5G Network & Service Strategies Operator Survey

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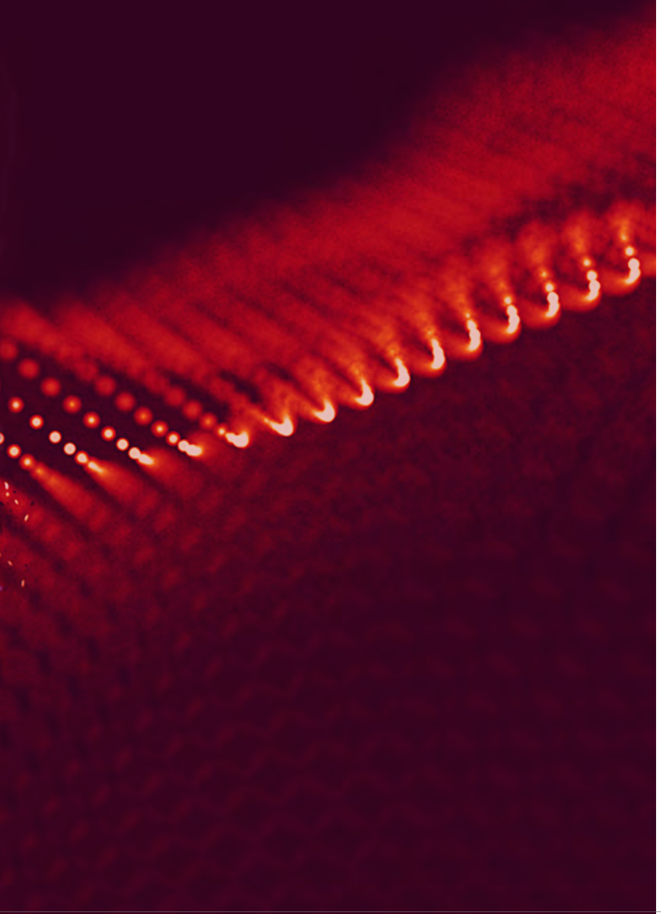


Introduction

This Heavy Reading 2021 **5G Network & Service Strategies Operator Survey** is designed to provide insight into how 5G networks and services will evolve as operators and the wider mobile ecosystem invest in and develop 5G technology. This is the third annual version of the survey, and it comes after almost a full year of disruption caused by the COVID-19 pandemic.

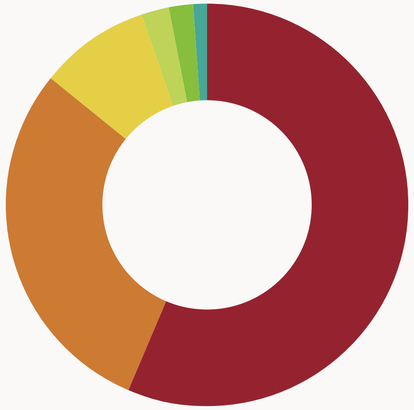
Developed in association with the report sponsors, the online questionnaire was fielded to respondents in the Light Reading service provider database in January and February 2021. It was open only to employees of communications service providers (CSPs).

This report analyzes the results of the survey in the following thematic sections:

- 5G service strategies: Scaling for the mass market
- 5G radio access network (RAN) evolution
- 5G core networks
- 5G edge cloud
- 5G transport networks
- 5G and lawful intercept
- 5G enterprise services
- 5G testing and service assurance
- 5G edge and endpoints

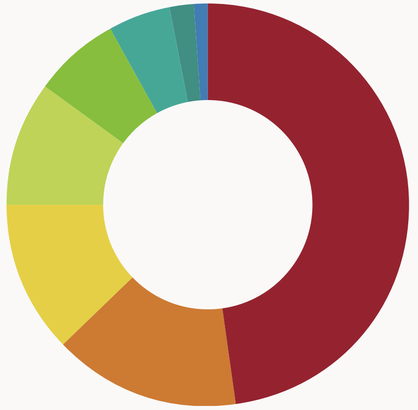
The questionnaire received a total of 82 responses from individuals who self-identified as working for CSPs. Rogue, suspicious, and non-operator responses were removed. Technical, engineering, and network operations personnel from large operators in advanced markets account for the majority of the responses. The US is the dominant region, with as many responses as the rest of the world combined; however, all major global regions were represented. **Figures 1 – 4** show the survey demographics. **Figure 5** shows that 50% of respondents work for operators that already offer 5G service; this reflects the rapid rollout of 5G globally over the past two years.

Figure 1:
What type of telecom service provider do you work for?



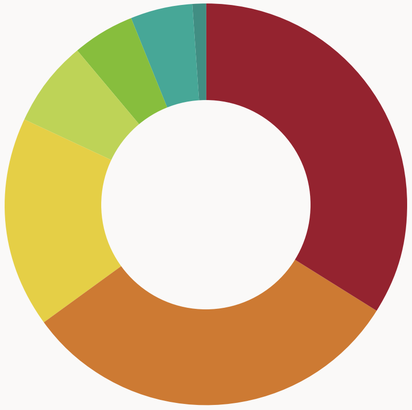
- **56%** Converged operator with a mobile network
- **29%** Mobile operator
- **9%** Cable operator with a mobile network
- **2%** Cloud provider
- **2%** Other
- **1%** MVNO

Figure 2:
In what region is your organization headquartered?



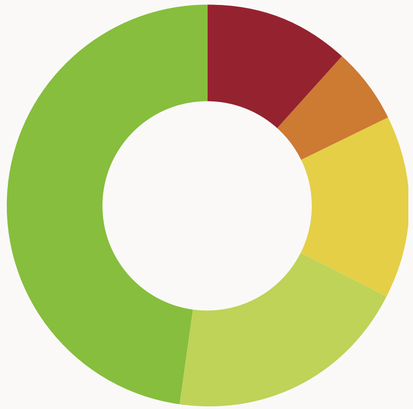
- **48%** US
- **15%** Asia Pacific (including Australia)
- **12%** Central/South America (including Mexico & the Caribbean)
- **10%** Western Europe
- **7%** Central/Eastern Europe
- **5%** Canada
- **2%** Middle East
- **1%** Africa

Figure 3:
What is your primary job function?



- **34%** R&D and technology strategy
- **31%** Network engineering & planning
- **17%** Network operations
- **7%** Marketing/sales
- **5%** IT and cloud
- **5%** Corporate management
- **1%** Other

Figure 4:
What is your organization's approximate annual revenue?



- **12%** Less than $250m
- **6%** $250–499m
- **15%** $500–999m
- **20%** $1–4.99bn
- **48%** $5bn or more

Figure 5:
When does your organization expect to launch 5G services commercially?

- **50%** Already offering
- **18%** 2021
- **15%** 2022
- **12%** 2023
- **5%** 2024 or later

Report Authors

Gabriel Brown: Senior Principal Analyst – Mobile Networks & 5G

Gabriel leads mobile network research for Heavy Reading. Starting from a system architecture perspective, his coverage area includes RAN, core, and service-layer platforms. Key research topics include 5G, LTE Advanced, virtual RAN, software-based mobile core, and the application of cloud technologies to mobile networking. Gabriel has more than 15 years' experience as a mobile network analyst. Prior to joining Heavy Reading, he was Chief Analyst for Light Reading's Insider research service; before that, he was editor of IP Wireline and Wireless Week at London's Euromoney Institutional Investor.

Jim Hodges: Research Director – Cloud & Security

Jim leads Heavy Reading's research on the service assurance and security impact of the virtualized cloud on the control plane and application layers, both in the fixed and mobile core and at the enterprise edge. Jim focuses on the security impacts that cloud-based technologies such as 5G introduce from a cyber-threat detection perspective, as well as billing and service assurance transformation implications. Jim joined Heavy Reading from Nortel Networks, where he tracked the VoIP and application server market landscape and was a key contributor to the development of Wireless Intelligent Network (WIN) standards. Additional technical experience was gained with Bell Canada, where he performed IN and SS7 network planning, numbering administration, technical model forecast creation and definition of regulatory-based interconnection models. Jim is based in Ottawa, Canada.

Sterling Perrin: Senior Principal Analyst – Optical Networks & Transport

Sterling has more than 20 years' experience in telecommunications as an industry analyst and journalist. His coverage area at Heavy Reading is optical networking, including packet-optical transport and 5G transport. He also authors Heavy Reading's Metro Optical Networking Market Tracker and Core Optical Transport Market Tracker. Sterling joined Heavy Reading after five years at IDC, where he served as lead optical networks analyst, responsible for the firm's optical networking subscription research and custom consulting activities. Prior to IDC, Sterling worked for Standard & Poor's, where he delivered global industry analysis on a range of IT segments. He is a former journalist and editor at Telecommunications Magazine. In addition to chairing and moderating many Light Reading events, Sterling is a NGON & DCI World Advisory Board member and past member of OFC's N5 Market Watch Committee. Sterling is a highly sought-after source among the business and trade press.

2021: The Year of the 5G Innovation Platform

2021: The Year of the 5G Innovation Platform

Weathering a year of the COVID-19 pandemic, over 100 commercial 5G networks were launched around the world, bringing online hundreds of millions of 5G subscribers, re-envisioning the way connectivity affects how we live, work and play.

By Chris Pearson, President, 5G Americas

It may not seem like it, but 5G commercial networks have only been around for a little over two years, beginning with launches in South Korea and with AT&T in the US in December 2018. But if it seems like we have been talking about 5G for a long time now, it is because we have! Serious scholarship on 5G principles began all the way back in 2009 with NYU Professor Ted Rappaport's seminal work on millimeter wave.

The anticipation cycle for 5G began very far ahead of its actual deployments. It took nearly a decade before academia's vision of 5G networks were commercially launched. But as of January 2021, there are now 156 5G networks around the world, and around 230 million 5G connections. Vision has not only become reality, but that reality is growing faster than any previous generation of wireless cellular.

Despite the extended hype cycle, 5G networks are only now emerging en masse. But at what a critical time for human connectivity! The perils of COVID-19 may have likely forever changed the way we conduct our personal and professional lives, as millions of people around the world work-from-home in an urgent, real-time global experiment of immense proportions. According to Nokia Deepfield's Network Intelligence Report, networks experienced a year's worth of traffic growth (30 to 50 percent) in just a few weeks, which stabilized to around 30 percent by September 2020.

Let's face it, despite working from home, most of the world is still a mobile place. Goods must still travel along complex supply chains to arrive at your door in a day or two. Services must continue to be delivered across time and space. To coordinate these activities requires mobile data. Cloud and edge computing resources must be connected to devices, objects, and people in real space. Wireless technologies like 5G offer the ability to connect data to a mobile world, of connecting people to people while they're in transit, and people to things on a massive scale.

The key to achieving this lies in understanding that 5G is actually an "innovation platform" as Ericsson puts it. 5G lies at the epicenter of the Fourth Industrial Revolution that is bringing together elements of artificial intelligence, cloud and edge computing, virtual and augmented reality, blockchain, Internet of Things, and robotics to allow people and objects to communicate with each other over vast distances.

But how is this platform coming together? Are we ready? To answer that question, you have to look at three key ingredients: network, spectrum, and devices.

When it comes to networks, 5G has just only gotten started, as most network operators have not yet even fully implemented their 5G standalone networks. In 2021, we are likely to see the full implementation of standalone 5G networks across a wide range of network operators. While some have already implemented standalone 5G systems in 2020, broad adoption this year will drive the 'full experience' of 5G to many millions more users. Standalone will unleash the power of the 5G core network, combining enhanced mobile broadband capabilities of up to 20 Gbps theoretical peak data download throughput – or 100 Mbps of typical user experience speeds – along with ultra-reliable low latency connectivity and connection density of up to 1 million devices per square kilometer.

Regarding spectrum, the increasing availability of mid-band spectrum in the United States and elsewhere (including CBRS band, C-Band, and the opening of a portion of the 5.9 GHz band for C-V2X activity in America) is beginning to open up 5G as a real platform for technology innovation. The success of the CBRS auction and the phenomenal result of the C-Band auction proceeds in the US demonstrated just how valuable and rare mid-band spectrum truly is, and how much network operators will go towards investing in its availability.

The upshot is that these spectrum investments will be directly translated in an operator's willingness to work with businesses to utilize it – and we should expect to see a many pilot use cases to emerge over the next few months that will take advantage of robust standalone networks matched with new mid-band spectrum.

