RCR Wireless News
INTELLIGENCE ON ALL THINGS WIRELESS

Will 6G be an evolution or a revolution?

The spectrum, standards, use cases, and road ahead

By Sean Kinney, Principal Analyst

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INTRODUCTION

Like it or not, it's time to start talking about 6G in earnest, including but not limited to spectrum (or lack thereof), standards, use cases and how those are aligned in a way that delivers value and makes money. In many ways, 6G looks evolutionary in deployment (a good thing, too), and potentially revolutionary in capability. But this isn't a binary; there's hopefully a narrow path that balances what's financially feasible and solves real problems versus what's technologically possible and a study of how to do something without first figuring out why it needs to be done.

This report will take stock of the 6G standardization process, examine new spectrum needs and what they suggest for mobile network operator (MNO) capex, consider how existing use cases could be emboldened and what new services could be realized, and of course look at the role artificial intelligence (AI) will play. The report also features insightful discussions with industry experts deeply engaged in guiding the industry from concept to reality.

RCR TECH KEY TAKEAWAYS

- **Spectrum defines ambition:** FR3 and even sub-THz frequencies expand the 6G toolbox, but auction costs and regulatory timelines risk repeating the cycle of overspending on spectrum and underspending on deployment.
- **Standards are evolving with intent:** Release 20 will continue the 5G Advanced chapter and set the foundation for 6G, with Release 21 expected to establish formal 6G work items. A standalone architecture and infrastructure re-use are emerging as consensus points.
- **Use cases span evolution and revolution:** Incremental growth will come from fixed wireless access, RedCap extensions, and expanded IoT capabilities. High-risk, high-reward bets include integrated sensing and communications (ISAC) immersive communications, and ubiquitous connectivity delivered by converged terrestrial networks (TNs) and non-terrestrial networks (NTNs).
- **MNO economics remain the constraint:** With flat to modest revenue growth and finite budgets, MNOs will prioritize software-based upgrades and spectrum re-use over new, capital-intensive infrastructure deployments.
- **AI is the enabler:** Whether improving spectral efficiency, automating network operations or enabling multi-RAT Spectrum Sharing (MRSS), AI is less a single use case and more the foundation of 6G's architecture.

The bottom line: 6G will be evolutionary in deployment and potentially revolutionary in ambition. Its success hinges on aligning spectrum policy, standards progress and revenue opportunities into a commercially viable whole.

THE SPECTRUM

To be clear, any and all 6G ambitions will be bounded by spectrum availability, which itself will vary in terms of both market and regulatory timelines. But in concept, 6G will include FR1 frequencies up to 7.125 GHz, FR2 frequencies from 24.25 GHz to 52.6 GHz, then FR3 (this is what's new) from 7.125 GHz to 25.5 GHz; FR3 is commonly referred to as the upper-mid band. There is also more specialized interest in sub-THz frequencies for ultra-high capacity, very short-range data transmission with wireless data exchange within a data center as a target use case.

Identifying candidate frequencies in the upper-mid band is one thing. Operators gaining control of those airwaves is another matter. In the U.S., the Federal Communications Commission lost spectrum authority in March 2023 with a partial restoration under the Biden administration and full restoration in July with the passage of the Trump administration's One Big Beautiful Bill Act. The bill directs the Assistant Secretary of Commerce and the FCC to identify at least 800 megahertz of spectrum within 1.3 GHz to 10.5 GHz for auction with target proceeds set at least at $85 billion.

This clearly raises cost concerns for operators who similarly spent billions to deploy 5G — and still are in the case of AT&T which is dropping $23 billion for Echostar's low- and mid-band holdings. Put simply, operators have a finite amount of money; overspending on spectrum means underspending on deployment, which could perpetuate a cycle of delayed capabilities to a market that's arguably jaded by what 5G has delivered. But if that $85 billion target for U.S. 6G spectrum auctions is even partially directionally indicative of what will happen at a more macro level, there are big implications for operators seeing relatively stagnant revenue growth.

Returning to the implied infrastructure trade-offs, there's growing consensus that 6G needs to rely more on software-based enhancements than new, capital-intensive infrastructure deployments. "Re-use" is a word you'll likely hear in industry discourse around 6G priorities. In practice that would mean putting 6G equipment on existing 5G sites, so antenna and other underlying technologies, both hardware and software, would need to enable a 6G radio transmitting in the upper-mid band

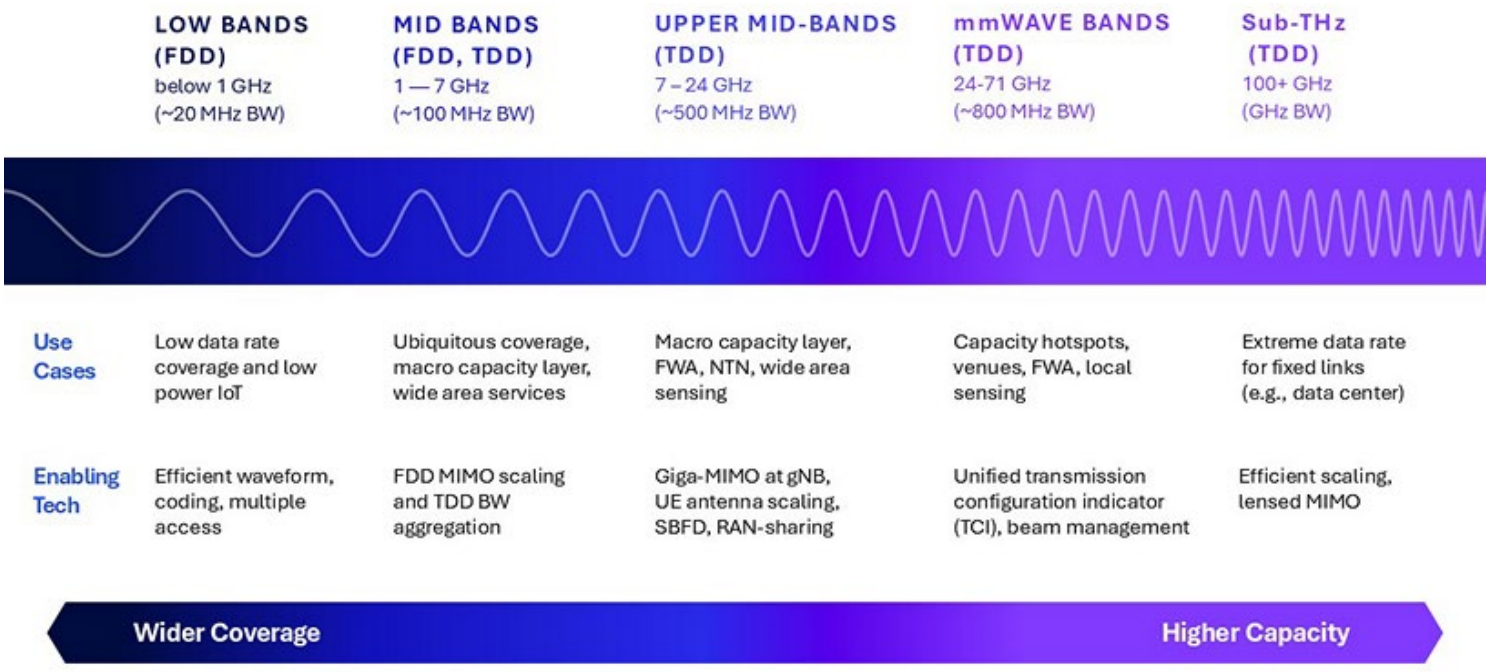


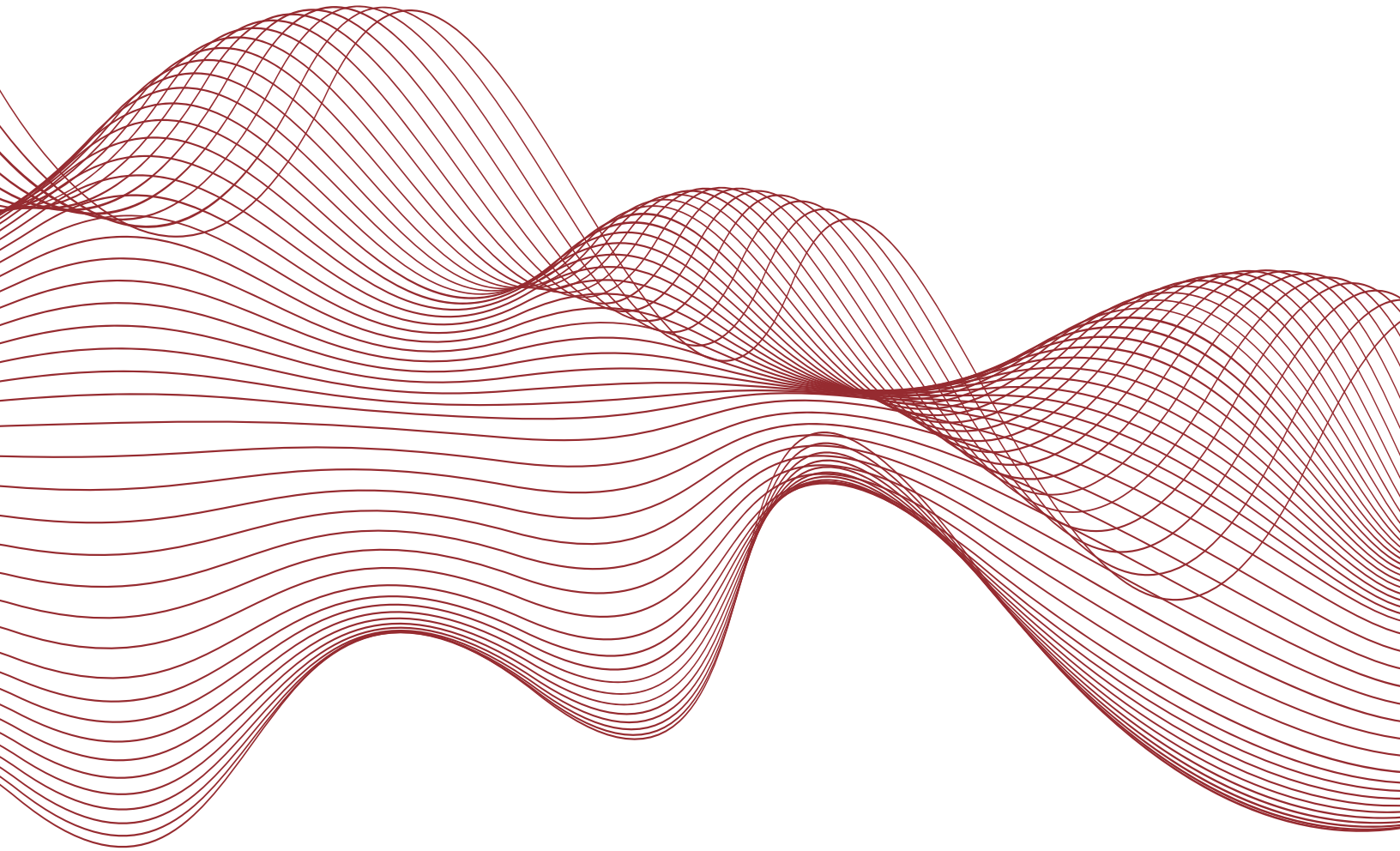
Image courtesy of Qualcomm Technologies.

