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BUILDING 6G

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By Juan Pedro Tomas, Editor, RCRTech

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INTRODUCTION: FROM FASTER NETWORKS TO INTELLIGENT INFRASTRUCTURE

The development of 6G is taking place against a backdrop very different from the one that shaped previous generations of mobile technology.

For much of the industry's history, each new generation has been defined primarily by improvements in connectivity: higher speeds, greater capacity, lower latency, and more efficient use of spectrum. Those capabilities subsequently enabled new applications and business models, sometimes in ways that were difficult to predict when the networks were being designed.

The emerging 6G vision is more deliberate. The industry is increasingly discussing artificial intelligence, integrated sensing and communications, distributed computing, digital twins, and non-terrestrial networks as integral elements of the next generation rather than simply as capabilities that will run on top of connectivity.

That shift raises a fundamental question: what should 6G actually be built to accomplish?

The responses gathered for this report suggest that there is no single answer, but there is a strong common thread. 6G needs to create value beyond incremental improvements in connectivity. It needs to support AI-native applications and operations while remaining secure, resilient, and energy-efficient. It needs sufficient spectrum and global interoperability. And it needs to evolve economically from the 5G infrastructure in which operators have already invested.

The contributors approach that transformation from different perspectives. ABI Research senior research director Dimitris Mavrakis argues that operators need to establish their role in the AI economy before 6G becomes fully deployed. NTT Docomo senior manager Hiroki Harada describes 6G as future social infrastructure built around sustainability, efficiency, customer experience, AI, and connectivity everywhere. Verizon CTO and senior vice president of technology development Yago Tenorio advocates a use-case-driven approach, particularly around the emerging AI-device ecosystem.

Keysight head of strategic thought leadership Stephen Douglas sees 6G evolving into a resilient, distributed fabric for communications, computing, sensing, and control. Next G Alliance managing director Jaydee Griffith puts new value generation at the center of the proposition. Battelle senior director of product development Mark Reudink emphasizes AI-native, context-aware infrastructure integrating communication, sensing and computing, while Nokia head of standardization and ecosystem engagement Uli Dropmann describes 6G as the first mobile generation in which communications, sensing and AI-native computing are deeply integrated, while stressing the need for a cost-effective evolution from 5G.

Together, their views point toward a transition in which the mobile network becomes something considerably broader than a connectivity platform.

But they also point to an important constraint: the more ambitious 6G becomes technically, the more important it will be to establish a clear purpose for those capabilities.

6G NEEDS TO SOLVE PROBLEMS, NOT SIMPLY IMPROVE PERFORMANCE

The strongest common theme across the responses is the importance of demonstrating tangible value. Mavrakis is particularly direct. He argues that the industry should avoid developing capabilities first and then searching for applications that justify them.

"The biggest challenge will be to design and deploy 6G as a truly capable system that solves industry problems, rather than design a solution looking for a problem," said Mavrakis.

He points to network slicing, private 5G, and APIs as examples of technologies that did not generate large returns for telecommunications operators, and argues that the industry needs to learn from that experience as it approaches 6G.

That concern is reflected in Griffith's assessment of the business case. He argues that the defining objective of 6G should be new value generation for both network operators and customers.

For B2B applications in particular, new 6G services will need to generate measurable value for enterprises, either through cost savings or new revenue opportunities, which can ultimately translate into value for network operators.

Keysight makes a similar argument from the perspective of the broader ecosystem, identifying return on investment as one of the central challenges facing the industry.

The distinction is important. 6G research can produce technically impressive capabilities without necessarily producing a sustainable commercial market.

That makes the transition from research to deployment fundamentally different from a technology race based purely on performance.

"The biggest challenge will be to design and deploy 6G as a truly capable system that solves industry problems, rather than design a solution looking for a problem."

— Dimitris Mavrakis, senior research director, ABI Research

AI IS MOVING FROM APPLICATION TO NETWORK ARCHITECTURE

Artificial intelligence is the technology most consistently identified as central to 6G.

But the responses make clear that the AI discussion is not simply about connecting more AI-enabled devices. The more fundamental change is the integration of AI into the network itself.

Mavrakis says 6G is expected to be AI-native, while operators are already introducing AI into individual network systems. The problem is that these efforts generally remain confined to individual systems and vendors.

"The biggest challenge is to identify the balance between significant network upgrades and value return," he said.