With the number of commercially available 5G devices now reaching 335, according to the GSA, consumers have had several months to get used to 5G networks. New 5G use cases are surely being created in the minds of innovators as the market does a fantastic job of seeding 5G availability into the hands of anyone who can get a 5G signal. This front-loading of 5G-capable devices has a welcome sight in that it

was the opposite of what occurred with 4G LTE, which required years to get consumers to adopt new devices. Basically, what this means is that the market is becoming “5G-ready” for the next big consumer innovation. Having such a large pool of 5G devices smooths the adoption path for when 5G services become developed – there will be very little friction when it comes to ensuring a 5G service or app can be used by a large target market.

So to answer the question – are we ready yet? Is the 5G innovation platform operating on all cylinders yet? No, not quite. Not all the pieces are in play – but they’re rapidly getting there.

We think 2021 is going to be a flash point for enterprise 5G innovation. Already, there is much activity taking place in gas and oil extraction, as well as manufacturing and utilities, that are focused on CBRS-based private networks. Key 5G service and application incubators like the 5G Open Innovation Lab are collaborating with a startup ecosystem to create the next big wave of connectivity applications. There are two immediate sectors which appear to be accelerating at high velocity: automotive and healthcare.

The automotive sector changes are being revitalized with the new designation in the U.S. of the slice of 5.9 GHz spectrum now to be allocated for cellular-vehicle-to-everything (C-V2X) technologies. At the same time, Tesla has completely up-ended the transportation sector with new advances in electric vehicle technology, as well as data-hungry AI systems, which will drive an increasingly powerful trend to modernize vehicles into smart mobile platforms.

In healthcare, the COVID-19 crisis has demonstrated the incredible need for mobile data in both patient-doctor virtual visits, as well as the need for ultra-reliability and low latency in an increasing array of health sensors, ranging from smart watches to continuous glucose monitors. The flexibility of 5G networks in delivering both extremely data transfer rates and massive connectivity will be key features in building tomorrow’s health care industry.

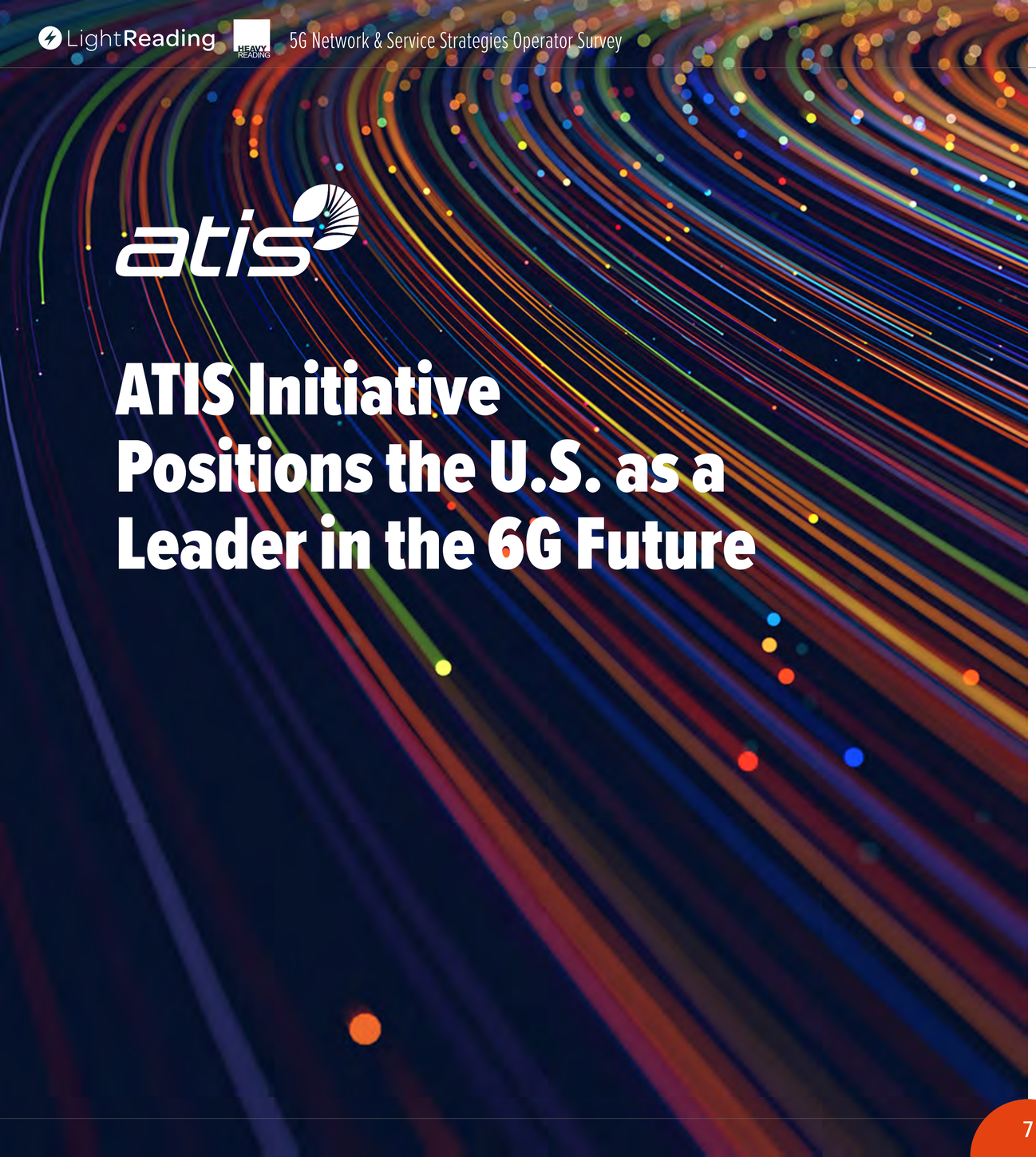
At the end of the day, enterprises would be well-advised to think about 5G as a platform for their own innovation. Businesses should ask themselves four questions involving how they could benefit – or be harmed by competitors using advances in 5G:

- What’s the impact of wireless data theoretical throughput rates of up to 20 Gbps on the downlink or 10 Gbps on the uplink?
- How will ultra-reliable low latency wireless connections impact my real-time operations?
- What if I could have up to 1 million devices per square kilometer managed wirelessly?
- What will I do with 5G that will change my industry?

Today, enterprises are already beginning to grapple with these questions. Those who find solutions for their business may end up creating entirely new business models from it and drive the engine of their digital transformation innovation for their industry. They will become the standard bearers of the new way of doing business. They will be the creators of tomorrow’s enterprises. And 5G will help them lead the way.

Chris Pearson, President, 5G Americas

Chris Pearson is the President of 5G Americas. In his executive role, he is responsible for the overall planning of the organization and providing management for the integration of strategy and operations in the areas of technology, marketing, public relations and regulatory affairs. With more than 33 years of experience in the telecommunications industry, Mr. Pearson is a recognized spokesperson in mobile wireless and 5G technology trends and has spoken at technology conferences throughout the world including CES, Mobile World Congress, CTIA, 5G World North America, and The Big 5G Event.



ATIS Initiative Positions the U.S. as a Leader in the 6G Future

ATIS Initiative Positions the U.S. as a Leader in the 6G Future

By Mike Nawrocki, ATIS Vice President – Technology and Solutions

As investments in 5G technologies begin to deliver real value in the U.S. market through the next generation of networks, devices and applications, the timeline for 6G development has already begun. ATIS is leading a major industry initiative to establish North America as a leader in the 6G future. This work is based on the premise that while innovation often occurs in response to current market needs, technology leadership at the global level takes strategic foresight and critical stakeholders committed to reaching the desired future state.

A Look Toward the Future with Today's Challenges In Mind

In a new world of global pandemic, communications networks are increasingly becoming the essential fabric connecting businesses to clients and customers, healthcare patients to providers, students to teachers, governments to citizens, and individuals to family and friends. Expanding and enriching critical services for this new world will require collaboration. Now is the time to harness the benefits that 5G innovation is making possible in digitized commerce and artificial intelligence, telehealth, distance learning and other areas. In doing this, we can build in the goal of extending the benefits of 5G commercialization to a 6G world with a strong North American preeminence — a world that delivers innovative services and customer experiences beyond network boundaries, physical environments and geographic constraints.

How North America can Achieve 6G Leadership

ATIS' Next G Alliance employs a holistic approach in helping North America achieve sustainable technology leadership in the 6G future. It is bringing together key stakeholders including industry, academia and the research community to create a national vision for the next decade that addresses the full technology lifecycle, from early R&D to market realization.

An important foundational goal for the Next G Alliance is development of a National 6G Roadmap that charts the course from today's robust 5G networks to a 6G vision. It will address research priorities, key government actions to spur innovation, development and manufacturing incentives, standards needs, standards leadership and market readiness. It will also forge commitment to a series of incentivized steps that will spur early private-sector investment, speed to market and widescale global commercial adoption. While the realities of different geographies, populations, economies and government oversight will always influence global market demands, it is the leadership of ideas coupled with the commitment of the key sectors around issues and actions such as these that will position the U.S. as the global information and communications technology (ICT) technology leader for the next decade and beyond.

As the Next G Alliance begins to look at the most critical goals in the near-term future, it believes that innovation should in no way be limited to meet a pre-established goal. However, there is indeed a national advantage in defining a set of core technologies that will foster inherent U.S. ingenuity and rapid technology development in the ICT sector. In the future, we expect that these core technologies will include those addressing:

- AI-enabled advanced networks and services
- Advanced antennas and radio systems
- Multi-access network services
- Healthcare
- Agriculture

An Immediate Imperative for Action

The time for this core technology planning is now. Other parts of the globe have already launched 6G research efforts and are developing regional market-based strategies for the next decade of mobile technology development. In addition, international organizations are beginning to develop 6G vision-based documents that will define 6G systems and applications.

Although free market principles will guide the thinking, the U.S. is competing with regions of the globe that greatly subsidize private sector development, violate intellectual property rights and sometimes introduce unfair trade barriers. From an industry perspective, the federal government can best counter these technology barriers by adopting a national plan for technological excellence that relies on a set of committed principles and actions:

1. Make available additional R&D funding focused on a core set of technological breakthrough areas where the U.S. can lead.
2. Expand R&D tax credits to encourage massive investment in a core set of technologies that will promote U.S. leadership.
3. Work with industry to develop a consumer- and business-centric solution to wireless spectrum challenges by creating a national spectrum policy.
4. Explore innovative ways to promote widespread commercial adoption of U.S. developed and produced hardware and software through financial incentives to public and private sectors.

ATIS' Role in Shaping the 6G Future

With a history of bringing together ICT companies to solve the industry's biggest challenges, ATIS is the organization that created the Next G Alliance in late 2020. Since inception, this industry coalition has rapidly grown to 44 members from a broad range of industry sectors that represent the future 6G ecosystem.

ATIS believes that North American market has the resources and innovative focus it will take to drive leadership in the development of 6G technologies and ultimately to create a robust 6G marketplace for North American innovation. But these forces must be coupled with a national agenda that joins government funding and incentivization of 6G with the industries and academic research capabilities that will drive the 6G market. This can only be accomplished through a coordinated and holistic approach to 6G development. The Next G Alliance offers the opportunity for a collective view of the private sector to guide the government sector and research community. North America wins by harnessing the power of innovation and thought leadership with government actions to lead the world on the path to the 6G future. Learn more about the work of the Next G Alliance.

Mike Nawrocki, ATIS Vice President, Technology and Solutions

Bringing extensive telecommunications strategy experience and a service provider perspective, Mike provides ATIS direction on emerging technology trends as well as next generation technologies and networks. Before ATIS, he served as Director – Standards for Verizon Technology, and previously, as principal technologist in Verizon's CTO organization. His extensive career with major service providers includes working in network planning and engineering positions at Verizon and AT&T Bell Labs. Mike has previously served on the MoCA Board of Directors and participated on FCC working groups, including the Technological Advisory Council, CSRIC and Network Reliability Council. At ATIS, he serves as a key policy interface with the FCC and other agencies.

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5G Service Strategies: Scaling for the Mass Market

5G Service Strategies: Scaling for the Mass Market

By Gabriel Brown, Senior Principal Analyst, Mobile Networks & 5G, Heavy Reading

Today, 5G is established in advanced markets. Network coverage is expanding, there is a wide range of devices available across the high- and mid-tier price points, and operators have real-world experience with 5G. It is critical now to understand how this capability translates to end-user services in the near and medium terms. The rate at which 5G scales to the mass market and the rate at which advanced services are offered have a direct impact on the entire mobile industry ecosystem.