to roughly serve the same area as a 5G radio transmitting in the mid-band.

During Mobile World Congress Barcelona, Qualcomm Technologies demonstrated its work on end-to-end Giga-MIMO systems that materially up the number of antenna elements compared to current massive MIMO systems, while maintaining a similar footprint to 5G infrastructure. Qualcomm has developed a prototype system for 13 GHz with 4,096 antenna elements and 256 digital chains in a form factor comparable to 5G. The company's Vice President of Engineering Tingfang Ji explained by comparing 3.5 GHz to 7 GHz for wide-area coverage; 7 GHz has half the wavelength of 3.5 GHz which brings propagation loss, but also means the antenna elements can be half the size. With more antenna elements in an array, you can increase signal strength and beamforming to offset propagation loss. "People typically think that the higher the frequency, the harder it is to actually get wide-area coverage," Ji said. "But one thing that's interesting is that as the Gs progress, we are getting better and better at making these massive MIMO arrays and Giga-MIMO arrays…As long as you can integrate more and more antennas, higher frequency is not a problem."

Looking at the big picture vision, Ji said, "We have the ambition to not only allow operators to deploy a new nationwide network to enable new services, but it also will give them incentive to upgrade their existing services." While maintaining backwards compatibility with existing 5G infrastructure and services, with 6G, "We'll also significantly increase operational efficiency of the entire network…Holistically speaking, we need all the spectrum assets to give us a 6G experience, enable the 6G service, at a cost that is much lower than 5G."

Tying together the standards and technology development with the spectrum needs, as well as the business environment operators face, Ji noted that "timing is everything…Everything needs to fall into place at the same time." But private sector technology advancements aside, if governments elect to optimize spectrum auctions for maximizing revenue, operators will likely optimize deployments for minimum viable spend, risking a misalignment between the goal of 6G and its eventual reality.



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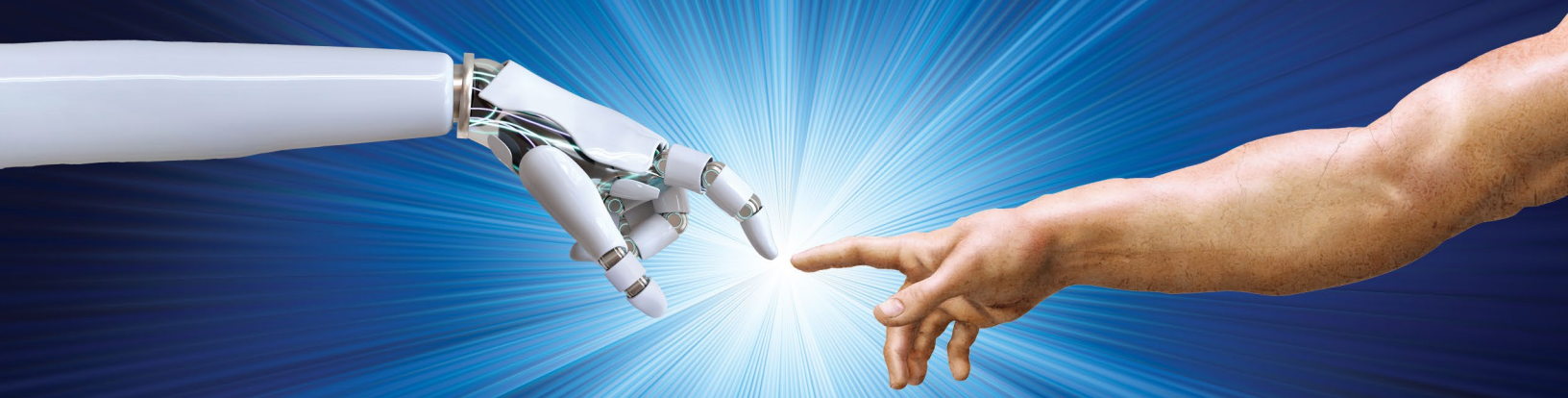
Universal Spectrum Multiplier (USM)



Spotlighting

- Powerful Geometric Channel Model
- Heart of USM from Zak-OTFS Wireless System
- Multi-Generational, 5G & Future 6G
- Solves ISAC Challenges in 5G low & mid-band FDD
- Innovative Open Application Interface for Verticals

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ASK THE EXPERT: JAYDEE GRIFFITH, MANAGING DIRECTOR, NEXT G ALLIANCE

"How do we ensure that 6G day one is a commercial success?... How do we ensure that everyone wins?"

Editor's note: This interview transcription has been lightly edited for clarity and length.

Q: Could you provide some background on Next G Alliance, specifically the organization's big picture goal and how you're working towards that?

A: ATIS started the Next G Alliance back in 2020…really looking [at] how do we advance North American leadership, primarily U.S. and Canada, in 6G and beyond communications as we started seeing the 5G being deployed in full force, really looking at, okay, what comes next? But we've really taken a holistic viewpoint.

Standardization is a core part of our business, but really we have to look at this [as a] whole. So all the way from the early foundational and applied research all the way to market readiness, commercial realization that we see after standardization. So that really was what built the research to realization mission of the Next G Alliance.

When we started, we had a lot of foundational publications around what 6G means, can and should be in North America, our 6G roadmap or roadmap for verticals. A lot of foundational technical publications, including some coming out soon around integrated sensing and communication, channel modeling and readiness. So stay tuned for more there. So we've really been providing a lot of this thought leadership in the North American market. However, as we see the standardization pick up and we start to move forward, we're looking at, okay, we still need to continue looking at what Release 21 is going to be day one 6G, there's going to be Release 22, 23, 24 after that. So what do future releases of 6G need to look like based off what we're seeing today in 3GPP?

How do we ensure that 6G day one is a commercial success? How do we ensure the best foot's forward? How do we maximize the opportunity for everyone in the value chain all the way from the research companies, R&D houses and academia through the component manufacturers, infrastructure manufacturers, operators, all the way down to the end user? How do we ensure that everyone wins?

Q: You referenced operators. Based on our conversations with operators, it's fair to say there's a good deal of hesitancy around 6G because 5G hasn't necessarily delivered the sweeping revenue lift the industry was hoping for. Based on what you're seeing and hearing from your members, what has 5G gotten wrong and what has it gotten right?

A: I think as we look back at the transition, even as 4G to 5G and then 5G to 6G, I do think there was a lot of, especially in the early days, over-promise and under-deliver particularly around use cases. And this is, I would say, you go back to even the early stages of IMT 2020 and the ITU-R, it was a lot of… moonshot goals for this 5G thing. It's all theoretical work on paper, but it wasn't really looking at, okay, once we get done to brass tacks, what does this practically mean? So I put it last year at the Brooklyn 6G Summit, we promised a mansion, but we delivered a foundation and said, 'All right, you can build the rest.' But this serves as a very important foundation for working 6G.

I think part of the hesitancy around, especially from MNOs who may not have seen the returns they kind of expected on 5G— granted there was a lot of variables in there. We had the pandemic, we had the semiconductor shortage, we had a lot of global change in this time period that's well outside industry's control. But a lot of it too as we look at it is looking at some of these end-to-end use cases, like we hear... I think a lot of my members still roll their eyes at telesurgery beyond some interesting hesitancy that may come with some of that because we're talking about health. But at the same time it's like, okay, well, who's going to build? There's an ecosystem here that isn't at the table. We can get the infrastructure vendors to work and the operators to build a network that supports it. Someone still has to build an autonomous vehicle, a UAV, a telehealth system that runs on this network, and then connect through and deliver an end-to-end service.