Mavrakis notes that there is currently no network-wide AI capability because of the fragmented nature of telecom networks. Operators considering more comprehensive transformations also face questions about talent, vendor dependence and what role they ultimately want to occupy in the AI market.

That leads to a strategic question for telecommunications companies. "Do telcos want to remain connectivity providers, or become AI landlords, AI infrastructure providers or AI application enablers?"

Mavrakis argues that these different positions involve different requirements and implementation paths.

NTT Docomo approaches the issue from an operational perspective. Harada says AI-native networks can reduce operational costs through automation and labor-saving while improving network design and quality by using operational data. But he identifies an important challenge: AI and telecommunications networks evolve on different cycles.

Harada therefore believes that networks need to continuously adopt the latest and most appropriate AI technologies without slowing the pace of AI innovation.

For Keysight, the challenge is more fundamental because AI introduces probabilistic behavior into systems traditionally designed around predictable interfaces and failure modes.

"From the early 6G research and innovation work we are undertaking with industry, I would say the biggest technical challenge is making AI part of the network control fabric without compromising performance, security, and interoperability," said Douglas.

Douglas identifies distributed data governance, model lifecycle management, federated and edge learning, inference placement, latency, energy consumption and the safe interaction of AI agents with RAN, core, transport, spectrum

"From the early 6G research and innovation work we are undertaking with industry, I would say the biggest technical challenge is making AI part of the network control fabric without compromising performance, security, and interoperability."

— Stephen Douglas, head of strategic thought leadership, Keysight

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— Jaydee Griffith, managing director, Next G Alliance

and application-layer control loops as important challenges.

The operational model also needs to change. AI-native 6G will require operators to move beyond conventional rule-based automation toward intent- and model-driven operations. That creates new requirements around model validation, observability, rollback, auditability, and lifecycle management.

The Next G Alliance highlights another problem: visibility into AI-driven network decisions.

“From a network operation standpoint, there is a challenge with the inherent ‘loss of visibility’ into the network that new AI-native features bring. It’s ‘risk vs. reward,’” said Griffith.

The organization argues that the industry will need to balance the risk of handing essential network functions to AI systems with limited visibility into their decision-making against the potential benefits of lower operating costs and faster decision-making.

Battelle similarly identifies reliable real-time models, high-quality distributed data, privacy and security, safe AI control loops, interoperability. and model lifecycle management as key challenges for AI-native 6G.

The industry is therefore not simply trying to make networks more automated. It is trying to determine which decisions can safely be automated, how those decisions can be validated, and how operators can retain sufficient visibility and control.

FROM CONNECTIVITY TO SENSING

Integrated sensing and communications is emerging as another defining element of the 6G vision.

Verizon sees integrated sending and communications (ISAC) as potentially the most disruptive technology in the 6G portfolio. "ISAC fundamentally transforms the network from a pure communications pipeline into a massive, globally distributed sensor," said Tenorio.

Tenorio argues that base stations and mobile devices could simultaneously detect objects, movement and the surrounding environment, generating information that could support applications including autonomous vehicle navigation and precision industrial automation.

Verizon also connects ISAC directly to spectrum policy. The company argues that sensing accuracy is related to channel bandwidth and therefore says the development of ISAC will influence the industry's approach to spectrum.

The Next G Alliance also identifies ISAC as having a particularly clear path toward long-term impact.

Battelle sees AI-native networking and ISAC as potentially transformative because they change the role of the network itself, moving it from a passive transport system toward an intelligent platform capable of sensing and interacting with the physical environment.

Keysight similarly identifies ISAC applications across industrial automation, transport, infrastructure monitoring and other environments.

At the same time, Mavrakis of ABI Research offers a more cautious assessment. "Sensing also have the capability to completely redefine the utility and value of the network, but its technical and commercial viability is yet unproven," he said.

That qualification is important. The potential of sensing is considerable, but its eventual contribution to the business case for 6G remains to be demonstrated.

"ISAC fundamentally transforms the network from a pure communications pipeline into a massive, globally distributed sensor."

— Yago Tenorio, CTO and senior vice president of technology development, Verizon

SUB-THZ MAY HAVE A TARGETED ROLE

The responses do not portray higher-frequency spectrum as a universal solution for 6G.

Mavrakis notes the importance of new frequency bands but also emphasizes that different technologies will have different commercial and technical roles.

Keysight similarly sees sub-THz as likely to have a more targeted role because of propagation characteristics, deployment density and device economics.

