a certain area (with appropriate privacy safeguards). Customers could be application developers, city authorities, enterprises, or even other service providers. This essentially turns the network into an information platform. 5G Americas has explicitly highlighted this model: by offering location, movement, and object recognition data through APIs, **mobile operators can unlock new revenue channels** [3]. This might be sold on a subscription or usage basis (e.g., \$X per thousand sensing queries, or tiers of service for different accuracy levels). It parallels how some cloud providers sell geolocation or mapping data today, but with the operator owning the live sensing feed.

- **Vertical Market Solutions:**

Many ISAC use cases will be offered as complete solutions tailored to specific industries (verticals) rather than as raw data. Operators, potentially in partnership with system integrators or equipment vendors, can develop solutions like “**smart factory safety package**”, “**smart city traffic management service**”, “drone airspace security service”, etc. These would bundle the network sensing capability with analytics software and even user interfaces/dashboards that deliver value out-of-the-box to that customer. The revenue model could be licensing, managed services, or outcome-based (for instance, charging a city a monthly fee per intersection monitored). Given operators’ existing enterprise sales channels and IoT solution offerings, ISAC capabilities can enhance those offerings. A telecom operator could, for example, approach a port authority with a combined 6G connectivity + area monitoring solution to track vehicles and ships in the port in real time – an end-to-end service that goes beyond connectivity. **High-value contracts** could be won by solving these industry problems. Moreover, some operators may partner with governments to implement public infrastructure monitoring (much like they do for public safety networks or smart lighting projects).

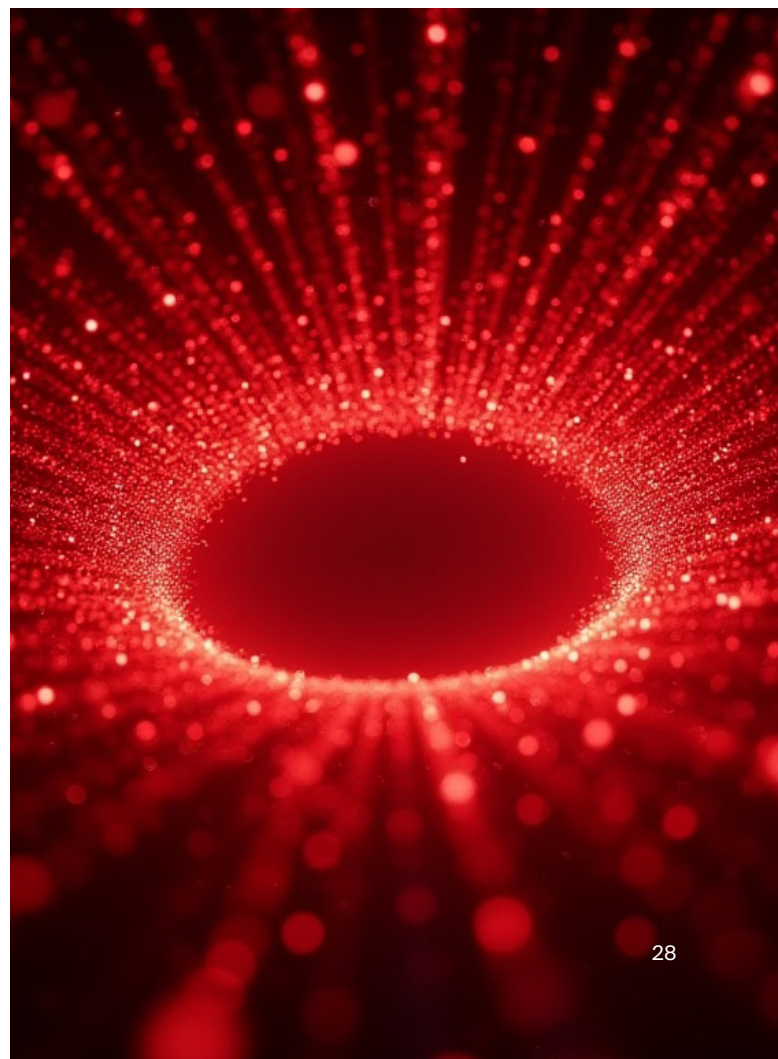
- **Premium Consumer Services:**

On the consumer side, some ISAC-enabled features might be used to upsell customers to premium 6G plans or devices. For instance, a **6G XR bundle** that promises the most seamless AR experiences using network sensing could justify a higher price plan. Or a security feature in your home 6G router that detects intruders might be part of a premium subscription tier (with the basic tier just providing connectivity). While each individual consumer might not pay a lot solely for sensing features, it can contribute to differentiation in a competitive market – potentially reducing

churn and allowing for tiered service packages. As an analogy, think of how some 4G/5G plans include added-value services like streaming or antivirus; in 6G, they might include things like “home motion detection” or “advanced navigation assistance” as part of a bundle.