That's really part of, I think, some of the hesitancy with 6G. We did see growth in fixed wireless access with 5G. Operators… want to capitalize on that more in 6G. But I think with, especially some of the new features being advertised, a lot of the improvements to 6G are more on the back end for operations and maintenance. So in terms of new services being offered to both enterprise and consumer customers, there's been hesitancy from operators. So this is very much just very similar to 5G capability, but we're starting to see with integrated sensing and communications, so the new AI services as well as what we're hearing from some of the verticals. But they're demanding there may be new opportunities for some revenue growth in the 6G era.

Q: What lessons learned from the standardization and commercialization of 5G can be applied to 6G to potentially make this a smoother transition for operators?

A: I think there's a number of lessons learned…I think one of the key ones we hear a lot is measure twice, cut once, no more Non-standalone/Standalone. 6G should be a standalone architecture. As well as the concerns about optionality…I think a lot of that optionality caused a lot of concern.

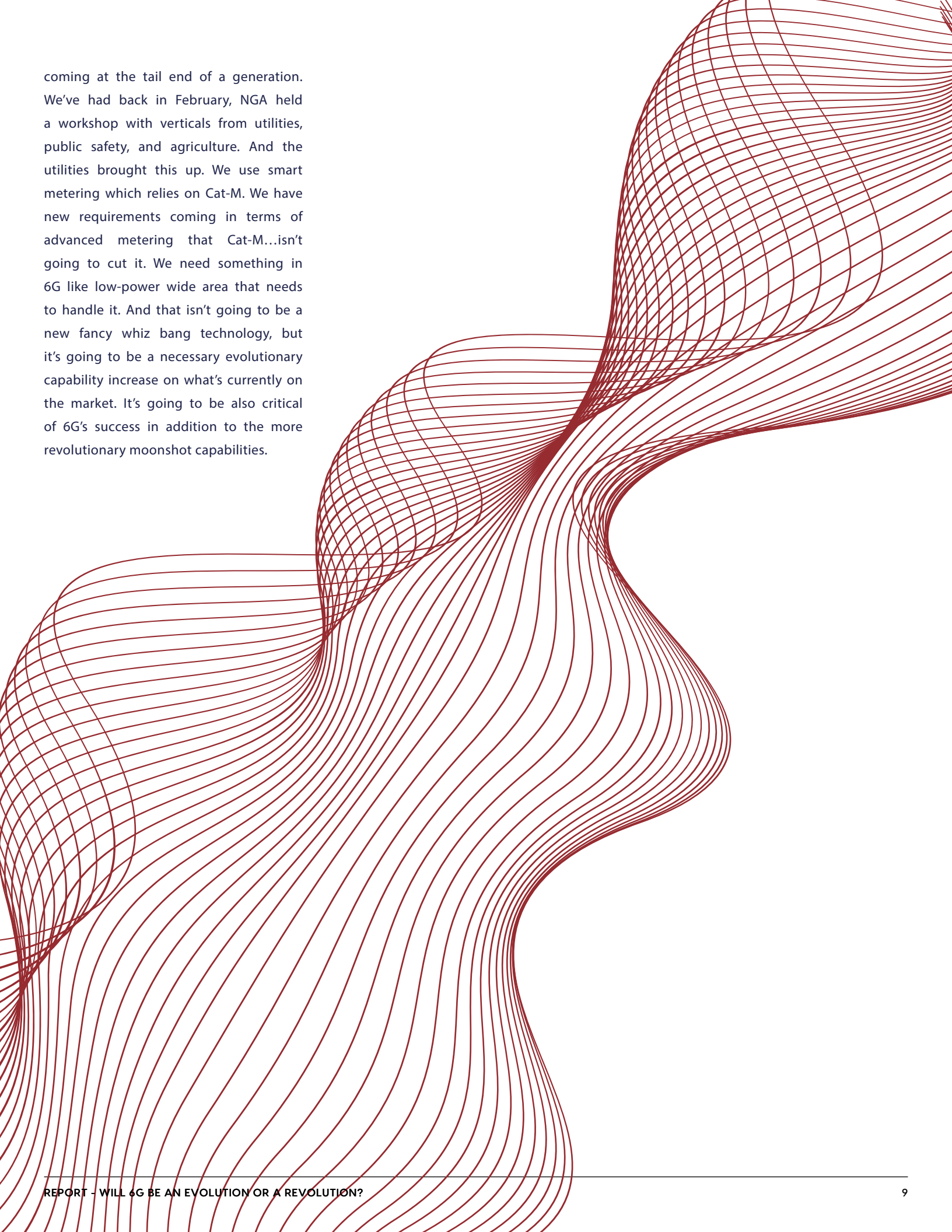
3GPP, we have a lot of brilliant engineers. But to an extent we need to, as a standard…[is to] focus on the core capabilities, interoperability, providing that framework for services so that players in the market and those infrastructure vendors, UE manufacturers, can innovate on that. And maybe it's a proprietary solution that does interoperate because we have some special sauce that they really want to build that makes their UEs more efficient, makes their base stations more efficient. But also, leave that opportunity for standardization in the future if there's a clear demand signal…Obviously, we saw a lot of features standardized that had no clear market demand.

Q: Can you talk about some of the broad 6G use cases that you're tracking and give us some perspective on whether you see those as evolutionary or revolutionary compared to 5G?

A: I think it's going to be a mix of both the revolutionary and evolutionary… Integrated sensing, I think some of the AI features…But I think we're really going to see those come to fruition in the 6G era and Release 21. I think those are going to be the key revolutionary, high-risk, high-reward game changers in this market. And I want to emphasize high risk and not only be slam dunks because they're unproven, there's no existing customer basis, but we're kind of betting on the future. But there's still some evolutionary use cases we need to keep in mind as we look at…how can we ensure that 6G is a holistic, complete solution. So kind of going back to your earlier question about operators. It's been no secret, many of our operators, biggest operators in the US and Canada, they don't want to have 4G forever. They want to start sunsetting 4G during the 6G era.

But there's a lot of services like what we see with LTE Cat-M that aren't currently supported in 5G, maybe enhanced RedCap can handle that, but that's also

coming at the tail end of a generation. We've had back in February, NGA held a workshop with verticals from utilities, public safety, and agriculture. And the utilities brought this up. We use smart metering which relies on Cat-M. We have new requirements coming in terms of advanced metering that Cat-M…isn't going to cut it. We need something in 6G like low-power wide area that needs to handle it. And that isn't going to be a new fancy whiz bang technology, but it's going to be a necessary evolutionary capability increase on what's currently on the market. It's going to be also critical of 6G's success in addition to the more revolutionary moonshot capabilities.



THE STANDARDS

"Consensus principles reminder: The attention of the delegates to the meeting is drawn to the fact that 3GPP endeavors to reach consensus on all decisions and therefore depends on a cooperative spirit of the individual members. In particular, individual members are encouraged to seek a consensus-based solution and only to sustain objections as a very last resort, and where absolutely necessary and well justified. The leadership will conduct the present meeting in a manner whereby informal methods of reaching consensus are encouraged, whilst ensuring that well justified concerns are taken into account."

Recently, standards body 3GPP began reading the previous block of text ahead of meetings. Before looking at the consensus that was developed during a meeting held in Bengaluru, India, in late August, we'll take a look back at 6G standardization activity which officially kicked off in March during a workshop in Incheon Korea. That confab brought together the RAN, core and terminals, and service and system aspect technical specification groups. This initial meeting was meant to outline the initial vision for 6G, timeline targets, a draft work plan and identify potential technologies. This was immediately followed by the 107th RAN Plenary with the main outcome there being selection of leadership.

In April, 3GPP and O-RAN Alliance convened a joint workshop in France meant to start a dialogue around alignment on 6G radio interfaces and open architectural standards. A few observations here: there's broad calls for 6G standards to define a simplified architecture as compared to its predecessor; slow adoption of 5G Standalone has, in some cases, been chalked up to too much optionality. At the same time, Open RAN is all about optionality. The O-RAN Alliance has worked since 2018 to standardize the interfaces between RAN components and into service management and orchestration (SMO) platforms and the RAN Intelligent Controller (RIC). That to say, development alignment is a good thing but it will be important to achieve the right amount of standardization