Griffith of Next G Alliance also points to propagation as a physical limitation that could affect adoption.

This suggests that the 6G spectrum story is likely to be more nuanced than simply moving toward ever-higher frequencies.

Different spectrum bands will serve different purposes, depending on propagation characteristics, capacity requirements, device economics, and deployment environments.

That makes spectrum policy and harmonization at least as important as the development of the radio technologies themselves.

SPECTRUM POLICY WILL HELP DETERMINE THE ECONOMICS OF 6G

The contributors broadly agree that spectrum availability and global harmonization will be critical.

Docomo's Harada says harmonization of spectrum allocation will be essential to cost-efficient global deployment, while noting that many candidate 6G bands are already assigned to other systems.

"For 6G to become widely adopted, global harmonization will be essential," said Harada.

The executive also says governments and regulators will need to lead discussions on spectrum reallocation, with standards bodies providing the information necessary to support those discussions.

Nokia identifies sufficient spectrum as one of three major policy priorities. "The AI era will drive significant growth in mobile traffic, making additional upper mid-band spectrum essential for cost-effective 6G deployment and a compelling user experience."

Verizon advocates a particularly ambitious approach to spectrum allocation, arguing that large, contiguous blocks will be required to fully exploit capabilities such as ISAC and robust uplink performance.

The company also argues for global standards uniformity and native open interfaces. "Standards bodies and industry players must align behind a single, global 3GPP standard," said Tenorio.

Verizon says fragmentation would undermine the scale required by the wireless ecosystem.

Battelle similarly calls for globally harmonized spectrum allocations, open and interoperable standards, collaborative research and testbeds, and updated regulatory frameworks supporting dynamic spectrum sharing, non-terrestrial integration and cross-industry experimentation.

The policy dimension therefore goes beyond simply making spectrum available. It encompasses harmonization, standards, interoperability, sharing frameworks, and the degree of regulatory flexibility available to companies developing new applications.

"For 6G to become widely adopted, global harmonization will be essential."

— Hiroki Harada, senior manager, NTT Docomo

SUSTAINABILITY HAS TO BE ADDRESSED AT THE SYSTEM LEVEL

6G is expected to deliver higher performance while also supporting significantly greater AI and computing workloads. The resulting energy challenge cannot be addressed solely through more efficient individual components.

Docomo argues that a "green network design" is essential to avoid a trade-off between traffic growth and environmental impact. Its approach combines architectural efficiency with resource sharing.

The company is exploring photonics-electronics convergence, AI-driven traffic prediction that can automatically power down unnecessary base stations during periods of low demand, as well as advanced spectrum sharing and infrastructure sharing.

Verizon similarly argues that sustainability requires a fundamental architectural shift. The company says a 6G network delivering substantially greater performance cannot simply increase the power consumption of existing hardware architectures. Instead, network layers need to dynamically allocate computing resources and put idle elements into deep sleep states.

Keysight advocates a system-level approach. "6G can balance higher performance with sustainability if energy efficiency is treated as an architectural requirement, not a post-design optimization."

Douglas points to energy efficiency for communications and computing, alongside energy-efficient AI scheduling, sleep states, dynamic spectrum and carrier management, efficient compute placement and network planning that avoids unnecessary densification.

The Next G Alliance highlights another dimension of the sustainability calculation: higher-frequency spectrum can require greater power output to maintain coverage, while lower-power operation may require network densification.

The industry therefore needs to evaluate both the energy efficiency of individual technologies and the wider consequences of deployment decisions. The sustainability issue is closely linked to the economics of 6G. Energy consumption, computing location, site density, spectrum, and infrastructure reuse all affect the cost of building and operating the network.

SECURITY, PRIVACY, AND RESILIENCE MOVE INTO THE ARCHITECTURE

The transition toward more autonomous and distributed networks also expands the security challenge.

Mavrakis describes comprehensive security as a full-stack trust infrastructure beginning with hardware roots of trust and secure execution environments. He also emphasizes crypto-agility because 6G infrastructure will have to consider a post-quantum environment.

As 6G becomes increasingly fragmented into micro-services and micro-domains, he argues that zero-trust architectures will become particularly important. He also identifies the need for dedicated governance around the integrity, confidentiality and privacy of AI models and their input and output data.

Docomo approaches resilience partly through its vision of three-dimensional networks combining terrestrial networks with satellites and high-altitude platform stations.