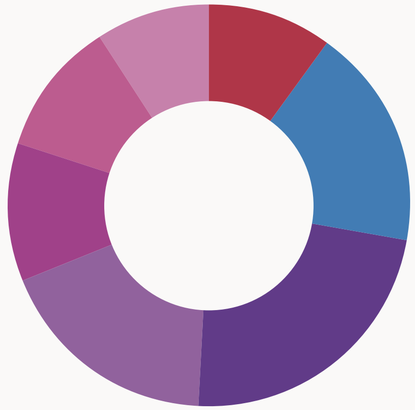
The key findings for this section are as follows:

- 28% of respondents think 5G will account for the majority of mobile network capital investment at their company by the end of this year. By the end of 2023, (three years after the survey was fielded), a large majority (>69%) of operators will allocate most of their mobile capex to 5G. By way of context, research firm Omdia (Heavy Reading's parent organization) forecasts that in terms of RAN equipment spending, 5G will cross the 50% threshold in 2021, driven by larger operators, particularly in China and the US.
- A quarter (28%) think there will be "many new 5G service offerings" in their service portfolio over the next three years. This is up from just 8% in the 2020 survey, which indicates growing enthusiasm and belief in 5G. The largest group, as in the 2020 survey, is the 64% that say there will be "some new 5G-only services," but that the portfolio as a whole will be "mostly common 4G/5G services."
- Operator respondents are bullish on network slicing and ultra-reliable low latency communication (URLLC). Roughly half expect these services to be offered within two years (i.e., by the start of 2023) in the WAN. The survey response is perhaps a little overly optimistic on timelines for these services, but the sentiment and direction of travel is clear.

A good indicator of how enthusiastic operators are on 5G is to look at their capex. The first question in the survey asks when will 5G account for more than 50% of their total mobile network capex. **Figure 6** shows that, by the end of this year, a combined 28% of respondents (already = 10%, 2021 = 18%) think that 5G will account of the majority of mobile network capex at their company. By the end of 2023 (three years after the survey was fielded), a large majority (>69%) of operators will allocate most of their mobile capex to 5G.

Omdia forecasts that in terms of RAN equipment spending, 5G will cross the 50% threshold in 2021. At first glance, this is a little more bullish on the 5G investment timeline than the survey. This difference is probably because demand is concentrated with larger operators (particularly in China and the US); not all operators will invest at such an aggressive pace. It is also worth noting that capex is also used for diverse facilities (offices, data centers, fiber plants, towers, etc.) and is not always an accurate proxy for network equipment spending.

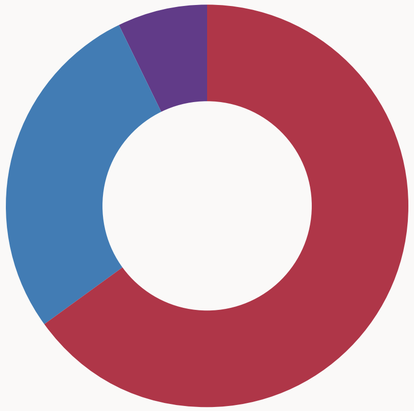
Figure 6:
When does your organization expect 5G to account for more than 50% of its total mobile network capex budget?



10%	Already the case	**11%**	2024
18%	2021	**11%**	2025 or later
23%	2022	**9%**	Don't know
18%	2023		

Services are the raison d'être for 5G. The opportunity to enable services that are not practical, or even possible, on 4G is the driving force behind 5G technology development and network investment. **Figure 7** shows the extent to which respondents think their company's 5G service portfolio will be different from, or the same as, the 4G service portfolio in the next three years. A quarter (28%) think there will be "many new 5G service offerings," up from just 8% in the 2020 survey, which indicates growing enthusiasm and belief in the 5G project. The largest group, as in the 2020 survey, is the 64% that say there will be "some 5G-only services," but that the portfolio as a whole will be "mostly common 4G/5G services." This is an entirely reasonable approach to the services portfolio over a three-year timeframe because operators serve the mass market and generally want to reach as many customers as possible.

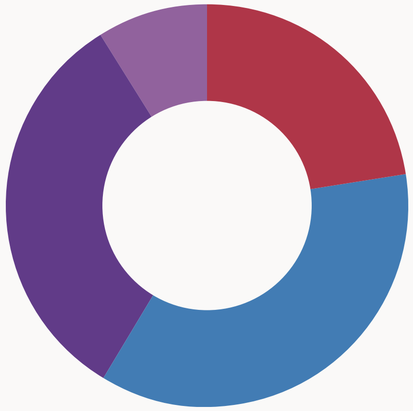
Figure 7:
How much common ground do you expect between your organization's 4G and 5G service portfolios over the next three years?



- **64%** Mostly common 4G/5G services with some 5G-only services 64%
- **28%** Many new 5G service offerings 28%
- **7%** Identical services portfolio 7%

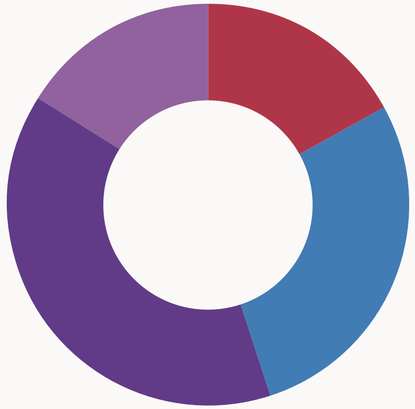
The next questions ask about three service types that have come to define 5G: network slicing, URLLC, and the Internet of Things (IoT). **Figures 8 and 9** show when respondents expect their company to start offering network slicing and URLLC, respectively. There are some small differences between the responses—network slicing is expected to come a little sooner than URLLC—but the overall pattern is similar in both questions. There is clearly a large group (roughly half) that expects these services to be offered within two years (i.e., by the start of 2023, based on when the survey was carried out. However, there is an equally large group (again, roughly half) that thinks it will take more than two years to introduce these services. Given that survey respondents are, in Heavy Reading's experience, typically a little overly optimistic on timelines, some caution is warranted with these responses, particularly the "in the next 12 months" group. Right now, Heavy Reading's other market information does not support a view that either service type will be offered commercially in the public WAN within that timeframe, although we do expect user trials of network slicing in 2021.

Figure 8:
When does your organization expect to start offering 5G network slices in the public WAN?



- **22%** In the next 12 months
- **37%** In 12-24 months
- **32%** After 24 months
- **9%** No plans yet / Don't know

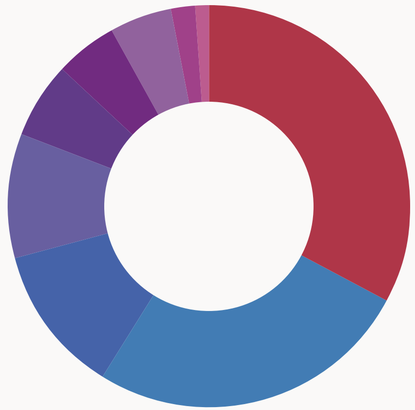
Figure 9:
When do you expect your organization to start offering URLLC services in the public WAN?



- **17%** In the next 12 months
- **28%** In 12-24 months
- **39%** After 24 months
- **16%** No plans yet /don't know

Figure 10 asks which IoT services will see the greatest benefit from 5G within a three-year timeframe. Survey takers were only able to select one answer to force a focused response. There appear to be two leading candidates: Industrial IoT (IIoT) & manufacturing with 33% and smart cities with 26%. IIoT scores consistently highly in 5G surveys and there is a plethora of marketing, media coverage, and real-world activity that supports the first-place position in this survey. The high score for smart cities is trickier to interpret. As a service category, smart cities always score highly in surveys, and there is a frequent association with 5G. However, smart cities incorporate so many different applications that perhaps the reason it scores well is because it offers something for everyone.

Figure 10:
Which IoT use case will see the greatest benefit from 5G within the next three years?



- **33%** Industrial IoT & manufacturing
- **26%** Smart cities
- **12%** Telemedicine and digital health
- **10%** Supply chain logistics (vehicle fleets, warehousing, etc.)
- **6%** Consumer wearables (e.g. smart watches, VR/AR headsets, etc.)
- **5%** Smart retail 5%
- **5%** Automotive / V2X applications
- **2%** Energy and utilities monitoring and control
- **1%** Video monitoring and computer vision

Radisys

Executive Summary

Since 2018, mobile operators around the world have continued to accelerate the pace of their 5G deployments, ramping up spending on spectrum and infrastructure. While these initial deployments have focused on mobile broadband use cases, 5G will open up a massive amount of new services and use cases that will benefit from its high-performance and ultra-low latency capabilities.

According to this new report from Heavy Reading, “services are the raison d’être for 5G.” The report highlights the key findings from a survey of global service providers on how and when 5G will scale for the mass market with new service types – network slicing, URLLC, and massive IoT – leading the demand. It is predicted that by 2023, the majority of service providers’ CapEx spends will be on 5G.

As a global leader in open telecom solutions and services, we are deploying our 5G Software Suite with service providers around the world to enable their 5G deployments in sub-6 GHz and mmWave spectrum to meet a variety of use cases. And our network services organization helps service providers build and operate highly scalable and high performance 5G network with our expertise in delivering full lifecycle services.

5G will change the world. It’s just a matter of when. We think soon.

VIAVI

5G RAN Evolution

5G RAN Evolution

By Gabriel Brown, Senior Principal Analyst, Mobile Networks & 5G, Heavy Reading

The RAN is the defining part of a 5G network. Operators are now deploying 5G New Radio (NR) network equipment in all global regions across low-band, mid-band, and high-band spectrum. The rate at which new coverage is deployed, how the different bands are combined into a layered RAN architecture, and the extent to which technologies, such as massive multiple input, multiple output (MIMO) and millimeter wave (mmWave), are integrated into the existing RAN footprint has a direct link to the customer experience, to operator economics, and, therefore, to every participant in the mobile ecosystem.

The key findings for this section are as follows:

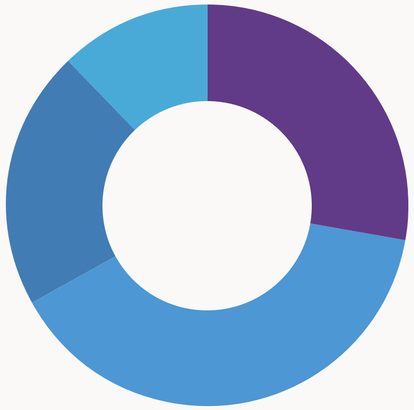
- A full 39% of respondents indicate 25–50% of their company's RAN footprint will support 5G by the end of 2022 (i.e., two years after the survey). This is a bullish view, but not unrealistic in advanced markets. The 21% that expect 51–75% of their footprint to be 5G-enabled in that timeframe show there is an appetite for even deeper penetration of 5G by some operators.
- On a three-year view, 56% of respondents say open RAN (O-RAN) is "important" to their network versus 16% "critical" and 26% "somewhat important." This probably represents market sentiment correctly, which is to say that O-RAN is important and has great potential, but that operators cannot wait for it to mature before they determine 5G RAN strategies. O-RAN will have to prove itself against exacting performance requirements and high benchmarks set by integrated products.
- In terms of challenges with 5G RAN field testing, the three leading answers testing URLLC (26%), testing FR1 to FR2 handovers (26%), and testing massive MIMO and beamforming (31%) are pretty evenly split just ahead of scaling and testing fiber infrastructure (17%). In other words, there are challenges across the board.

In 2020, operator investment in 5G RAN increased substantially from 2019. Much of the focus was on scaling the mid-band and mmWave networks that went live in 2019; however, it was low-band deployments that had the greatest impact on coverage. 5G NR was deployed in "digital dividend" spectrum (e.g., 600MHz and 700MHz) and, for the first time, in existing LTE bands using dynamic spectrum sharing (DSS) technology. In leading markets, a 5G signal is now commonplace, if not yet ubiquitous. The challenge for operators going forward is to combine low-band coverage with mid- and high-band densification to ensure capacity and end-user performance.

Figure 11 shows the extent to which respondents expect 5G to be deployed in their RAN footprint by the end of 2022 (i.e., two years after the survey). The largest group, 39%, indicate 25–50% of their RAN footprint will support 5G. This is a bullish view, but not unrealistic in advanced markets. The 21% that expect 51–75% of their footprint to be 5G-enabled show there is some appetite for even deeper penetration of 5G in this timeframe. A not insignificant 28% think that less than 25% of their RAN footprint will support 5G access and this constituency should not be discounted.