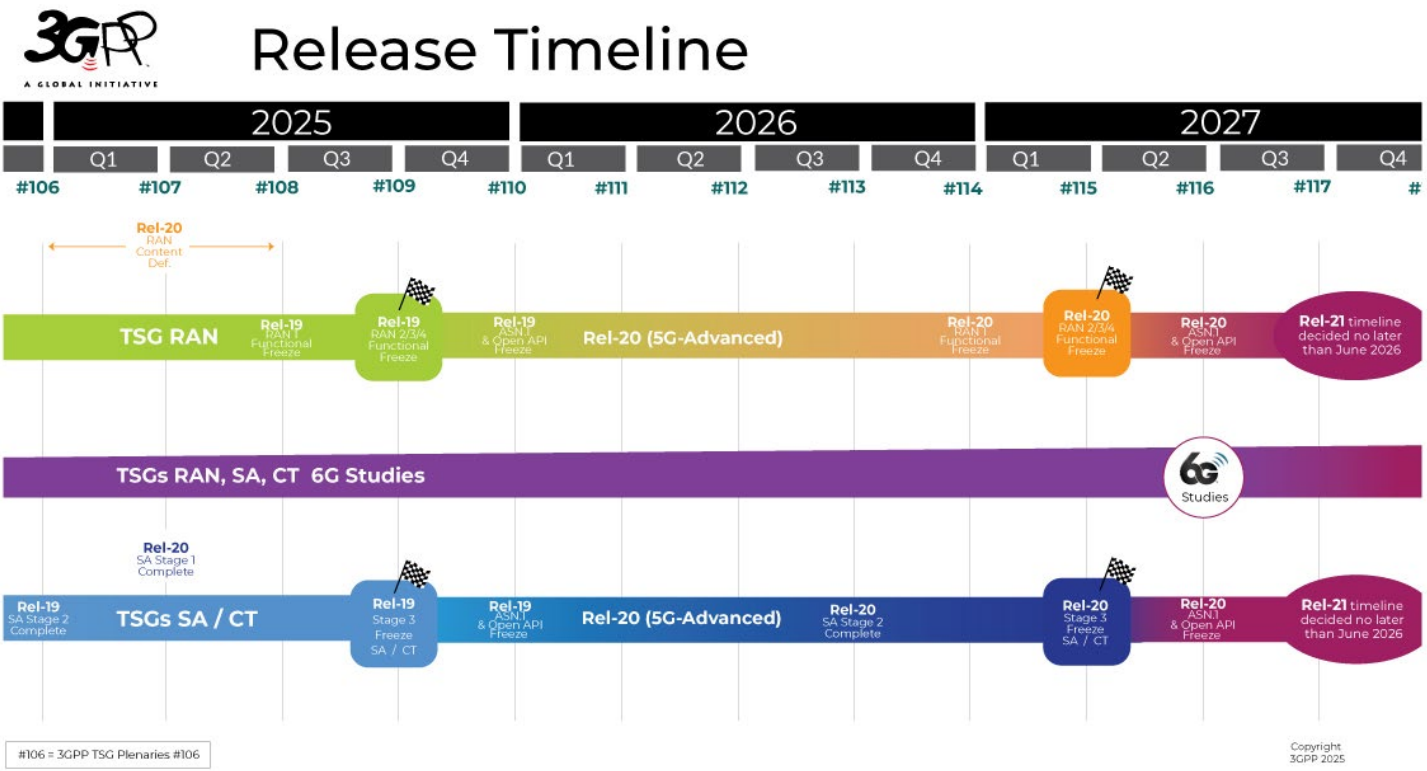


Image courtesy of 3GPP.

that makes 6G as easy as possible while maintaining the optionality (and innovation built on top of it) embodied by Open RAN.

June marked the 108th RAN Plenary in Prague. The significant bit here is that there's agreement on the initial scope of Release 20. To be clear, Release 20 will be a 5G Advanced release but it'll also lay the foundation for the future 6G standard in that it defines official technical study projects that focus on foundational wireless technology areas for 6G. You'd expect 6G work items in the subsequent standard, which will be Release 21. The Release 21 timeline will be nailed down no later than June 2026; there's not a formal timeline yet for Release 22.

The Release 20 study items include a technology framework, physical layer structure, radio interface protocol architecture and procedures, mobility, core and performance requirements, RAN architecture, migration and interworking, wireless AI, and RF sensing.

In a blog post summarizing the Prague plenary, Qualcomm Vice President of Technical Standards Juan Montojo wrote: "Drawing from the lessons of 5G deployments, the 3GPP consensus is that 6GR [6G radio] should adopt a standalone…architecture with a simplified system design. This approach will support both existing and new services, meeting diverse usage scenarios, requirements, deployments and design principles."

"An essential part of the 6GR study is the overall physical layer structure," Montojo continued. "This is expected to feature improved OFDM-based waveforms and modulations, a unified frame structure for 5G-6G spectrum sharing, numerology for wider bandwidths, efficient initial access, synchronization and broadcast signals, evolved channel coding and enhanced MIMO and duplexing."

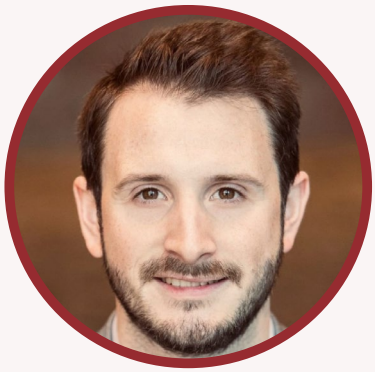
Montojo also detailed work on the 6G radio interface architecture, end-to-end RF design, migration, interworking, mobility, wireless AI and RF sensing."The road ahead is filled with exciting challenges and opportunities," he wrote.

The latest comes from the 6G RAN working group meetings hosted Aug. 25-29, in Bengaluru, India. Based on accounts posted to LinkedIn, delegates agreed to re-use the OFDM waveform from 5G. Jio Platform's Spyridon Louvros commented, "On the surface, the news seems 'happy': stability, continuity and backward compatibility are guaranteed, giving operators and vendors a smoother migration path from 5G." However, he continued, while OFDM is "proven and reliable" it "should not be mistaken for a final victory…True 6G use cases…may require waveforms more resilient and efficient than legacy OFDM can offer…The concern is clear: by sticking to [OFDM], 6G risks being seen as '5G Advanced +' rather than a generational leap. New challenges around energy efficiency, spectral conditions, AI-native architectures and integrated sensing may not be solved by simply reusing 5G's waveforms."

Analyst Dean Bubley put it more bluntly: "So much for 'AI-native' at the radio then…This certainly opens the door for non-3GPP versions of 6G even wider. Let's see if path dependency can be worked around. Sometimes fragmentation is a good thing."

ASK THE EXPERT: PAUL HARRIS, PRINCIPAL WIRELESS ARCHITECT, CTO OFFICE, VIAVI SOLUTIONS

"The challenge here is that with AI, without quality data, there is no AI, right? We need to have good data sets."



Editor's note: This interview transcription has been lightly edited for clarity and length.

Q: Generally, do you see the transition from 5G to 6G as evolutionary or revolutionary?

A: I think there's going to be a bit of both when it comes to evolution and revolution. And I think even more so there maybe needs to be a balance here that needs to be still an opportunity to look for what's next. Look for where we can find those value adds for delivering new networks. What things will people actually see as a valuable addition or businesses, what things can be monetized, i.e. what are people willing to pay for that we don't currently do today?

But at the same time, I think it's fair to say that for…6G, there [is] a lot of hesitancy. And I think it's fair for that kind of perspective to have been there. And the focus was more on this kind of TCO reduction, minimal changes, and considering software updates and things like this and minimizing new capex. But I think that aspect is still important of course, but it goes hand in hand with some other elements which are not service opportunities that are important for network operators for reducing operating costs, improving energy efficiency. So some of the energy saving feature capabilities that we've already seen start to get explored in 5G will continue to be pretty important along with the combination and leveraging of AI. Not just for services, but also for improving the efficiency and optimization and management of networks.

Q: Can you give us a snapshot of the current state of 6G standardization, acknowledging that we're very early in that process?

A: We've obviously come along a bit of a way now in the timeline for studies and initial workshops on stuff in 3GPP. And this is the, I guess, latest news at least on the RAN side: so during the June meeting…we had the working group level study items defined, which highlights some of those key objective areas…I think we can see some of that balance between evolving what we know and what we need to continue to do well…certain onset capabilities and IoT and things like this. These are known revenue drivers for MNOs now. So it's important for them to have support to continue for the migration from sunsetting 4G and moving towards a 6G system.

Some of these things we could see like the…re-use of the site grids. These are

opportunities for us to look ahead for expansion as needed for frequency bands that we can see would give a good balance of coverage and capacity and could allow us to rapidly get deployment based on the grids we already have. Harmonization of terrestrial and non-terrestrial. Again, arguably we've already started that journey, but I think that will be a key foundation to make that a native aspect of 6G from the start. And then we have, as mentioned, some of those maybe more revolutionary opportunities on the sensing side, so the ISAC and the JSAC kind of thing. And also maybe some new opportunities for AI when it's used more in a native fashion from day one.

Q: Tell us about the collaborative work between 3GPP and O-RAN Alliance, and how that may influence what 6G ends up being.

A: [In] April…3GPP and O-RAN had their first joint workshop to kind of discuss how the two groups can work together and maybe improve the working relationship as we move into the 6G era. We have since then had some more discussion in 3GPP that's ongoing. But I think the overall key thing here is that for the most part, it looks like this is I ikely to stay similar to today. So 3GPP defining the core functionality of the 6G system, the architecture signaling, all the things that are needed for defining a 6G solution. And O-RAN building upon that to add value and complement 3GPP-derived standards with different solutions and obviously leveraging the open vendor ecosystem. I think that one of the areas here that's been particularly contentious, let's say, is around the fronthaul interface that there's been discussion, which as I say, is still ongoing as to how that will be approached.

There's some that we'd like to see that included and mentioned within 3GPP specs, others that like to keep it entirely separate. That's due to be hopefully concluded in, well, next month in September…We've had sort of a meeting cycle or two already on that. Yeah, understandably there's some different views there. But I think overall, the key thing is that this was a good workshop, good opportunity for us to try and align working efforts and hopefully, whether it's even just having additional synchronization meetings and things between the two groups, we can continue the success of both organizations.

Q: 6G is being described as AI-native but today we're seeing activity around AI in, on and for the RAN largely driven by the AI-RAN Alliance membership. How do you see that playing out?