The company says seamless switching between terrestrial and non-terrestrial networks will be important in Japan, where natural disasters can disrupt terrestrial communications.

The AI-native architecture creates another security concern. Docomo says future networks will need to be prepared for vulnerabilities including attacks targeting AI algorithms themselves, such as data tampering.

Privacy also becomes more complicated as digital twins and sensing expand. Docomo warns that the 6G era will increase the volume and sensitivity of data circulating across networks, including human movement patterns, location information, and confidential data. It argues that privacy protection needs to be embedded into 6G from the outset.

Nokia similarly argues that trust must be built into 6G from the beginning. "Trust must be built into 6G from day one, not added later," Dropmann said.

The Nokia executive identifies privacy, resilience, and security as fundamental requirements as networks become increasingly AI-native.

Keysight takes a similarly broad view of the trust model. "The main 6G security challenge is that the network will be more autonomous, software-defined, and exposed to cross-domain dependencies, so the trust model has to cover not only radio and core functions but also AI models, training data, orchestration layers, APIs, and supply chains," said Douglas.

The company argues that testing and assurance need to become part of the architecture, including validation of zero-trust access controls, privacy-preserving telemetry, signed models and datasets, AI behavior, and resilience against cyber and physical failures.

"Trust must be built into 6G from day one, not added later."

— Uli Dropmann, head of standardization and ecosystem engagement, Nokia

For Battelle, security by design similarly means integrating Zero Trust, strong identity and authentication, end-to-end encryption, AI-assisted threat detection, distributed and redundant architectures, secure supply chains, and rigorous testing and certification.

The implication is straightforward: trust cannot be a feature added once the architecture is complete.

TESTING MUST EVOLVE WITH AI AND SENSING

The emergence of AI-native networks and ISAC also changes what it means to test a mobile network.

Keysight identifies AI-driven physical-layer functions, new radio frequencies, integrated sensing and communications, and AI-native network operation as areas requiring new testing approaches.

AI-driven physical-layer research increasingly involves neural receivers, AI-based channel estimation, CSI compression, beam management, and waveform optimization under realistic propagation conditions. This requires workflows combining high-fidelity channel models, digital twins, hardware-in-the-loop testing, and RF measurements.

ISAC presents an even more fundamental change. A network that is expected not only to transmit data but also to measure its environment requires new performance metrics. Traditional RF measurements need to be complemented by measurements including range, velocity, angular resolution, detection probability, and false-alarm rates.

AI-native operation changes validation again. Keysight says the industry must move from validating network functions to validating autonomous decision-making. That requires digital twins, realistic traffic and mobility emulation, synthetic and live data and closed-loop validation before AI-driven functions are deployed operationally.

This is where digital twins become particularly important. Keysight says the complexity and software-defined nature of 6G make sequential design, prototyping and field testing increasingly impractical. Instead, engineering teams need connected digital workflows spanning algorithm development, RF design, protocol validation, and system performance.

Digital twins can enable developers to train and validate AI models, evaluate new physical-layer techniques, emulate radio environments, and correlate simulation with laboratory and over-the-air measurements.

The objective is not to replace physical testing. Instead, digital twins can make physical testing more targeted and repeatable by creating a continuous validation loop between simulation and measurement.

That role could extend into commercial operations, where operators will need environments in which they can validate new models, test policy changes and assess resilience before changes are introduced into live networks.

6G WILL NEED TO BUILD ON 5G

Despite the ambition surrounding 6G, the responses consistently point toward evolution rather than wholesale replacement.

Nokia identifies a cost-effective evolution from 5G as a defining objective.

On the radio side, that means enabling 6G deployment on largely the same network grid as 5G, even when higher frequencies are introduced, while supporting spectrum sharing between 5G and 6G. In the core network, Nokia says 6G needs to build on investments already made in 5G Standalone architectures.

Keysight reaches a similar conclusion when considering which technologies are most likely to reach market scale.

The innovations most likely to achieve scale, according to Douglas, will be those that can be introduced incrementally on top of existing network investments, create new revenue opportunities or materially reduce operating costs.

Nokia's perspective is particularly relevant because 6G development is taking place alongside continuing 5G-Advanced work.

The implication for operators is clear: the value of 6G will depend partly on how effectively they can use existing sites, spectrum, core infrastructure, and other investments while introducing new capabilities.

THE POLICY AGENDA EXTENDS BEYOND SPECTRUM

The responses suggest that governments and regulators will influence the outcome of 6G in several areas.