It is worth noting that similar questions in the 2019 and 2020 surveys generated quite similar responses. This suggests operators have well developed deployment plans and are holding their course in the face of the pandemic. One might have expected low-band and DSS to have enabled operators to hasten 5G rollouts across the existing footprint; however, given the pandemic and the delays to spectrum auctions in some markets, it is understandable that operators may be cautious.

Figure 11:
How much of your RAN footprint will be running 5G access by the end of 2022?

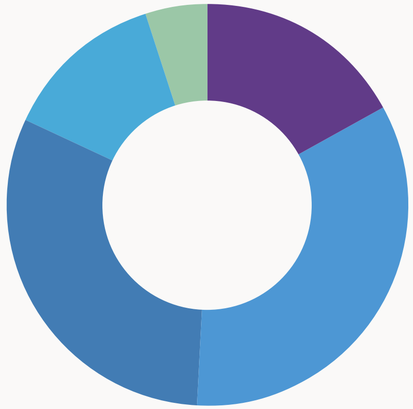


- **28%** Less than 25%
- **39%** 25 - 50%
- **21%** 51 - 75%
- **12%** More than 75%

The most popular spectrum, based on the number of deployments worldwide, is mid-band time-division duplexing (TDD) spectrum, known as "C-band" in some markets. The use of active antenna systems with massive MIMO in this spectrum enables operators to use beamforming to increase cell capacity and improve performance for cell edge users, relative to passive antenna systems. Massive MIMO works particularly well in TDD spectrum with wide channels. It is, however, a little more costly to deploy than passive systems and uses a little more power.

Figure 12 shows how operators are thinking about the deployment of massive MIMO expressed as a percentage of RAN sites. Relatively few respondents expect to deploy the technology on more than 51% of their sites by the end of 2022. In some ways, this is unsurprising given the fairly tight timeline and the fact that massive MIMO is most likely to be worthwhile in areas of high demand density, such as urban centers (as a rule of thumb, the busiest 20% of sites in a network generate 80% of the traffic). About a third of respondents (31%) of respondents do think 26–50% of their sites could have massive MIMO within this timeframe, which is perhaps a little bullish, but reflects that massive MIMO products are advancing rapidly and indicates an appetite to deploy this technology beyond the most heavily-trafficked urban hotpots. Just over half of respondents think less than 25% of sites in their company's network will use massive MIMO by the end of 2022, which is made up of the 34% that think 10–25% range looks about right and 17% that expect less 10%.

Figure 12:
What percentage of your sites do you expect to migrate to massive MIMO by the end of 2022?



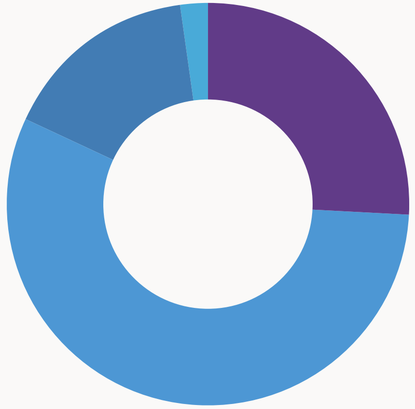
- **17%** Less than 10%
- **34%** 10 - 25%
- **31%** 26 - 50%
- **13%** 51 - 75%
- **5%** More than 75%

O-RAN is one of the most active topics in the mobile industry, drawing attention from policymakers, operators, and new entrants and existing vendors. The idea is to disaggregate the RAN into multiple functional modules and to "softwarize" the RAN by deploying software on white-box hardware platforms (e.g., a commercial off-the-shelf [COTS] server) and by introducing programmatic control. The goal is to accelerate innovation by making it easier for new technologies and specialist suppliers to enter the market. Over time, this should increase vendor diversity and competition, and ultimately result in lower cost, higher performance RAN systems.

Figure 13 asks how important O-RAN will be in the next three years and 16% say O-RAN is "critical—it's a strategic priority." Some might be surprised that it does not score higher, given the levels of hype and media coverage around O-RAN. Realistically, however, operators will need to rely on vendor-integrated systems for some time as they introduce O-RAN. About a quarter (26%) say it is "somewhat important," which is to say interesting, but not a priority.

The 56% that say O-RAN is "important" to their network in the next three years probably represents the overall market sentiment correctly. O-RAN has great potential, but operators cannot wait for it to mature before they determine 5G RAN strategies, and they also cannot depend on it developing sufficiently to replace vendor-integrated solutions within this timeframe. O-RAN will have to prove itself against exacting requirements and high benchmarks set by integrated products.

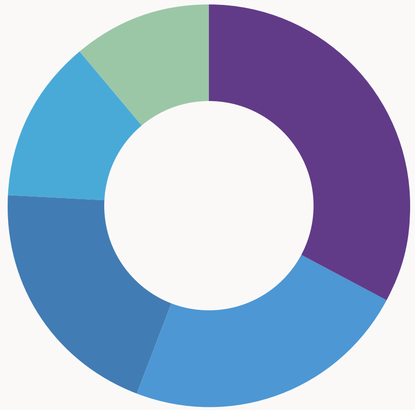
Figure 13:
How important will "open RAN" be to your network in the next three years?



- **16%** Critical – it's a strategic priority
- **56%** Important
- **26%** Somewhat important – but not a priority
- **2%** Not important at all

Figure 14 asks about the biggest challenge in a multi-vendor O-RAN deployment. There is a spread of responses with none above 50%. The finding, therefore, is that there are challenges across the board. The largest response is the 33% that selected "interoperability of different elements." This is an expected and logical result because, by definition, O-RAN disaggregates base station products, which must then be re-integrated in the new model. Performance (23%) also ranks highly in the list of challenges, as perceived by operators. Achieving performance parity with integrated systems—or something close to parity—is a key issue for O-RAN.

Figure 14:
For O-RAN multi-vendor deployments, what do you see as the biggest challenge?



- **33%** Interoperability of different elements
- **23%** Achieving similar performance to single-vendor networks
- **20%** Achieving substantial cost savings
- **13%** Harder to outsource network maintenance and testing so need to do more in-house
- **11%** Implementing virtualized/cloud RAN

5G RAN field testing is required through the operating lifecycle, from acceptance testing to ongoing performance monitoring. Because 5G introduces new spectrum bands and technologies, it introduces new challenges for testing. **Figure 15** asks which aspect of 5G field testing is of greatest concern to operators. The three leading answers of testing URLLC (26%), testing FR1 to FR2 handovers (26%), and testing massive MIMO (31%) are evenly split just ahead of scaling and testing fiber infrastructure (17%). In other words, there are challenges across the board.

Figure 15:
What aspect of 5G field testing is your greatest concern?

- **31%** Massive MIMO and beamforming performance validation
- **26%** Inter-technology and FR1 and FR2 performance management (Hand overs between 4G, 5G and mmWave band)
- **26%** Low latency validation for URLLC applications
- **17%** Fiber infrastructure scale and testing of fiber network

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Executive Summary

As standards continue to evolve and 5G is deployed in more and more cities across the world, data clearly shows that the new 5G radio access network (RAN), whether deployed non-standalone (NSA) or standalone (SA), is a fundamental piece of the 5G puzzle. With 5G, however, there is a need for a more flexible, liquid, and virtual open RAN architecture—one that is more adaptive and intelligent.

New interfaces are created that offer access points to data intelligence as we move to a disaggregated and open 5G RAN architecture. Protocol layers are split across the various network elements to satisfy cost and flexibility. With mobile edge computing (MEC), you may now find that the application service is much closer to the edge (for low-latency applications, for example). The user plane function typically accessed at the core now will be accessed in the RAN. In addition, previous RAN technologies have always been cell-centric. That model starts to disappear with 5G as we move to a 3D beam-centric model with both coverage and users' beams.

With any major new technology comes business risk—particularly with the 5G RAN being more complex and open. Multi-vendor deployments create a need for the operator to own more of the testing and assurance given that one vendor will no longer own the domain. Interoperability testing and E2E performance and assurance become fundamental elements of any 5G operator RAN strategy.

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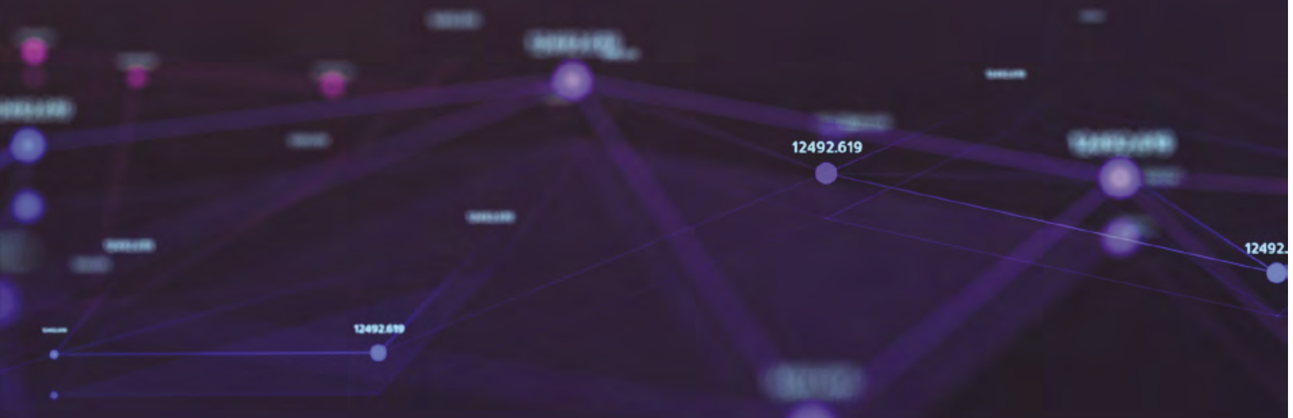
5G Core Networks



5G Core Networks

By Gabriel Brown, Senior Principal Analyst, Mobile Networks & 5G, Heavy Reading

The packet core controls sessions, authentication, policy, and mobility in a mobile network. Externally, it connects to the internet, to cloud providers, and directly into enterprises. The 140+ commercial 5G networks launched, to date, use a 5G RAN connected to a 4G core in non-standalone (NSA) mode. In 2020, the deployment of 5G core and standalone (SA) operation got underway following the commercial release of core network products and compatible chipsets and devices.

Around a dozen 5G core networks are now live in some form (excluding private networks) and many more operators are deep in the evaluation and planning phases. However, deployment and scaling the 5G core is a multi-year process that affects end users' devices, RAN, transport, and telco cloud strategies. It will take time for this technology to be deployed to the global mass market. Ultimately, the 5G core is expected to be a critical enabler of new service types, such as network slicing, edge applications, and URLLC.

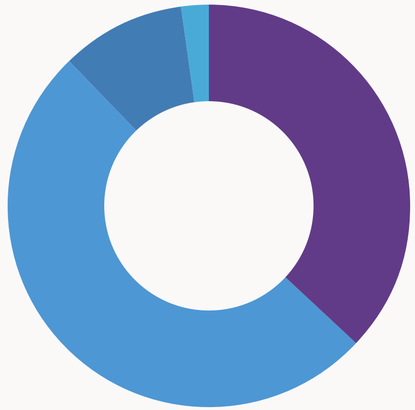
The key findings for this section are as follows:

- Operators agree with the view that the 5G core is services driven (88% support). A substantial 37% "strongly agree" with this view. However, a larger 51% simply "agree." This does not change the major finding, which is positive for services, but it does hint at some uncertainty around what 5G core-enabled services might look like and how they will be different from 4G.
- There is a strong preference for a common 4G/5G core, with 40% expecting this from early in the deployment and 21% expecting it "at a later stage." The argument for a common core is sound, but the risk to existing 4G services is high. So, while the sentiment is understandable, it may be more appropriate to think in terms of common network functions, or groups of network functions, in initial deployments, rather than in terms of a fully integrated common core on day one.
- In terms of cloud deployment options for a 5G core, the response is roughly evenly split between primarily virtual network functions (VNFs) (39%), primarily cloud-native network function (CNFs) (29%), and a "mixture of VNF and CNFs" (33%). Cloud infrastructure is one of the most critical decisions in a 5G core deployment and operators must weigh the ambition for deploying a cloud-native platform against the need for tried, tested, and operational infrastructure, as they strive to meet commercial deployment timelines.