A: I think we all know AI has been spoken about everywhere. Any aspect of the network or industry in general, there'll be AI being pushed into it. But I think that one of the things we kind of observed with AI is that whilst 3GPP and O-RAN will be defining architectures and mechanisms for AI to operate, that's typically a framework and a signaling exercise and providing the right hooks in order for these systems to work. And then naturally the standards try to define the minimum required and allow innovation and competition between vendors with their developments. But the challenge here is that with AI, without quality data, there is no AI, right? We need to have good data sets. And a lot of the time, that's quite sensitive and is a proprietary kind of approach, especially when we're talking about gathering data in the networks and how that can be leveraged by third parties.

So through the AI-RAN Alliance… we're looking at applications across all aspects of the RAN, whether that's for the RAN, so helping with improving and enhancing the telecoms system itself. And RAN where we're bringing, I guess, the harmonization of the compute and the RAN together on the same system, and then on RAN where we're looking at new services. But the commonality between all of these is that the data aspect needs to be there and that won't be provided by the standards. There may be some reference data sets, but typically that won't be there.

So we initiated this new group, which we're chairing in the AI-RN Alliance, [focused on] data for AI, which is looking at trying to help the industry with that issue and find approaches for how we can clean up, anonymize, and share data effectively across the industry and create a larger data pool that can really be valuable for development, training, and testing of AI.

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THE USE CASES

We all know and love the 5G triangle delineating the three broad use case categories. It's time to get to know the 6G hexagon. The progression from 5G to 5G Advanced is poised to bring capability increased to those three broad use case categories — enhanced mobile broadband (eMBB), massive machine-type communication (mMTC) and ultra-reliable, low latency communication (URLLC).

In the move from 5G Advanced to 6G, Ericsson sees eMBB giving way to "immersive communication," mMTC giving way to "massive communication" and URLLC giving way to "hyper reliability and low latency." In addition to these evolutionary improvements, Ericsson also highlighted (arguably) revolutionary new use cases, specifically integrated sensing and communication (ISAC), integrated AI and communication, and ubiquitous connectivity based on TN/NTN convergence.

ISAC is arguably the hottest. The premise is that networks will transmit data and sense the physical environment using the same infrastructure and spectrum. ISAC could enable a number of service categories, including:

- **Network as a sensor:** embedding sensing into mobile infrastructure to achieve reach and scale that standalone sensors can't.
- **Sensing-as-a-service:** fusing ISAC with other sensing systems (e.g., cameras), with MNOs aggregating and exposing environmental data to third parties.
- **Sensing for communications:** using environmental awareness to optimize network functions such as handover or beam management.

Critics, however, point out that many ISAC use cases already have cheaper, better solutions. For traffic management, cameras coupled with AI are already available today. For defense and security, ISAC has obvious appeal but can militaries alone provide a sustainable market? And

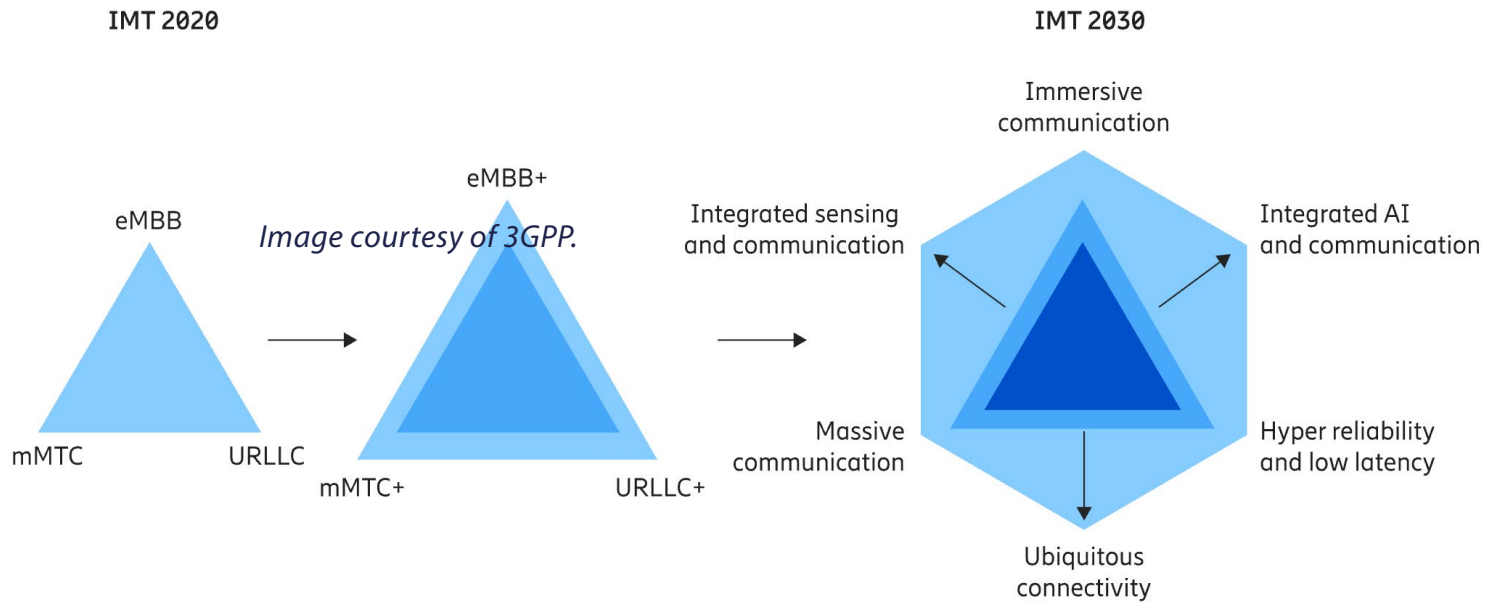


Image courtesy of 3GPP.

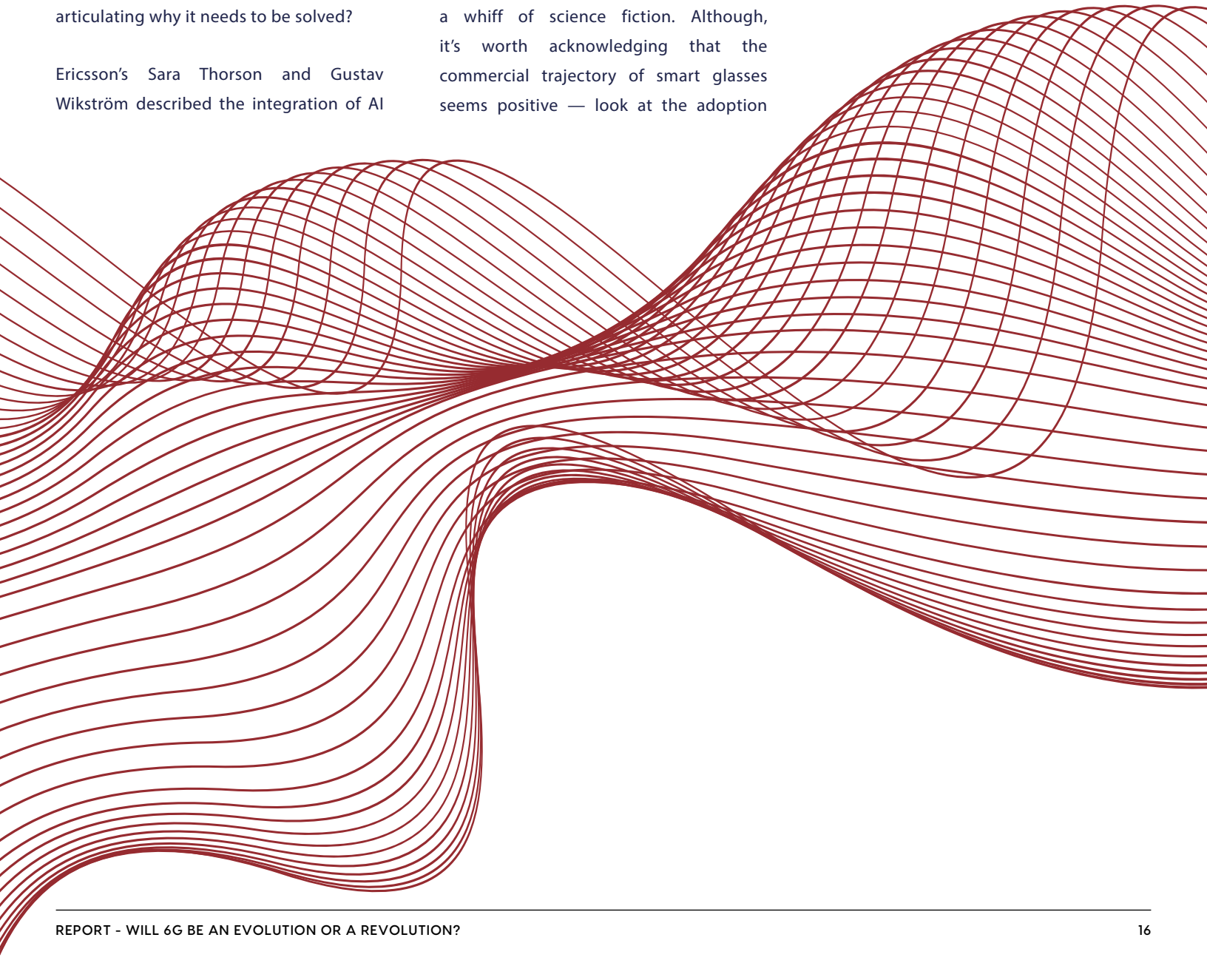
Image courtesy of Ericsson.

across the board, ISAC faces steep hurdles in standardization, economics, and technical maturity.