Spectrum is clearly one of them, but the policy discussion also includes standards, interoperability, security, AI governance, infrastructure sharing, and non-terrestrial networks.

Keysight calls for internationally aligned spectrum roadmaps, commercially practical spectrum-sharing regimes and standards focused on global interoperability, open and testable interfaces, common data and AI governance models, and conformance frameworks for AI-native and sensing-enabled systems.

Battelle similarly argues that regulators should modernize frameworks to support dynamic spectrum sharing, non-terrestrial integration, and cross-industry experimentation, while maintaining strong security and resilience requirements.

The Next G Alliance highlights another policy connection: the potential dependence of national AI ambitions on mobile infrastructure.

That creates a broader policy question. If 6G becomes an infrastructure layer for AI-enabled physical systems, robotics, sensing and other applications, decisions made within telecommunications policy could affect wider technology strategies.

DEPLOYMENT ECONOMICS WILL SHAPE INCLUSION

Docomo identifies the high cost of building and maintaining advanced infrastructure as the biggest challenge over the next decade. In Japan, declining birth rates, an aging population and rural depopulation make it difficult for telecommunications carriers to bear rural infrastructure costs and recover investments independently.

Docomo therefore sees cross-industry ecosystems and infrastructure sharing as important to overcoming that challenge. The company also sees NTN as a means of extending communications beyond areas traditionally served by terrestrial networks.

Docomo also says mountainous regions, territorial waters and airspace remain outside conventional terrestrial communications coverage despite very high population coverage. It expects NTN to extend services into these areas and potentially support administrative and medical services in remote rural areas, as well as applications such as smart forestry and smart fisheries.

These examples provide a concrete connection between 6G technology and broader objectives.

But they also show why the economics of deployment matter.

The ability of 6G to provide new services in underserved locations will depend on whether the infrastructure can be deployed and maintained at a sustainable cost.

SPECIFIC PUBLIC BENEFITS ARE MORE CREDIBLE THAN BROAD PROMISES

Battelle points to public safety, environmental monitoring, and large-scale scientific research as areas where integrated sensing, precise positioning, and high-capacity connectivity could create measurable benefits.

Its emergency-response example is particularly concrete. “One example is real-time situational awareness for emergency responders during disasters.”

Reudink of Battelle describes a potential system combining drones, body-worn cameras, environmental sensors, and autonomous robots. Command centers could receive real-time three-dimensional maps of damaged areas, locate victims, and coordinate responders.

Docomo’s examples of remote precision medicine, smart agriculture, autonomous driving, and remote construction provide another set of potential applications.

These examples are more useful than making a generalized claim that 6G will automatically deliver broad societal benefits.

6G could support new public-interest and remote-area applications where its capabilities address concrete needs and where the economics of deployment can support them.

THE COMMERCIAL READINESS TEST

The industry is now moving from broad 6G research toward more defined standardization milestones.

That makes the transition from research to deployment increasingly tangible, but standards progress alone will not establish commercial readiness.

Keysight emphasizes the importance of aligning standards milestones with hardware and silicon roadmaps and field evidence. The company argues that the industry needs evidence that the capabilities being standardized deliver genuine value and are realistically deployable.

A specification is not a commercial network. For 6G to move from research to deployment, standards need to align with hardware, spectrum, devices, testing methodologies, operator economics, and actual demand.

THE OPPORTUNITY: A NETWORK THAT COMBINES INTELLIGENCE, SENSING, AND COMPUTING

Despite the caution around economics and deployment, the contributors see substantial opportunity in what happens when the different elements of 6G are combined.

Keysight describes the opportunity as the evolution of mobile networks into trusted digital infrastructure supporting communications, computing, sensing, and AI as an integrated platform.

"The greatest opportunity is for 6G to evolve mobile networks into trusted digital infrastructure that supports communications, computing, sensing and AI as an integrated platform, with success increasingly defined by intelligence, sensing, and resilience," the Keysight executive said.