To test the assertions that the 5G core is an enabler of new services and, by extension, if 5G core is necessary, the survey asks to what extent respondents agree or disagree with this statement: "It will be difficult to offer the full range of 5G services using a 4G core; we need a 5G core to capture the full benefits of 5G."

The first finding **(Figure 16)** is that only 10% disagree with this assertion. In other words, operators as a group support the view that the 5G core is services driven. The question then is how enthusiastically do they agree? Those responses are a little mixed. A substantial 37% "strongly agree," which is clearly very positive. However, a larger 51% simply "agree." This does not change the major finding, which is still positive from a services point of view, but it does hint at some uncertainty around what 5G core-enabled services might look like and how they will be different from 4G. This is consistent with the view, expressed earlier in the survey, that 5G services portfolios will be similar to 4G and complemented by 5G-only services.

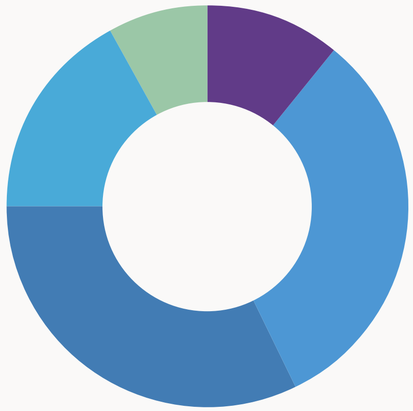
Figure 16:
To what extent do you agree or disagree with following statement: It will be difficult to offer the full range of 5G services using a 4G core; we need a 5G core to capture the full benefits of 5G?



- **37%** Strongly agree
- **51%** Agree
- **10%** Disagree
- **2%** Don't know

The first 5G core networks are now live. **Figure 17** shows expectations for deployments over time. The primary finding is that a majority of respondents expect their company to deploy 5G core in the next two years; 32% in the next 12 months and 32% in the next 24 months. This is a good indication that 5G core deployment is now underway and set to scale. Some caution is needed here, however. The survey represents the view of advanced operators in advanced markets, particularly in the US, and it is not representative of the global market as a whole. It will likely take much longer than two years for most mobile operators in the world to deploy a 5G core.

Figure 17:
When do you expect to deploy a 5G core and standalone 5G?



- **11%** Already deployed
- **32%** Within 12 months (by the end of 2021)
- **32%** Within 24 months (by the end of 2022)
- **17%** Within 36 months (by the end of 2023)
- **9%** In 2024 or later

In terms of supplier selection, **Figure 18** indicates that many operators are likely to use "two or three vendors" in their 5G core. With a score of 43%, this is some distance ahead of multiple vendors for a best-of-breed core (24%) and likely to use a single vendor (23%). Depending on the definitions, the mobile core consists of half a dozen to a dozen different network functions. Selecting two or three vendors, each providing a few closely coupled functions, is reasonably common in 4G, especially among larger operators, so it is logical that multi-vendor models will become somewhat more common in the 5G core.

Figure 18:
Thinking about your 5G core network, do you plan to assemble the functions that make up the service-based architecture (SBA) 5G core from multiple vendors or from a single vendor?

- **43%** Likely to use two or three vendors to assemble a 5G core
- **24%** Likely to use multiple vendors to create a best-of-breed 5G core
- **23%** Likely to use single-vendor
- **10%** Don't know / too early to say

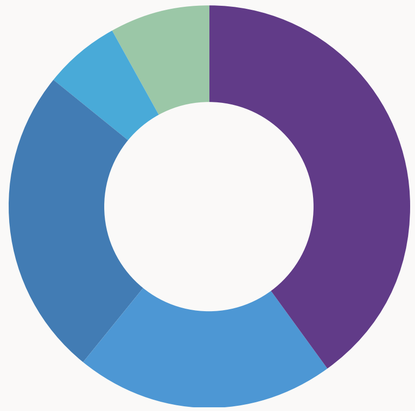
The 5G core is widely expected to be deployed on software-defined infrastructure. A key question is will that be primarily virtualized infrastructure with VNFs deployed in virtual machines or CNFs deployed in containers and centrally orchestrated. **Figure 19** shows there is no clear answer to this question and that diverse strategies are under consideration. The response is roughly evenly split between the three options presented "primarily VNFs" (39%), "primarily CNFs" (29%), and a "mixture of VNF and CNFs" (33%). Cloud infrastructure is one of the most critical decisions in a 5G core deployment, so operators must weigh the ambition for cloud-native platforms against the need for tried, tested, and operational infrastructure, as they strive to meet commercial deployment timelines.

Figure 19:
On what infrastructure platform do you expect to deploy your initial 5G core?

- **39%** Primarily as VNFs running in VMs on virtualized infrastructure
- **33%** A mixture of VNFs and CNFs
- **29%** Primarily as CNFs running on bare-metal with a cloud native orchestrator

Operators today typically operate one packet core for 3G and 4G. With the introduction of 5G, there is an opportunity to continue this common core approach, or to introduce 5G core as an overlay. **Figure 20** shows a strong preference for a common 4G/5G core, with 40% expecting this "early in the 5GC deployment" and 21% "at a later stage." The argument for a common core is sound, but the risk to existing 4G services is high. While the sentiment is understandable, it may be more appropriate to think in terms of common network functions or groups of network functions in initial deployments, rather than in terms of a fully integrated common core.

Figure 20:
Does your organization expect to deploy a common 4G/5G core?



- **40%** Yes – from early in the 5GC deployment
- **21%** Yes – but at a later stage
- **25%** Under evaluation
- **6%** No
- **9%** Don't know

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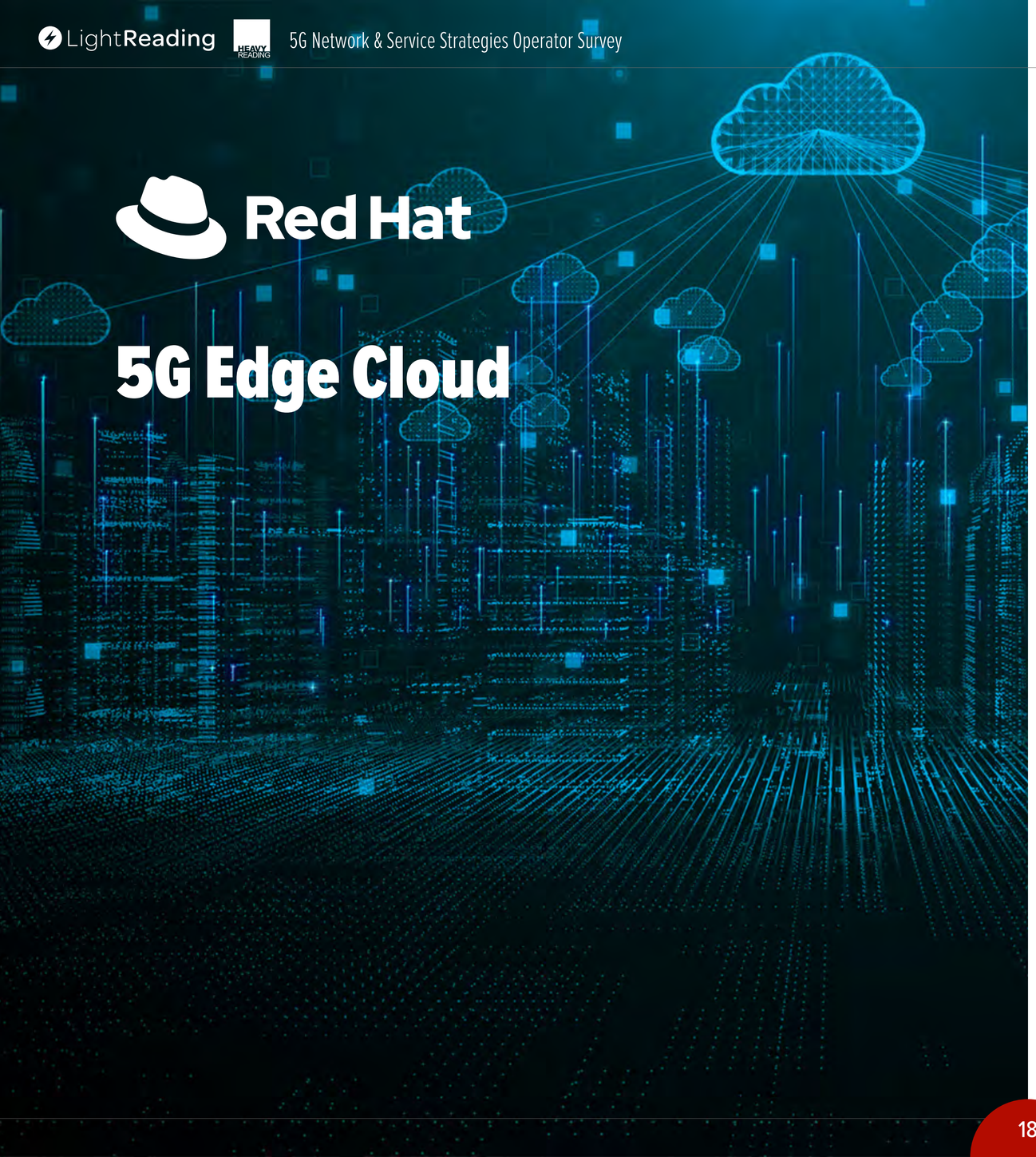
Executive Summary

The 4G Evolved Packet Core (EPC) is significantly different from the 5G core, with the 5G core leveraging virtualization and cloud-native software design at unprecedented levels. The new 5G core, as defined by 3GPP, utilizes a cloud-aligned, service-based architecture (SBA) that spans across all 5G functions and interactions, including authentication, security, session management, and aggregation of traffic from end devices. The 5G core further emphasizes network function virtualization as an integral design concept with virtualized software functions capable of being deployed using the multi-access edge computing infrastructure that is central to 5G architectural principles.

The move to a cloud-native, service-based architectures brings great flexibility for the operator but also significant complexity. E2E testing before deployment, with stress testing the impact of RAN traffic on the core network, ensures reliability and performance when deployed. In addition, as networks evolve to support uRLLC, the requirement for automated and predictive test and assurance systems becomes more and more critical. These services have more stringent and often disparate demands on the network.

Statistical insight of past events—along with predictive analytics—now must be embedded as a key part of the network to ensure smooth network operation, high availability, and enable new, exciting 5G revenue streams.



5G Edge Cloud

By Gabriel Brown, Senior Principal Analyst, Mobile Networks & 5G, Heavy Reading

The 5G network architecture enables operators to deploy edge cloud infrastructure to radically improve how services perform on mobile networks. By hosting applications and content closer to customers, operators can make the best use of high bandwidth low latency access and deliver the advanced services for which 5G is designed. The deployment of edge infrastructure has many variables and is expected to occur in phases. This section of the survey investigates some of the key steps that operators must take as they implement this new service delivery architecture.

The key findings for this section are as follows:

- To "improve application performance in general" is the leading reason operator respondents give for investing in the 5G edge, which, with a score of 35%, is just ahead of "to better support vertical industry applications" with 28% and to support "differentiated communication services" with 16%, and to "reduce bandwidth use/cost" with 21%. These results indicate that operators will focus their 5G edge strategies on end-user services, rather than on efficiency.
- Operators are bullish on the timeline for the edge with 18% planning to offer services this year, a large 49% next year, and then 21% in 2023. This makes an 88% commitment to edge services over the next three years. The conclusion, therefore, is that activity related to edge architecture, vendor selection, and deployment, will be high in the near term.
- The two biggest perceived barriers (cost and complexity at 32% and availability of certified use cases at 26%) tell the story of 5G and the edge as it exists today: a good idea with great potential, but one that needs development and investment over a sustained period to become a mainstay of 5G service delivery.

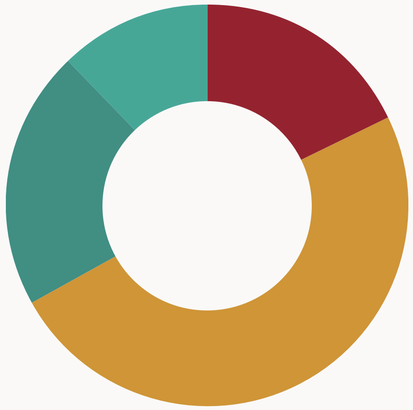
It is always useful to ask why a new technology or architecture is needed. **Figure 21** shows that operators have a wide variety of motivations to move workloads to the edge. The largest response, as might be expected, is to "improve application performance in general" with 35%. In second and third place are the 28% with the intention "to better support vertical industry applications" and the 16% that aim to "offer differentiated communication services," both of which, in combination, show that many operators will be targeted in their edge performance strategies. On the efficiency side, "to reduce bandwidth use/cost" scores a solid 21%. The overall picture, therefore, shows a strong bias toward improving service performance, but with a split between an intention to improve services in general and those with an intention to be more targeted.