- **Network Data Monetization (Indirect):**

Even if operators don’t sell sensing data outright, the **insights gleaned from ISAC could inform other revenue strategies**. For example, understanding foot traffic patterns (from network sensing) could feed into more effective location-based advertising or inform where to deploy small cells that then improve network usage revenues. There is also the possibility of selling aggregated, anonymized insights to urban planners, advertisers, or researchers (subject to regulations). Operators must tread carefully here with privacy, but there is precedent in how some carriers monetize location data or mobility trends in aggregated form. ISAC adds a new dimension of data that could enrich those insight products.



• **Cost Savings and Network Value:**

As mentioned, using ISAC internally to optimize networks can reduce operational costs (which, though not direct revenue, improves margins). It can also enhance the **value perception of 6G networks**, which supports premium pricing. If Operator A's 6G network is known to have superior safety services for cars and Operator B does not, Operator A could justify higher ARPU from partnerships or subscriptions. In essence, some monetization will come from **competitive advantage** – being able to claim capabilities that attract high-end users (e.g., autonomous vehicle companies might prefer operators with the best sensing-supportive networks, leading to lucrative enterprise agreements).

• **Ecosystem and Developer Innovation:**

By opening up ISAC capabilities, operators can stimulate creation of new apps that they can then host or data they can carry. Much like GPS in phones led to countless apps (and more data usage), ubiquitous network sensing could lead to, say, AR gaming experiences that drive heavy data consumption or new device types that require 6G subscriptions (e.g., smart sensor gadgets that leverage network sensing data). This indirect effect can grow the overall market and thus operator revenues. The key is that operators should nurture an ecosystem around ISAC – providing tools, SDKs, and maybe sandbox environments for developers to experiment with sensing data. **Parallel business development efforts** are already being encouraged in the industry to align with technology evolution, focusing on use case refinement and ecosystem building [2].

• **SLA-based Revenue for Reliability/Safety:**

Some ISAC use cases are so mission-critical (e.g., collision avoidance, emergency response) that customers might pay for guaranteed service levels. This could take the form of specialized 6G network slices that

include sensing. For instance, a city might pay extra for a **“public safety slice”** that ensures the sensing data for first responders has ultra-low latency and high reliability, with contractual SLAs. This is an extension of the network slicing monetization concept from 5G, now incorporating sensing quality metrics as part of the agreement.

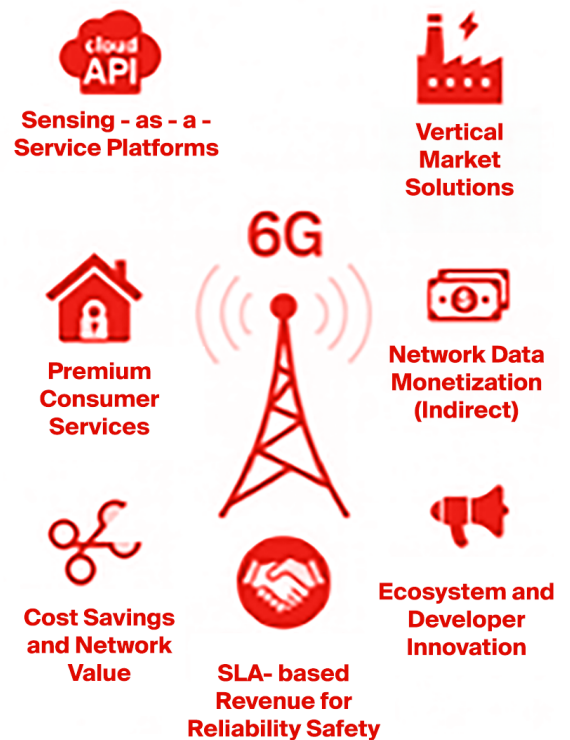


Figure 11: ISAC Monetization Opportunities

It's worth noting that while these opportunities are promising, operators will need to address certain business challenges. One is **data privacy and ownership** – who owns the data sensed by the network? If an operator's cell tower is observing my property for motion, how is that governed? Clear policies and perhaps user consent frameworks will be needed to avoid backlash and comply with regulations. Another challenge is that operators typically have less experience in delivering analytical services (as opposed to pure connectivity), so they may need to develop new capabilities or partner with specialists in cloud, AI, and vertical solutions to fully monetize ISAC.