Another headline 6G ambition is to unify terrestrial and satellite systems to provide seamless, global coverage. Here the commercial landscape is more tangible given falling satellite launch costs (thanks to SpaceX and others) and commoditized cellular components are already enabling NTN-enabled emergency messaging. The bigger question is who is willing to pay for true ubiquity and if the goal is even rational? Is this another example of engineers going heads down to figure out how to solve a problem without clearly articulating why it needs to be solved?

Ericsson's Sara Thorson and Gustav Wikström described the integration of AI and communications as revolving around "improve[d] human communication with people, devices and surroundings." They gave the example of noise-cancelling hearing aids able to pull out specific sounds, visual assistance rendered in smart glasses and they even mentioned "brain interfaces." All things that "must work seamlessly everywhere and at all times, which places high demands on connectivity. This includes requirements for resilient and trustworthy networks, low latency and robust security and privacy measures to safeguard sensitive data."

The idea of connected AI to improve humans' physical capabilities carries a whiff of science fiction. Although, it's worth acknowledging that the commercial trajectory of smart glasses seems positive — look at the adoption of Ray-Ban Meta AI Glasses as a proof point — connected health sensors like continuous glucose monitors are moving from clinical use to wellness, and there are companies like Elon Musk's Neuralink studying biological/digital interfaces. Still, the question remains whether these are niche applications or can they reach the scale required to justify the investment?



ASK THE EXPERT: ANTON MONK, SENIOR VICE PRESIDENT OF STRATEGY, COHERE TECHNOLOGIES

"If we really want to optimize things as has been done in prior Gs and have this continuous innovation that we've had in the past, we have to understand where the revenue's going to come from so that we don't repeat the mistakes of 5G."

Editor's note: This interview transcription has been lightly edited for clarity and length. Monk's commentary came prior to the 3GPP RAN working group meetings hosted in Bengaluru, India, Aug. 25-29.

Q: To start, can you give some background on Cohere and how the work you're doing today in 5G will be applicable to 6G?

A: We're a startup. We've been around a while, punching I think above our weight, given the technologies that we've invented…We have two technologies that we focus on: the one that's getting some really great traction with operators we call USM, Universal Spectrum Multiplier. It's a software solution that sits alongside the base station. We've shown spectral efficiency improvements of up to 50% with Vodafone and with Bell Canada. And we use our long experience operating in the Delay Doppler domain, which was developed…through our OTFS waveform technology. But we utilize similar understanding of the geometry of the channel to fingerprint the wireless channel and basically improve the spectral efficiency through spatial re-use.

This has value throughout the spectrum, I think really low-band spectrum. We can operate FDD or TDD, 4G or 5G, and it's standards based. So this is an offshoot of our original technology that allows us to use the existing standards. And again, low band, we don't often talk about low band. It's been there a long time, but there's significant congestion. I think it's really interesting with all the NTN work. That is the ideal band for non-MSS licensed spectrum for NTN operators. They're looking to reuse this low band spectrum. It's very expensive for operators to give up that spectrum. And so, leveraging those low bands for these new LEO NTN capabilities and making more spectrum available is really critical.

OTFS, Orthogonal Time Frequency Space: you can think of it as a generalization of OFDM and TDMA and prior waveforms that have come before…We tried to get [it] into 5G…We were not successful in 5G, but 6G..brings a whole bunch of new use cases and applications — the enablers such as integrated sensing and communications. And OTFS is a super interesting waveform, which gives significant performance benefits, way more than 50%, could be operating where OFDM cannot in complex channels, especially those like FR3.

We're also big believers in Multi-RAT Spectrum Sharing [MRSS]. Anything that happens in 6G has to fit into the MRSS paradigm, which basically allows the scheduler to reuse the time frequency scheduling paradigm. And our approach is, hey, as long as you can allocate resources there, you should be able to come up with any new waveform if you can show the performance benefits.

Q: These novel approaches seem important for 6G given the disconnect between channel bandwidth and availability of new spectrum. How do you see that shaping up over time?

A: I mentioned some of the low band stuff, but the thing is with FR3 you have these more complex channels. So in the past, when we've gone to higher frequencies, like FR2, it's been a completely new paradigm in terms of how infrastructure is deployed, much smaller distances that can be coverage line of sight. This is probably part of the problem where we didn't see the expected growth in that market because of the infrastructure costs, the line of sight requirements. Despite the fact that there was a lot of, a ton of, research showing that in some circumstances you could get through windows, you could work in some limited amount of dispersive channels. But the reality is it was a different type of architecture. FR3, at least, from what I've been hearing, holds the promise of an overlay with FR1. So now you have yet another paradigm. You have high frequencies, not necessarily super-high frequencies, just above 7 GHz that leads to higher Doppler.

If you want it to be an overlay and support mobile traffic, you have to deal with it, the significantly higher Doppler. You still have larger delay spreads. So the question is, to what extent does 3GPP, or to what extent are they willing to, focus on performance benefits for FR3 versus the path that you've heard from a number of operators, particularly European operators?..The use cases that we expected to generate significant new market opportunities, some people would say have failed. I would say they haven't failed, they just haven't emerged as fast as people hoped. And so, there's a reluctance, I think, by some to consider new infrastructure options. But that's really this evolution versus revolution fundamental question. I think there's really great opportunity at these new bands, particularly FR3, to optimize the channel. This is separate from ISAC.

Q: Can you elaborate on your comment around channel complexity in FR3; is that strictly Doppler considerations or are there other factors at play in the upper-mid band?

A: Doppler just scales with frequency linearly. So if you've got a car, I don't have the numbers on the top of my head, traveling at, I don't know, 60, 90 kilometers per hour on a freeway. In a macro cell, you have a certain Doppler, let's say, at 3 GHz. You go up to 7 GHz or 14 GHz, you're doubling or quadrupling the Doppler. The way that OFDM handles that is it increases the sub-carrier spacing, moves the sub-carriers further apart. And OFDM is reasonably effective at doing that. That's not the problem. The problem is OFDM, many of the modulations, most modulations, have advantages and pros and cons, so to speak. And one of the downsides of OFDM is it has a cyclic prefix. And that basically chews up capacity. So you want, ideally, that cyclic prefix is as small as possible. Traditionally, when we go to high frequencies, the network architecture changes and you have much lower Doppler spread. So you can make that cyclic prefix much smaller.

If that doesn't happen, you have a huge amount of overhead. And there are other capabilities, other solutions like OTFS, that don't have that problem. Again, the question is to what extent will 3GPP members be willing to really consider new waveform concepts, given the concern by some operators that they just want software solutions. But that begs the question, to what extent can that be revolutionary versus evolutionary if there aren't infrastructure changes? That's the real topic.

Q: Circling back to ISAC, do you view that as a primary use case of 6G or is it an enabler of multiple use cases?

A: The question is are you reusing the same waveform? Are you adding waveforms on top of it? How's the waveform constructed? So I would say yeah, ISAC is a key enabler. I think it's one of two or three new enablers along with AI. I wouldn't say AI is a use case on its own either, it's an enabler. And I would put ISAC in the same category.

And back to, since I'm biased with our own technology, this OTFS waveform is actually unique in that information is not carried in the frequency domain as it is with OFDM. It's not carried in the time domain as it is with TDMA or GSM. It's carried in the Delay Doppler domain; it's a very stable view of the channel. The Delay Doppler domain is the radar domain. It's the sensing domain. So again, it's an ideal waveform in many senses for ISAC. Of course, the question is to what extent will that be seriously considered? Back to your question, we see huge amount of interest from a key vertical, which is the [Department of Defense]. Defense, public safety, very interested in using existing or future infrastructure to sense things like drones…many people may have heard of

Golden Dome, a new initiative from the administration. How do you detect this massive country, at least in the US, how do you detect drone swarms?

And traditional radar is not going to cut it in terms of the coverage that we need. So how do you use existing infrastructure or 6G infrastructure to do that is critical. So… [a] ton of interest from DOD, willingness to pay. Real question is... And a key driver, I think, for ISAC, that's where we're putting a lot of our effort because we see it as a new paradigm, new metrics. Communications engineers now have to become radar engineers. That hasn't happened before. New metrics like how many targets can you resolve? What's the target resolvability? What range can you achieve? How much power do you need? Do you need things like monostatic versus bistatic radar? All new concepts for 3GPP well known to the DOD and the radar community. The real question there is who is deploying the infrastructure? It's the operators and where are the revenue streams coming from? The new markets that will drive the need to deploy new systems, new optimized systems.