Figure 21:
What is your primary motivation to move workloads to the edge?

- **35%** Improve application performance in general
- **28%** To better support vertical industry applications
- **21%** Reduce bandwidth use/cost
- **16%** Offer differentiated communications services vs competitors (e.g. video conferencing, etc.)

Operators are bullish on the timeline for the edge with 18% planning to offer services this year, a large 49% next year, and then 21% in 2023. This makes an 88% commitment to edge services over the next three years, according to **Figure 22**. This probably paints an overly optimistic picture of the schedule and it might be better to think that this result reflects the ambitions of the advanced operators that predominate in the survey demographic. Nevertheless, the data is clear: operators are committed to the edge and activity related to architecture, vendor selection, and deployment will be high in the near term.

Figure 22:
When will your organization start to offer 5G edge services?

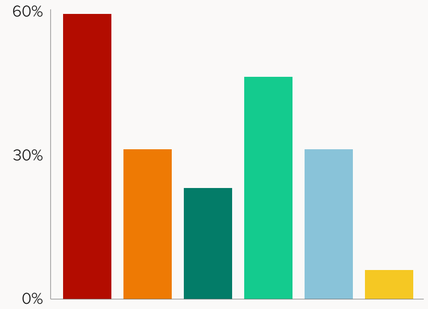


- **18%** 2021
- **49%** 2022
- **21%** 2023
- **12%** 2024 or later

The next question asks how operators will offer edge services and, specifically, on what kind of infrastructure? This is a "select all that apply" question to reflect the likelihood that operators will pursue multiple edge strategies. There are 160 votes from 82 individual respondents, which indeed shows that operators will employ diverse strategies.

Nevertheless, **Figure 23** shows a clear preference, with a majority (59%) selecting "hybrid public/private telco cloud infrastructure" some distance ahead of the other options. In second, with 46%, is "on our own telco edge cloud platform." Both cases show, unsurprisingly, that operators favor edge cloud models that make use of their own unique network infrastructure. The advantages of owning and controlling network assets are also seen in the third-place option of "public cloud infrastructure installed within our network" at 31%, which comes ahead of "public cloud not deployed within our network" at 23%.

Figure 23:
How will your organization offer edge services?

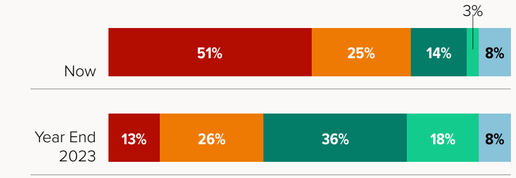


- **59%** On hybrid public/private telco cloud infrastructure
- **31%** Via public cloud infrastructure installed within our network
- **23%** Via public cloud infrastructure not deployed in our network
- **46%** On our own telco edge cloud platform
- **31%** Using on-prem edge (e.g. at the enterprise location)
- **6%** Don't know

The edge cloud is made up of diverse hardware (switches, servers, network interface cards [NICs], racks, power supplies, etc.), but this is generally considered software-defined infrastructure. Currently, there are two major solutions: virtualized infrastructure to run VNFs and cloud-native infrastructure to run CNFs. Cloud native is, as the name implies, more advanced, and is important at the edge for many reasons, particularly because when operating across a larger number of locations, automation is critical, and the need for centrally orchestrated solutions and efficient operation is, therefore, greater.

Figure 24 asks respondents to estimate the ratio of their company's workloads that are containerized today and will be by the end of 2023. This implicitly contrasts from virtualized workloads and is a way to get a feel for the rate at which the edge will move to cloud native. Only 17% (14% and 3%) say over half their workloads are already cloud native today. Over the next three years, this grows to 54% (36% and 18%). This increase is expected because cloud native is relatively new, but it is perhaps a little surprising that the transition to containerized workloads is not faster. The overall picture from the survey is that a combination of virtualized and containerized workload types will persist over the medium term.

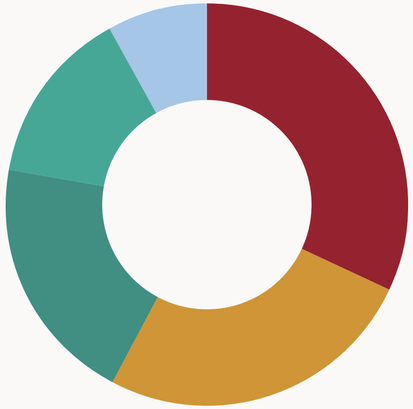
Figure 24:
What percentage of your edge cloud workloads are containerized now and what percentage will be containerized by the end of 2023?



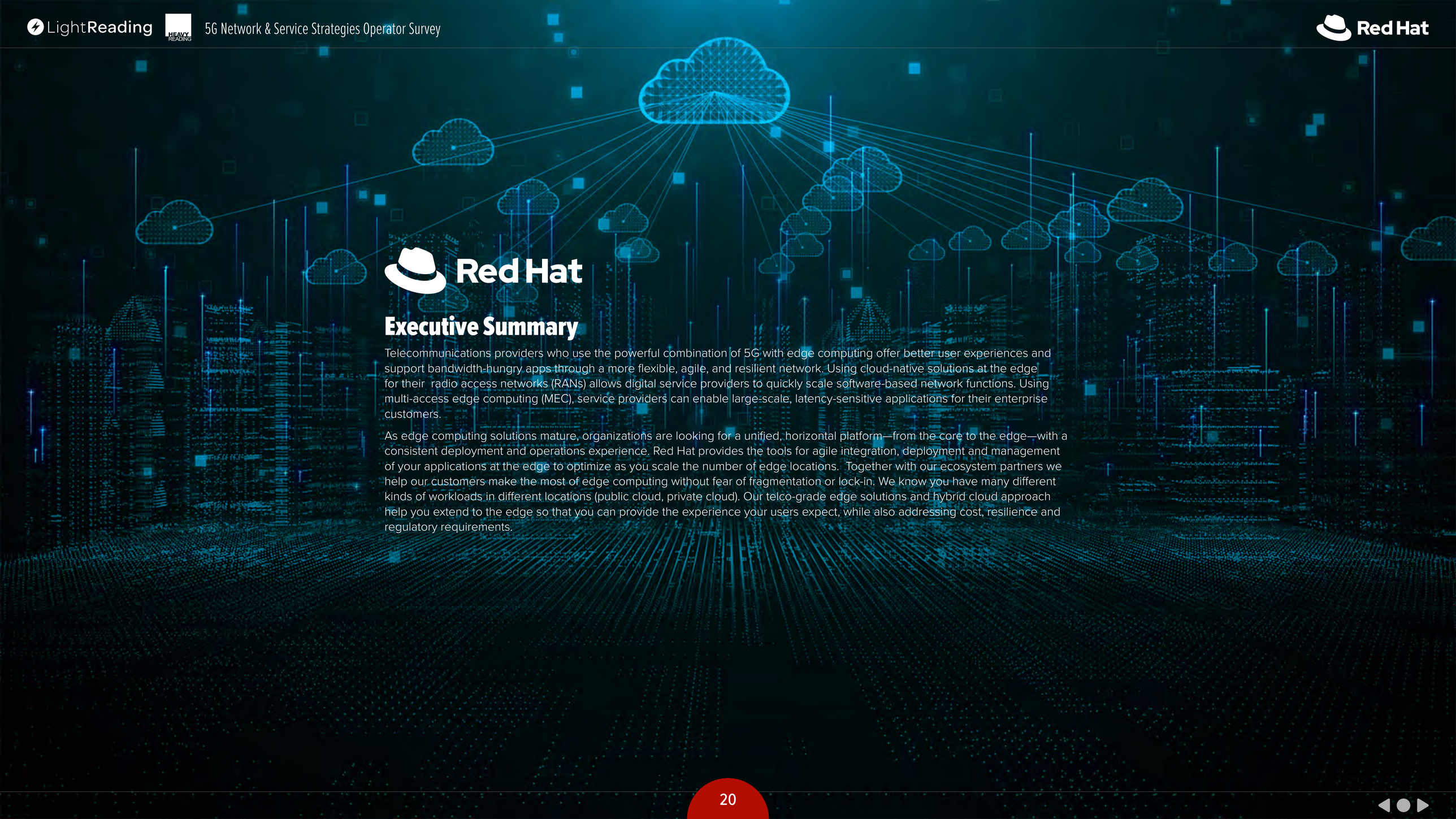
- Less than 25%
- 25–49%
- 50–75%
- More than 75%
- Don't know

Figure 25 asks what is limiting 5G and edge cloud deployments. The response is evenly split. It is perhaps a surprise to see "internal skills" at only 9%, given that the edge is such a significant change in architecture and a new service delivery model. It is encouraging to see "limited customer demand" scores only 20%. The two biggest perceived barriers ("cost and complexity" at 32% and "availability of certified … use cases" at 26%) tell the story of 5G and the edge as it exists today: a good idea with great potential, but one that needs development and investment over a sustained period to become a mainstay of the 5G service delivery.

Figure 25:
What is limiting your 5G and edge cloud deployment the most?



- **32%** Cost and complexity of infrastructure
- **9%** Internal skills and readiness
- **26%** Availability of certified/tested/validated ecosystem applications and use cases
- **20%** Limited customer demand
- **14%** Application providers are not yet ready



Red Hat

Executive Summary

Telecommunications providers who use the powerful combination of 5G with edge computing offer better user experiences and support bandwidth-hungry apps through a more flexible, agile, and resilient network. Using cloud-native solutions at the edge for their radio access networks (RANs) allows digital service providers to quickly scale software-based network functions. Using multi-access edge computing (MEC), service providers can enable large-scale, latency-sensitive applications for their enterprise customers.

As edge computing solutions mature, organizations are looking for a unified, horizontal platform—from the core to the edge—with a consistent deployment and operations experience. Red Hat provides the tools for agile integration, deployment and management of your applications at the edge to optimize as you scale the number of edge locations. Together with our ecosystem partners we help our customers make the most of edge computing without fear of fragmentation or lock-in. We know you have many different kinds of workloads in different locations (public cloud, private cloud). Our telco-grade edge solutions and hybrid cloud approach help you extend to the edge so that you can provide the experience your users expect, while also addressing cost, resilience and regulatory requirements.

5G Transport Networks

5G Transport Networks

By Sterling Perrin, Sr. Principal Analyst, Heavy Reading

To support the initial 5G commercial launches, the focus in the transport network has been on greater capacity. With 3GPP Release 16, 5G moves into a new phase of advanced use cases and rich possibilities for consumers and enterprises. To meet these new demands, operators must continue to invest in the transport network connectivity and the capabilities needed to support advanced services.

This part of the survey addresses 5G transport technologies and plans.

The key findings for this section are as follows:

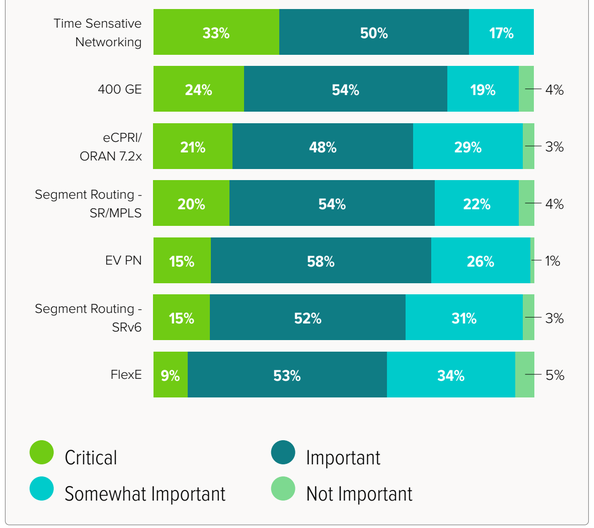
- Operator priorities for new transport technologies align with their expectations for advanced 5G capabilities. Operators rank time-sensitive networking (TSN) at the top of the list of 5G transport technologies (selected as "critical" by 33% of respondents). Selected as "critical" by 24% of operators, 400GE ranks second at 24%, followed by eCPRI/O-RAN 7.2x, selected by 21%.
- Fronthaul connectivity will factor heavily at operators' 5G macro cell sites. At 52%, the majority of operators expect from 25–49% of their macro cells site sites will have fronthaul links in three years' time. Ambitiously, an additional 19% of respondents expect that more than half of their macro cells will have fronthaul connectivity.
- Efficiently handling a mix of CPRI and eCPRI traffic in fronthaul networks will be required for most operators. Survey data indicates that a mix of approaches will be used, but transporting CPRI over Ethernet using the IEEE 1914.3 Radio over Ethernet (RoE) will be used most often. RoE was selected by 49% of operators. Still, CPRI to O-RAN 7.2x and CPRI to eCPRI are also important, based on survey results.