On the positive side, the **incremental cost of enabling ISAC on existing infrastructure can be relatively low** (since it often uses the same hardware with software upgrades) [2]. Thus, the additional revenue from sensing services could have healthy margins once the initial R&D and deployment costs are covered. Ericsson estimates that ISAC capabilities can be added at "low incremental cost" to mobile networks, but with potentially broad value creation [2]. This value will be realized only if operators craft viable value propositions and business models around the new data.

Encouragingly, the industry is taking a proactive approach: even before 6G standards finalize, companies are experimenting with business models in testbeds and early deployments (like the airport case study, which not only proved technical feasibility but also gauged the airport's willingness to invest in such a capability). As 6G development continues, we can expect to see **more pilot projects that involve end-to-end ISAC solutions** – these will provide templates for scaling and monetization. By the time 6G rolls out, the goal is to have mature ecosystem and business frameworks in place, so that ISAC isn't just a tech demo but a revenue-generating feature from day one [2].



7. Conclusion

Integrated Sensing and Communication is set to be a game-changer for 6G, expanding the role of mobile networks from connectivity **providers to providers of spatial intelligence**. Over the course of this paper, we explored how ISAC technology can enable a wide array of use cases – from factory robots that coexist safely with humans, to vehicles that see around corners, drones that fly securely, cities that sense their environment, and homes that monitor our well-being. These use cases carry the promise of not only new services and efficiencies but also new revenue streams and business models for those in the telecom industry. In many ways, ISAC epitomizes the 6G vision: a network that is **hyper-connected and context-aware**, able to perceive as well as transmit.

The progress toward this vision is well underway. Standardization efforts in 3GPP Release 19/20, industry collaboration in forums like 5G Americas and Next G Alliance, and research prototypes are all converging to build the technical foundations. **The global momentum behind ISAC is strong**, as evidenced by formal studies (ETSI's comprehensive use case analysis, IEEE's Wi-Fi sensing standard, etc.) and high-level endorsement by leading companies. There is a clear recognition that integrating sensing into wireless infrastructure can unlock tremendous value. As one industry report put it, ISAC represents a category of use cases with “high potential” that merits accelerated development to secure early adoption and leadership [2]. Regions that move quickly to pilot and deploy ISAC capabilities could gain advantages in technology leadership and in cultivating new markets.

That said, challenges remain in both technology and commercialization. Issues of interference, accuracy, privacy, and ecosystem coordination must be addressed through continued R&D and cross-industry cooperation. On the business side, operators and stakeholders need to experiment with and refine the value propositions – whether it's selling data, services, or outcomes – and establish trust with users regarding the sensing functionality. This includes educating end users and enterprises on the benefits of ISAC and ensuring transparency in its usage.

Strategically, ISAC can be seen as part of a broader trend in 6G toward merging the physical and digital worlds (sometimes referred to as 6G's support for “contextual services” or digital twins). It will likely work in tandem with other 6G innovations – such as AI-native networks, enhanced positioning, and ubiquitous connectivity – to enable applications we can only begin to imagine. The monetization opportunities will grow as the ecosystem around these applications matures. Telecom operators should start positioning themselves now: developing partnerships (with automotive companies, city planners, industrial automation firms, etc.), investing in pilot projects, and advocating for supportive policies and spectrum allocations for ISAC.

In conclusion, the integration of sensing and communication in 6G holds the potential to **fundamentally broaden the scope of wireless networks**. It is a chance to create new business lines and to solve real-world problems in novel ways using the mobile network as a platform. The journey will require innovation, collaboration, and careful balancing of technical and societal considerations. But if successful, ISAC in 6G could very well be remembered as the development that unlocked a host of “wireless x-ray vision” applications – making our cities smarter, our industries safer, and our lives more connected to the world around us. The stage is set for networks that don’t just carry information, but also collect and act on information about the physical environment, heralding a truly intelligent wireless infrastructure for the future.