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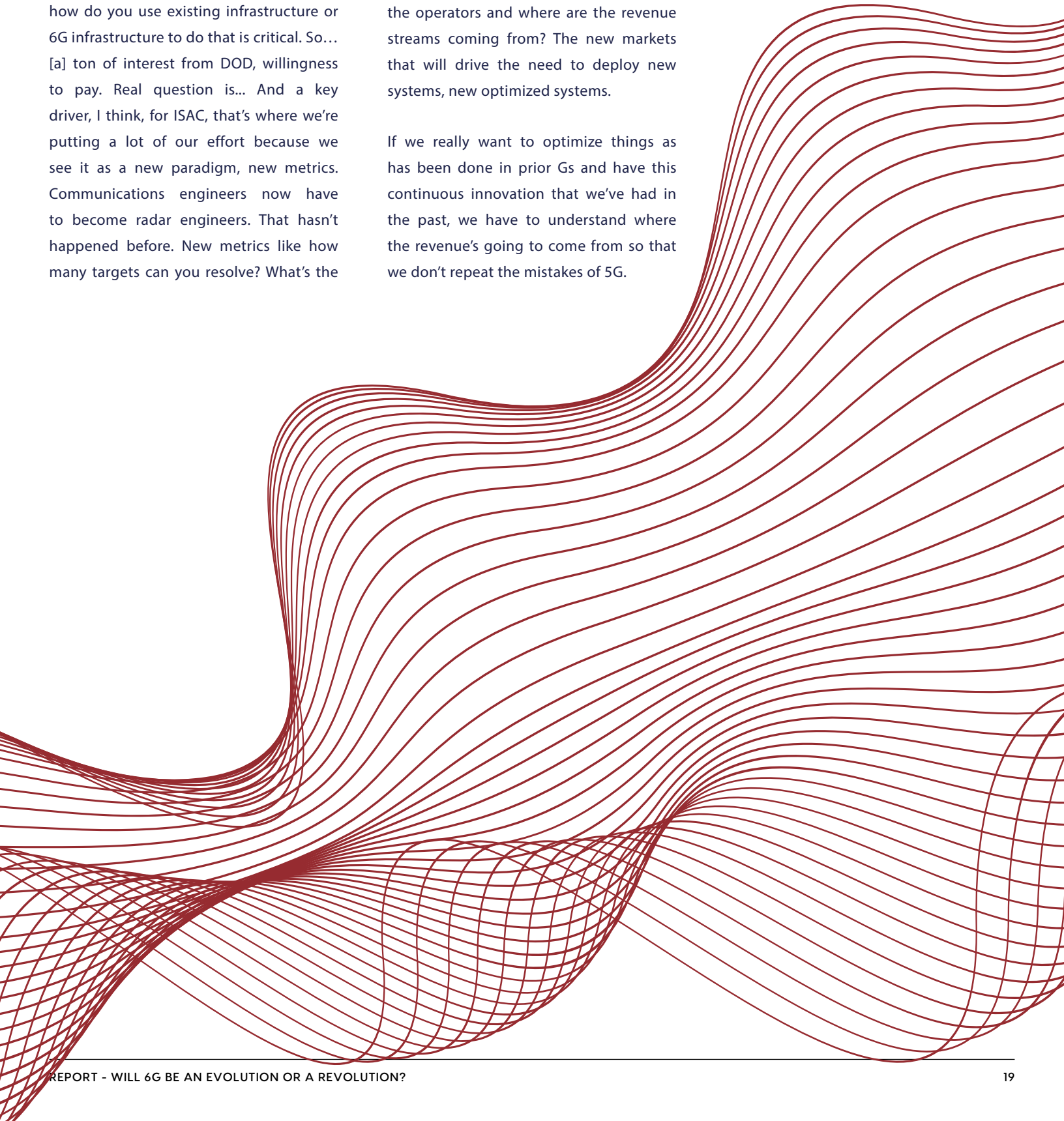
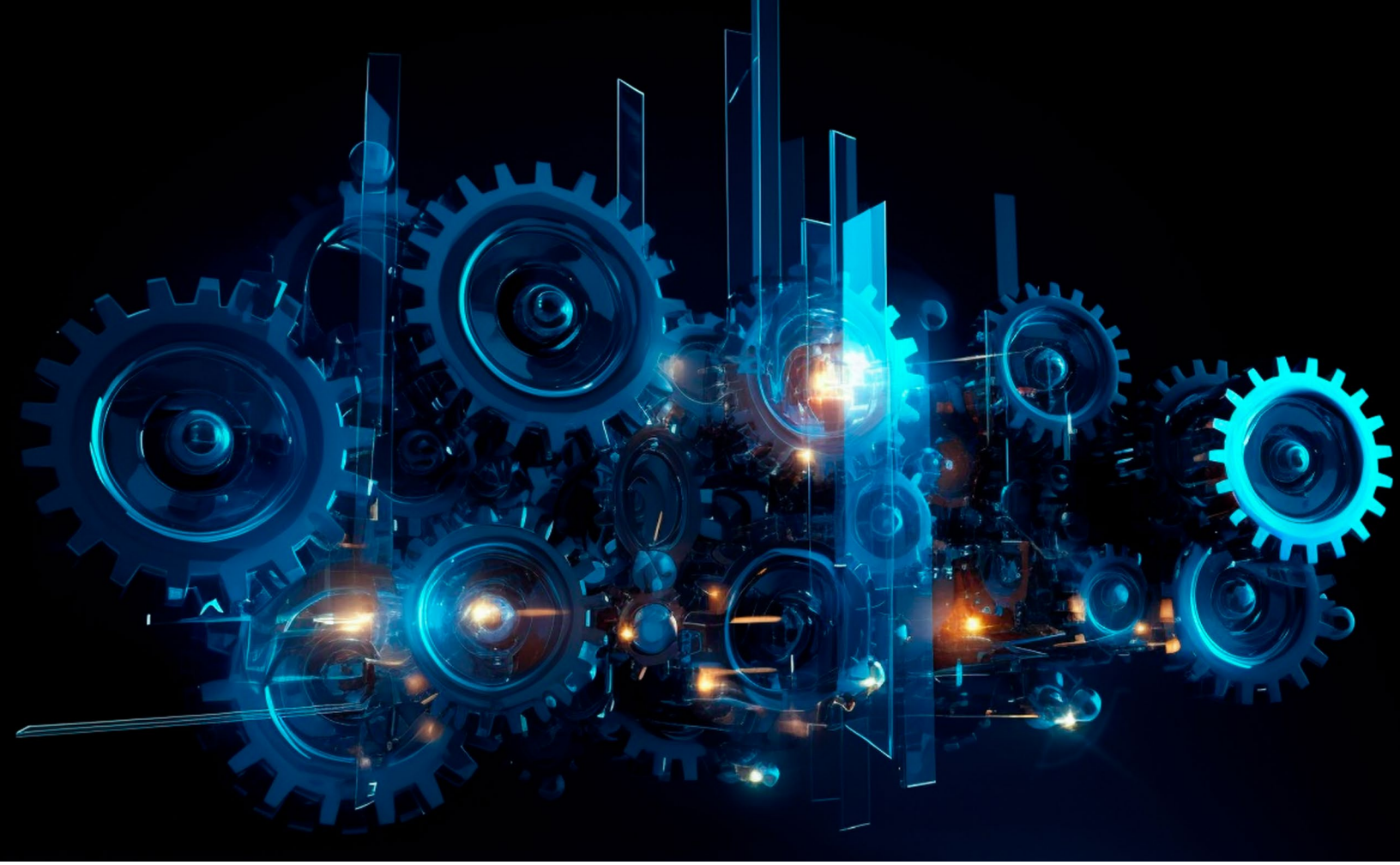




GETTING TO AI-NATIVE

The industry likes to talk about 6G as AI-native. The phrase signals a network where AI is everywhere and always has been, not bolted on after the fact. But that's wrong. AI will gradually permeate every network and operational domain. It will eventually be leveraged for optimization, spectrum sharing, services and everything else. But with the exception of speculative greenfield 6G network deployments (likely private networks), MNOs are working with legacy infrastructure that will be upgraded bit-by-bit over time, not swapped out wholesale.

In other words: AI-native is not a light switch. It's a destination. The journey will be marked by gradual steps that deliver measurable cost savings and operational value along the way, because without that momentum the aspiration risks stalling out.

NVIDIA's Chris Penrose framed it as a progression during a discussion on the sidelines of TM Forum's DTW Ignite show. Referencing the group's Autonomous Networks (AN) Project maturity index, most operators today sit somewhere between 1.5 and 2.5 on a scale of zero to five. Some domains, like customer care and coding assistance, are already seeing broad use of AI. Network operations are beginning to follow, with early value in design, planning, and troubleshooting. But full autonomy will take time, trust, and a steady build-up of capabilities. "The network is their most precious asset," Penrose said. "And there's serious issues if the network goes down. You have to be very confident, 100% confident."

He continued: "I think as we build more and more capabilities, and as they use it more and more, they are gaining confidence…I think we're still in the age of human-in-the-loop but really accelerating the ability to do planning, to do troubleshooting, to get to that answer much more quickly…The telcos are saying, 'Bring me something real. We don't want Powerpoints anymore. We

want to see real, working things that bring immediate impact."

The radio access network (RAN) illustrates both the challenge and the opportunity. Operators spend heavily to modernize and densify the RAN, even as it remains their biggest cost center. Each wave of innovation — Open RAN, Cloud RAN, and now AI RAN — has promised the same thing: tame complexity and cost while opening the door to monetization. As Dell'Oro Group's Stefan Pongratz said, "AI RAN is happening." But he also cautioned that in the near term, it's about efficiency gains, not new revenue.

The AI-RAN Alliance, chaired by SoftBank's Alex Choi, has articulated the ambition across three fronts: AI for RAN (efficiency and spectral gains), AI and RAN (better use of shared infrastructure), and AI on RAN (delivering new services at the edge). Proofs-of-concept already show promise, but scaling them will demand more RAN compute — CPUs and GPUs working together in hybrid architectures that can handle both control-plane logic and compute-intensive Layer 1 tasks like beamforming.