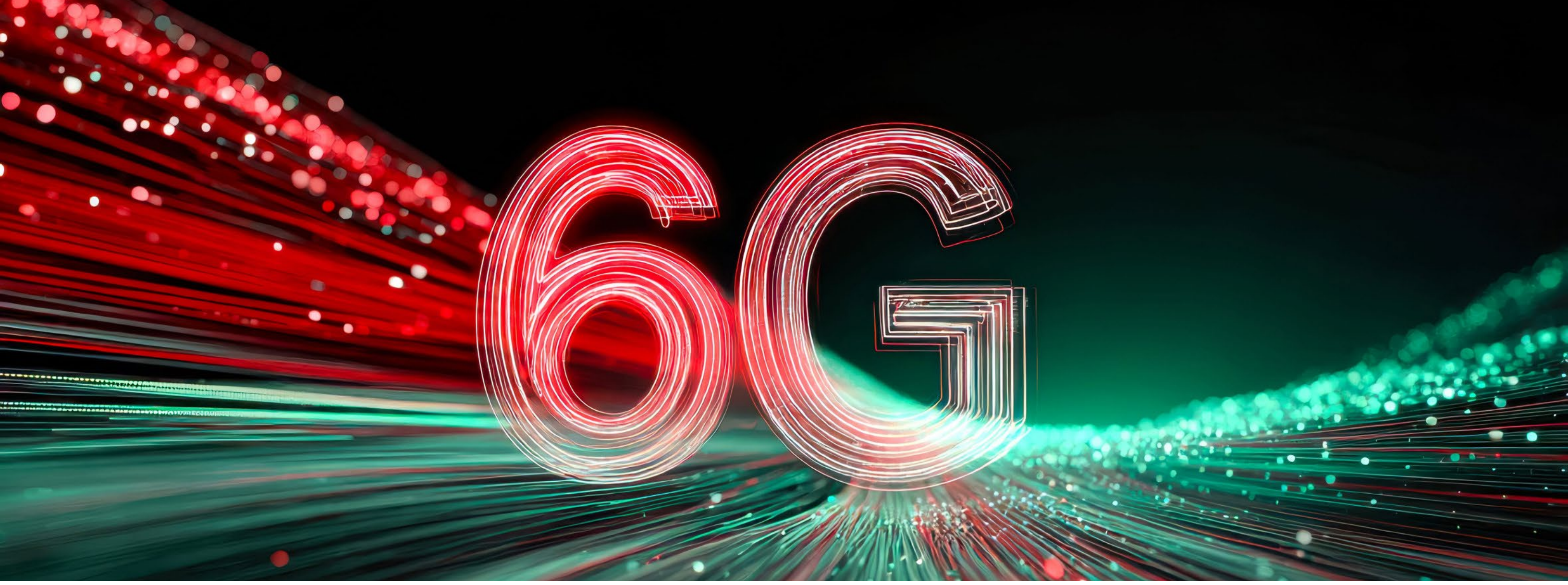
Douglas identifies the opportunity in using the network as a platform for AI, transforming radio infrastructure into an integrated sensing platform and making resilience an explicit measure of network performance.

Nokia describes a similar convergence. Its vision is one in which communications, sensing, and AI-native computing are integrated deeply into the network, with AI embedded into network functions, optimization, management, and orchestration.

Battelle similarly describes 6G as moving the network from passive data transport toward an intelligent platform that can perceive, learn from and interact with the physical environment.

Verizon's vision is explicitly use-case driven, particularly around AI-enabled devices. Tenorio argues that the industry should build 6G around the emerging AI ecosystem rather than first maximizing network performance and waiting for applications to emerge.

This is perhaps the most important conceptual difference between 6G and earlier generations. The network is increasingly being designed around the interaction between connectivity and other capabilities.



CONCLUSION: MAKING 6G PURPOSEFUL

The responses gathered for this report reveal a 6G industry that is technologically ambitious but increasingly conscious of the need to justify that ambition.

AI-native networking, integrated sensing, distributed computing, digital twins, and NTN could fundamentally expand the role of the mobile network. But the contributors also agree that technical capability alone will not determine 6G's success.

The business case, spectrum availability, interoperability, security, sustainability, and the ability to build economically on 5G will all matter.

The most credible path therefore appears to be one in which 6G is developed around specific problems and measurable value, rather than around performance targets alone.

That means aligning technology with market demand, policy with global scale, security with increasingly autonomous operations and sustainability with the economics of deployment.

The result could be a network that does considerably more than connect people and devices: a distributed infrastructure capable of combining connectivity, computing, sensing, and intelligence.

Whether 6G ultimately fulfills that promise will depend less on how advanced the technology becomes than on how effectively the industry aligns those capabilities with real-world needs.

ACKNOWLEDGEMENTS

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