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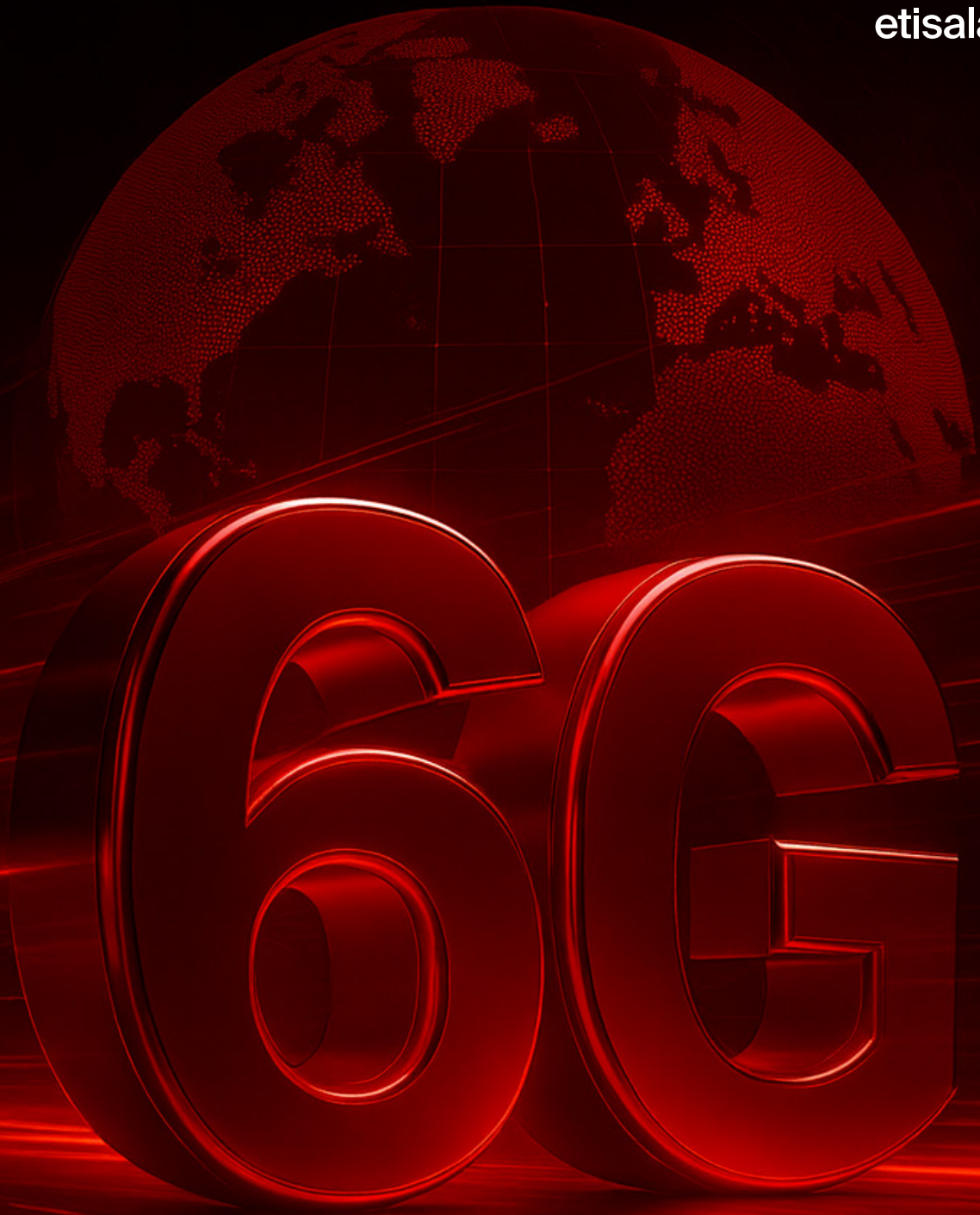
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Integrated Sensing and Communication in 6G:

e&'s Perspective on Strategic Applications, Monetization
Potential, and Global Roadmap