Operators are looking to new transport technologies to support advanced functionality delivered by 5G, particularly from Release 16. Among the transport technologies of interest, TSN tops the list, selected as "critical" by 33% of survey respondents. Selected as "critical" by 24%, 400GE ranks second, followed by eCPRI/O-RAN 7.2x in third, selected by 21%. The IPv4-based flavor of segment routing (SR/MPLS) ranks fourth on the list, followed closely by eCPRI/O-RAN fronthaul **(see Figure 26)**.

TSN is a set of standards defined by the IEEE 802.1 working group aimed at providing quality of service (QoS) guarantees for time-sensitive and mission-critical traffic. Within 802.1, the TSN for Fronthaul standard (802.1CM) defines QoS and synchronization specifically for fronthaul transport networking in a centralized RAN architecture.

Having never asked about 400GE for 5G transport before, the high ranking of 400GE technologies comes as a bit of a surprise. Clearly, in the access network, 400GE is overkill, but operators are interested in standardized 400ZR pluggable optics for high density aggregation sites, as well connectivity for 5G edge locations.

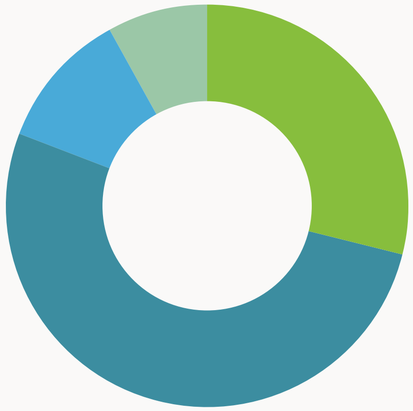
Figure 26:
How important are the following technologies and protocols for your 5G transport network?



Fronthaul connectivity supports centralized RAN (C-RAN) architectures in which operators seek the efficiencies that come from centralized (i.e., pooled) baseband resources and tight coordination across radios.

Fronthaul connectivity will factor in heavily at macro cells **(see Figure 27 below)**. At 52%, the majority of operators expect 25–49% of their macro cells site sites will have fronthaul links in three years' time, and an additional 19% of respondents expect that more than half of their macro cells will have fronthaul. Still, the trend is not universal. For 29% of operators, less than 25% of their macros are expected to have fronthaul, indicating that, for these operators, traditional distributed RAN architectures with backhaul connectivity-only from the macro sell will dominate.

Figure 27:
What percentage of your 5G macro cell sites are expected to contain fronthaul functionality in addition to backhaul by the end of 2023 (i.e., three years from now)?



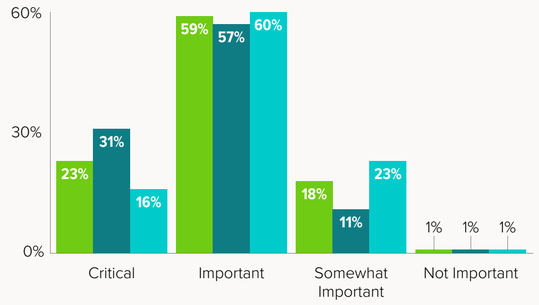
- **29%** Less than 25%
- **53%** 25% - 49%
- **11%** 50% - 75%
- **8%** More than 75%

Many capabilities are important to operators' 5G IP transport fabrics, but software-defined networking (SDN) control and automation functions top the list. For 31% of respondents SDN control/automation is a "critical" capability and an "important" capability for an additional 57%. Thus, automation is at least important for an overwhelming 88% of respondents **(see Figure 28)**.

Following automation, security functions rank second in priority in 5G IP transport fabric requirements. Integrated security and native MACSec encryption are seen as "critical" by 23% of respondents, with an additional 59% selecting the security functions as "important." At 19%, a minority of respondents view integrated security as "somewhat important" and "not important."

Finally, though still significant, disaggregated architectures rank third in the survey, behind automation and security functions. Just 16% of respondents see disaggregated, scale out fabrics as "critical" for 5G IP transport, though an additional 60% believe disaggregation is important.

Figure 28:
How important are the below capabilities for your 5G IP transport fabric?



- Integrated Security, Native MACsec Encryption
- SDN Control/Automation
- Disaggregated Scale Out, Fabric Architectures

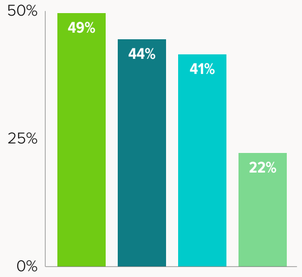
Operators view eCPRI as an essential technology for 5G fronthaul, with the 10x bandwidth efficiency improvement able to make or break the business case for a build. Efficiently handling a mix of both CPRI and eCPRI traffic in fronthaul networks will be required for most operators.

The survey shows that a mix of approaches will be used to achieve this, with CPRI over Ethernet using the IEEE 1914.3 RoE most common, according to the survey. RoE was selected for CPRI migration by 49% of operators, as shown in **Figure 29**.

CPRI to eCPRI conversion is also important. Operators want to take advantage of the statistical multiplexing efficiencies gained by converting to eCPRI—a benefit that is absent in RoE encapsulation. At 44%, the largest percentage of operators expect to use CPRI to eCPRI conversion based on the O-RAN 7.2x split. Here, operators want both the statistical multiplexing efficiency and the interoperability benefits of O-RAN.

Not all operators require O-RAN interoperability. Last among the options, but still significant based on the survey results, is CPRI to eCPRI interworking, which is defined in the eCPRI specification. CPRI to eCPRI Interworking Function (IWF) provides conversion, but does not specify any vendor interoperability. This option was selected by 41% of operators.

Figure 29:
Which of the following approaches to CPRI migration has your organization either adopted or has plans to adopt?



- CPRI over RoE (IEEE 1914.3)
- CPRI to ORAN 7.2x
- CPRI to eCPRI IWF
- Not applicable / No plans for CPRI migration

JUNIPER NETWORKS

Executive Summary

With 5G, new benchmarks of reliability, capacity, latency, and accessibility will expand the boundaries of what is possible. Long envisioned use cases, shelved due to practical limitations, are now within reach. Increased technological openness and new platform business models will facilitate innovation and disruption.

The unquenchable thirst for digital content is inspiring the cloudification of traditional networks:

- Link speeds of 25, 50, 100 and 400GE throughout the xHaul and metro domains
- Spine-leaf architectures to foster agility and improve reliability
- Virtualization of network elements to facilitate automation and openness
- Network slicing for mass customization

This time the network, formerly known as a dumb pipe, will play a more prominent role in next generation digital services. Juniper Networks is working with network operators worldwide to ensure successful 5G deployments that ultimately deliver differentiated user experiences, with the network retaining its central role in the digital value chain. Juniper partners with service providers, cloud providers, and enterprises to change networking for the cloud era.

BAE SYSTEMS

5G and Lawful Intercept

5G and Lawful Intercept

By Jim Hodges, Research Director Cloud and Security, Heavy Reading

The deployment of a 5G core will have profound implications on how essential services, such as lawful interception (LI), are supported. This section of the survey documents the strategies operators will use to ensure LI coverage and performance are not negatively impacted as they deploy cloud-based 5G core networks.

The key findings for this section are as follows:

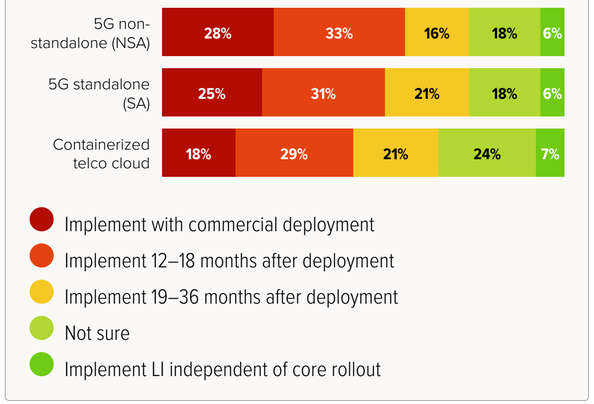
- Deployment of cloud-based LI is strongly tied to the rollout of 5G core networks. Most operators plan to implement cloud-based LI coincident with 5G core deployment (NSA, 28% and SA, 25%), or 12–18 months after deployment (NSA, 33% or SA, 31%) deployment. Only 6% of operators plan to implement cloud-based LI independently of 5G core rollouts.
- A good number of operator respondents (46%) say their company prefers to purchase a single standalone cloud-based LI solution instead of purchasing a managed LI service (16%) or bundling an LI solution into their core network purchase (33%). This reinforces that standalone LI solutions will continue to be as relevant in the cloud era as they are in previous generations of mobile networks.
- There is strong agreement that 5G will have a major impact on existing LI security practices. In the survey, 88% of operators agree that the deployment of a 5G core will require that operators increase threat intelligence and cyber awareness within an LI team. Similarly, 85% agree that it is necessary to run more cyber-risk assessment exercises and implement new security controls.

One of the key 5G-related LI implementation challenges relates to the fact that the two core implementation options—NSA and SA—possess different core network performance characteristics. Despite this, as **Figure 30** shows, operators are generally adopting similar timelines to support of cloud-based LI.

The preferred timeline for NSA, SA, and even fixed containerized telco clouds (29–33%) is to support cloud LI 12–18 months after network deployment. In second place, are the most progressive operators (18–28%) that will implement cloud LI at the same time as their commercial 5G core deployments.

The other important consideration is that only a very small range of operators (6–7%) will implement LI independent of core network deployment, which confirms that a cloud-based core network is the leading LI upgrade trigger.

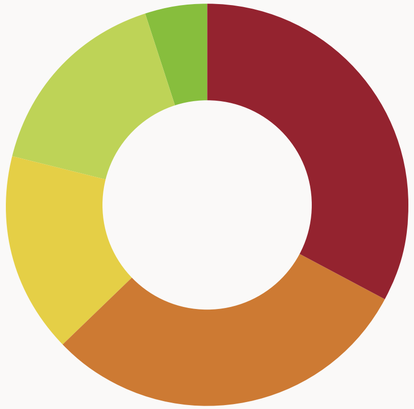
Figure 30:
When do you plan to support cloud-based LI for the following core network configurations?



One of the key decision points that operators must address in the LI implementation timeline is which type of LI solutions they will integrate in the cloud. As **Figure 31** shows, almost half of operators (46%) prefer to purchase a single standalone LI solution.

This 46% is made up of 30% that prefer to integrate with internal resources and 16% that would use a vendor to integrate. In contrast, 33% would integrate an LI solution purchase into their 5G core purchase. Overall, this input reinforces that standalone LI solutions will continue to be as relevant in the cloud era as they are in previous generations of mobile networks.

Figure 31:
What is your preferred approach for purchasing a 5G-compliant Lawful Interception solution?



- **33%** Bundle this function into our 5G core infrastructure purchase and integration process
- **30%** Purchase as a single solution and integrate with internal resources
- **16%** Purchase as a single solution and have the vendor integrate
- **16%** Purchase as a third-party managed service
- **5%** Whatever our 5G core vendor recommends (e.g. either single solution or 5G core purchase integration)

The transition to cloud LI, in some cases, may trigger the replacement of existing standalone LI platforms with a consolidated platform that can manage not only 5G LI, but other services as well. This is not unexpected, given the potential to use software-based platforms to achieve enhanced scale and seamless multi-service support at the lowest possible cost point.

As **Figure 32** reinforces, this shift to a consolidated LI platform is driven by the opportunity to increase cost effectiveness (40%), followed by improved functionality (21%), cloud core compatibility (20%) and faster operations (also 20%).

Figure 32:
What is the primary driver for replacing an existing Lawful Interception platform with a consolidated single platform covering 5G and other services?