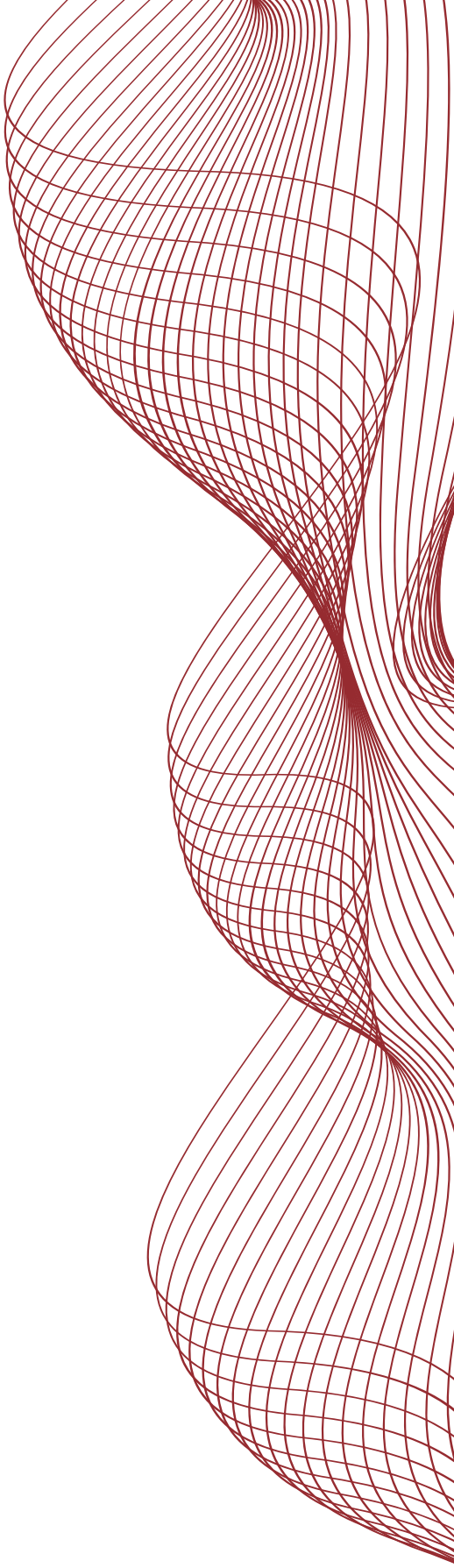
Looking further ahead, 6G's embrace of MRSS all but guarantees AI will become foundational. Allocating spectrum dynamically across 5G, 6G, Wi-Fi, satellite and beyond is not something humans can manage manually. AI models will predict occupancy, balance loads and enforce efficiency at speeds no operator workforce could match.

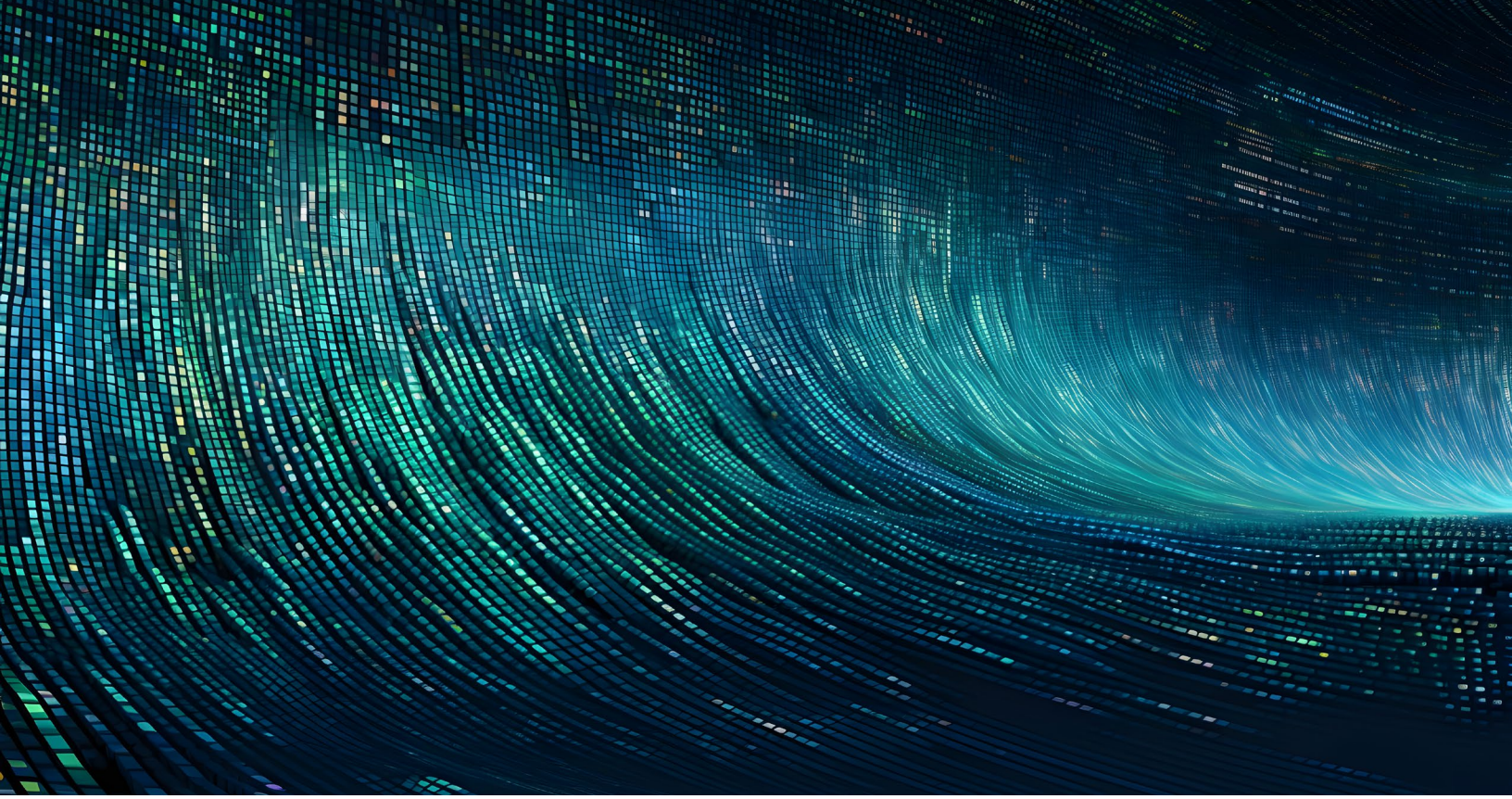
"We are seeing clear indications it's evolving to a hybrid computing platform," AI-RAN Alliance Chairman Alex Choi explained in an interview. CPUs are well-suited for Layer 2 and Layer 3 control plane tasks, but when you get into compute-intensive Layer 1 tasks like signal processing or massive MIMO beamforming, there's a case for GPU-enabled parallel processing. "It delivers clear cost/performance advantages," Choi said.

The case for AI RAN potentially becomes necessary in the 6G era when the contra-forces of massive channel bandwidths and lack of spectrum will create a forcing function making AI RAN necessary. Choi highlighted MRSS as the mechanism to govern shared spectrum across 5G, 6G, Wi-Fi, satellite-based, and other radio access mediums. "As we move toward 6G, we are entering an era where spectrum sharing, massive bandwidth, and ultra-dense deployments make…conventional, manual network management completely impossible."

He continued: "Without artificial intelligence technology, the complexity and speed required for the efficient MRSS operation in 6G would be practically unmanageable, making AI-native RAN architecture in 6G an essential foundation for the future."

That said, the trajectory to AI-native will not be linear or uniform. Incumbent vendors are protecting their positions. MNOs are reluctant to fund speculative infrastructure. And the revenue side of the equation remains flat. The pragmatic view is that AI-native will emerge step by step from today's efficiency-focused pilots, to broader automation in 5G's later stages, to a 6G architecture where AI is an assumption. Regardless, AI-native is an ambition — not a day-one reality — that must be built deliberately, one cost/value step at a time.





6G AS EVOLUTION, REVOLUTION, PERHAPS A BIT OF BOTH?

The story of 6G is not one of clean breaks or easy answers. On one hand, the path to 6G will look evolutionary with the re-use of spectrum and sites, software-centric upgrades and a strong focus on efficiency and cost control. On the other, its ambitions around IASC, immersive communications, ubiquitous connectivity and end-to-end incorporation of AI are revolutionary.

The tension lies in how much of the revolutionary promise can be realized within the evolutionary constraints of MNO budgets and market realities. Spectrum auctions designed to maximize government revenue may leave operators with little left to spend on deployment. Standards bodies may pursue moonshot features that lack a clear commercial demand signal. And MNOs, still digesting (and investing in) 5G, may hesitate to fund another generation without a credible path to new revenue.

AI sits at the heart of this balancing act. Incrementally, it improves spectral efficiency, automates routine operations and takes cost out of the network. Fundamentally, it makes possible the level of complexity management and spectrum sharing that a 6G-era network will demand. In that sense, AI is both an evolutionary bridge and the revolutionary enabler.

Whether 6G ends up being remembered as an evolution, a revolution, or something in between will depend less on the technology itself than on timing, alignment and execution. Spectrum policy, standards development, operator economics and use case maturity will all need to fall into place at the same time. The narrow path forward is clear: build on what works, take measured bets on what's new and ensure that the commercial foundation is strong enough to carry the weight of ambition.

Acknowledgements

COHERE

Cohere Technologies is the innovator of Universal Spectrum Multiplier (USM) software for 4G, 5G, and Multi-G O-RAN. USM improves mobile networks by 50% or more in any FDD and TDD spectrum band. Cohere is the creator of the Orthogonal Time Frequency Space (OTFS) wireless system since 2011.

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