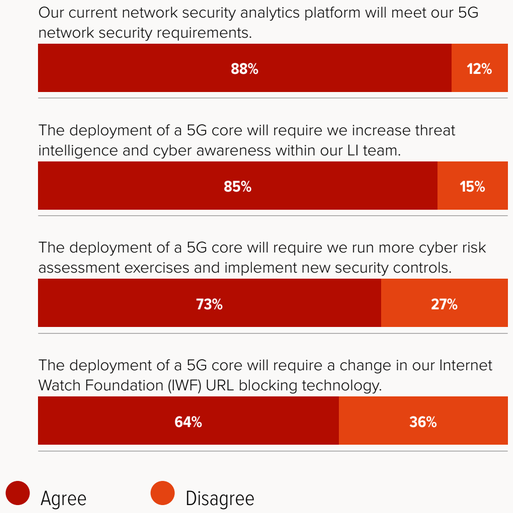
- **40%** Cost effectiveness
- **21%** Improved functionality
- **20%** Faster operations
- **20%** Compatibility with our cloud core

Another consideration for expanding LI systems to support additional capabilities is that it is generally held that cloud-based LI is more sensitive to cyberthreats. This is useful because LI teams and platforms will need to evolve to address a higher threat level as 5G cores are deployed.

This viewpoint is validated in the survey data. **Figure 33** shows that 88% agree that the deployment of a 5G core will require that operators increase threat intelligence and cyber awareness within an LI team.

Similarly, 85% agree that it will be necessary to run more cyber-risk assessment exercises and implement new security controls. Meanwhile, 73% of operators believe that they will need to change even very specific capabilities, such as their Internet Watch Foundation (IWF) URL blocking strategies to restrict access to online sexual abuse content.

Figure 33:
Do you agree or disagree with the following statements?

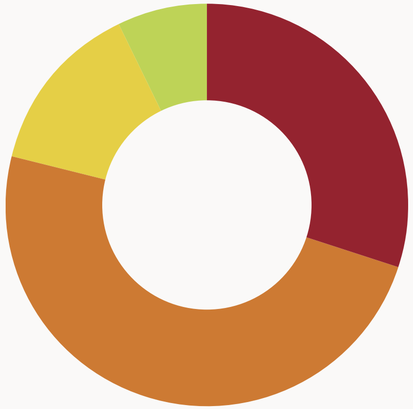


Like LI systems, business support system (BSS)/operation support system (OSS) solutions will also need to evolve to support cloud-based systems. In turn, these BSS/OSS changes will need to be supported by LI systems to support key administration, provisioning, and monitoring functions.

This is reinforced in **Figure 34**. As illustrated, only a very small percentage (7%) of operators believe that 5G-related BSS/OSS changes will not impact their existing Lawful Disclosure/Data Retention solutions, which reinforces that a flexible software-based architecture for LI systems will be a vital component of an effective cloud LI strategy.

In terms of timing, 30% of operators are already updating their LI solutions to meet known requirements, while the largest group of operators (49%) believe they will need to upgrade LI systems to meet new BSS/OSS requirements within two years.

Figure 34:
Will any of the BSS/OSS changes planned for 5G (or related program) impact your lawful disclosure/data retention solution?



- **30%** We are already changing this solution to meet our needs
- **49%** Not immediately, but within two years
- **14%** Not until 2023 or later
- **7%** Not at all

BAE SYSTEMS

Executive Summary

At BAE Systems, our advanced technology protects governments and businesses around the world and keep critical information and infrastructure secure. We do this using our unique set of solutions, systems, experience and processes – working with complex data sets is at the heart of our business.

We have been supporting our CSP customers' journey for more than three decades through cyber security, digital transformation and regulatory compliance (lawful interception and data disclosure) offerings. With the emergence of 5G and a cloud-native era, BAE Systems is at the forefront of evolving lawful interception industry standards and ensuring long-term compliance for CSPs as failure to comply with these standards could delay CSPs being able to launch new services in the market. As criminals increasingly use social media and smartphones to facilitate their crimes and activities, the data they generate – which is transported by the CSPs – is of huge value to Law Enforcement Agencies (LEAs).

5G network transformation, especially the move towards 5G-Core (5GC) will have a direct impact on network solutions. Through this survey, we have tried to assess and validate the extent of impact on lawful interception. Next-gen, cloud-based lawful interception and disclosure solutions will pave the way forward and provide a trusted transition path from fixed to hybrid to elastic networks.

intel

5G Enterprise Services

5G Enterprise Services

By Sterling Perrin, Senior Principal Analyst, Heavy Reading

Consumer services dominate early 5G deployments globally and although strong subscription growth is encouraging, operators are keenly aware that revenue growth is challenging. Many operators see 5G as a way to open up new large and profitable opportunities in the enterprise. The enterprise-centric capabilities introduced in 3GPP Release 16 are viewed as particularly important.

This section investigates operator views on the future of mobile enterprise services, including private mobile networks.

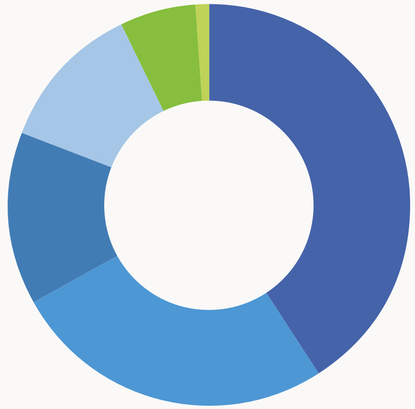
The key findings for this section are as follows:

- Operators want to be right at the table when engaging with customers for private enterprise networks. According to the survey results, 41% of operators intend to lead customer engagements themselves, while an additional 26% expect to share the role in a partnership of equals. Operators have far less enthusiasm for passing the lead role to integrators, vendors, or public cloud providers.
- Operators prefer licensed spectrum for private mobile network deployments. Globally, 41% of operators say they are "very likely" to use licensed mmWave spectrum for private mobile networks, followed by local area licensed spectrum ("very likely" for 39%), and sub-6GHz spectrum ("very likely" for 38%). Unlicensed spectrum for Wi-Fi 6 or 5G scores a little less likely among operator respondents, but nevertheless still has decent support.
- An overwhelming majority of operators view network slicing and 3GPP Release 16 as important for their enterprise services strategy. In separate survey questions, 83% rate each technology as at least "important" over the next three years. For 20% of operators, network slicing is "absolutely critical." At 15%, a lower percentage view Release 16 as "absolutely critical."

How best to engage with customers is a major question for operators targeting enterprise private mobile networks. Survey results show that operators intend to lead these engagements, with this option selected by the most respondents, at 41%. For those that do not intend to lead alone, close involvement is still desired. Equal partnership models with other stakeholders garnered the second highest percentage, at 26%. In total, just over two thirds of operators surveyed (67% of the group) intended to either lead enterprise engagements or work closely with equal partners to work with end customers **(see Figure 35)**.

Following these two telco-centric models, operator preferences fall off sharply. Just 14% of operators surveyed expect vendors to lead engagements and even fewer—just 12%—see systems integrators in the lead role.

Figure 35:
For your organization, which of the following will be the dominant customer engagement model for private enterprise networks?



- **41%** We (telco operator) will lead engagements
- **26%** Partnership models, with vendors, SIs, and telcos as equal partners
- **14%** Vendors will lead engagements
- **12%** System Integrators will lead engagements
- **6%** Don't know
- **1%** Public Cloud will lead engagements

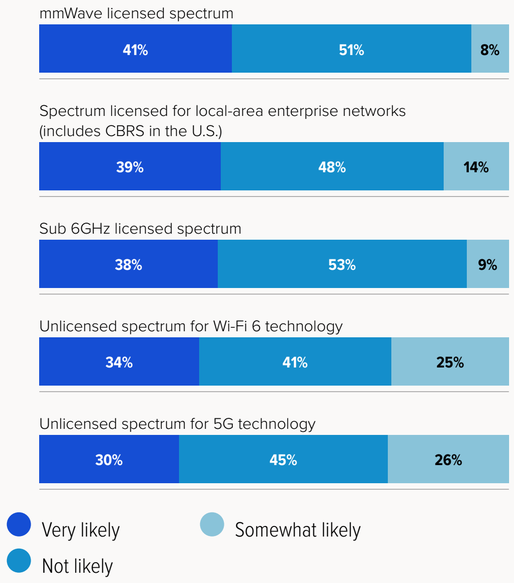
5G is not tied to a single spectrum band. This diversity of spectrum options also applies to private mobile networks (where, in addition to 5G, Wi-Fi is also an option). **Figure 36** shows that although operators prefer licensed spectrum options by a small, but not insignificant, margin, they appear happy to use any spectrum, including unlicensed, where appropriate.

Topping the list, operators show a preference for mmWave licensed spectrum (41% "very likely"), spectrum licensed for local area enterprise networks (39% "very likely"), and sub-

6GHz licensed spectrum (38% "very likely"). Unlicensed spectrum options, including unlicensed spectrum for Wi-Fi 6 and unlicensed spectrum for 5G, hold lower appeal, but nevertheless score well (34% and 30%, respectively, "very likely").

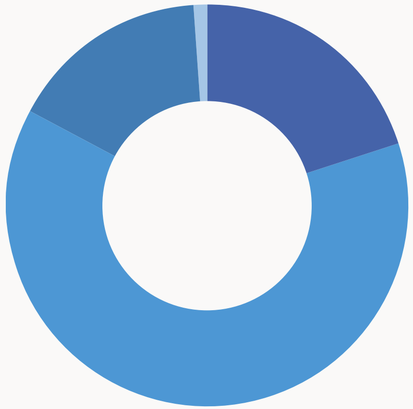
Breaking out results geographically between the US and Rest of World (RoW) respondents, there is general agreement in interest for mmWave and sub-6GHz licensed spectrum, but a sharp divide in preferences for other options. For example, while a majority of US respondents (51%) are "very likely" to use spectrum licensed for local area networks (e.g., the Citizens Broadband Radio System [CBRS]), just 27% of RoW respondents see this option as very likely. Similarly, 43% of US operators surveyed view unlicensed Wi-Fi 6 as very likely compared to 26% of their RoW counterparts. And 43% of US respondents see unlicensed 5G spectrum as a very likely enterprise option, but just 17% of RoW survey takers are very likely to use this spectrum for enterprise.

Figure 36:
How likely is your organization to use the following spectrum bands for enterprise private mobile network deployments?



Network slicing is an important concept in 5G and is closely associated with enterprise 5G services. An overwhelming majority of operators agree that network slicing is important for their enterprise 5G strategy and, for a minority, it is "absolutely critical." According to the survey, 83% of respondents said network slicing is at least important for their enterprise strategy and 20% said their enterprise strategy cannot succeed without slicing **(Figure 37)**. For 16% of respondents, slicing is expected to play only a limited role and just 1% see no role at all for slicing in enterprise 5G.

Figure 37:
How critical is network slicing for your enterprise 5G strategy over the next three years?

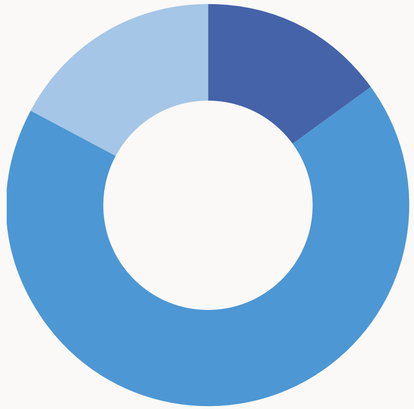


- **20%** Absolutely critical – enterprise strategy cannot succeed without slicing
- **63%** Important – but other factors will play a bigger role in enterprise 5G success
- **16%** Somewhat important – network slicing will play limited role in certain applications
- **1%** Not important at all – slicing will play no role

3GPP Release 16 is closely associated with the enterprise 5G opportunity, due to additions for URLLC, IIoT, vehicle-to-everything (V2X) communications, and other significant enterprise-focused features.

Not surprisingly, operator views on Release 16 align closely with their views on network slicing. **Figure 38** shows 83% of respondents report that Release 16 is at least important to their enterprise services strategy, and 15% of the group said that Release 16 is absolutely critical. Just 17% of respondents see Release 16 playing a limited role as they sell mobile services to enterprises.

Figure 38:
How important is Release 16 to your enterprise services strategy over the next three years?



- **15%** Absolutely critical – enterprise strategy cannot succeed without Release 16
- **68%** Important – but other factors will play a bigger role in enterprise 5G success
- **17%** Somewhat important – Release 16 will play limited role in certain applications

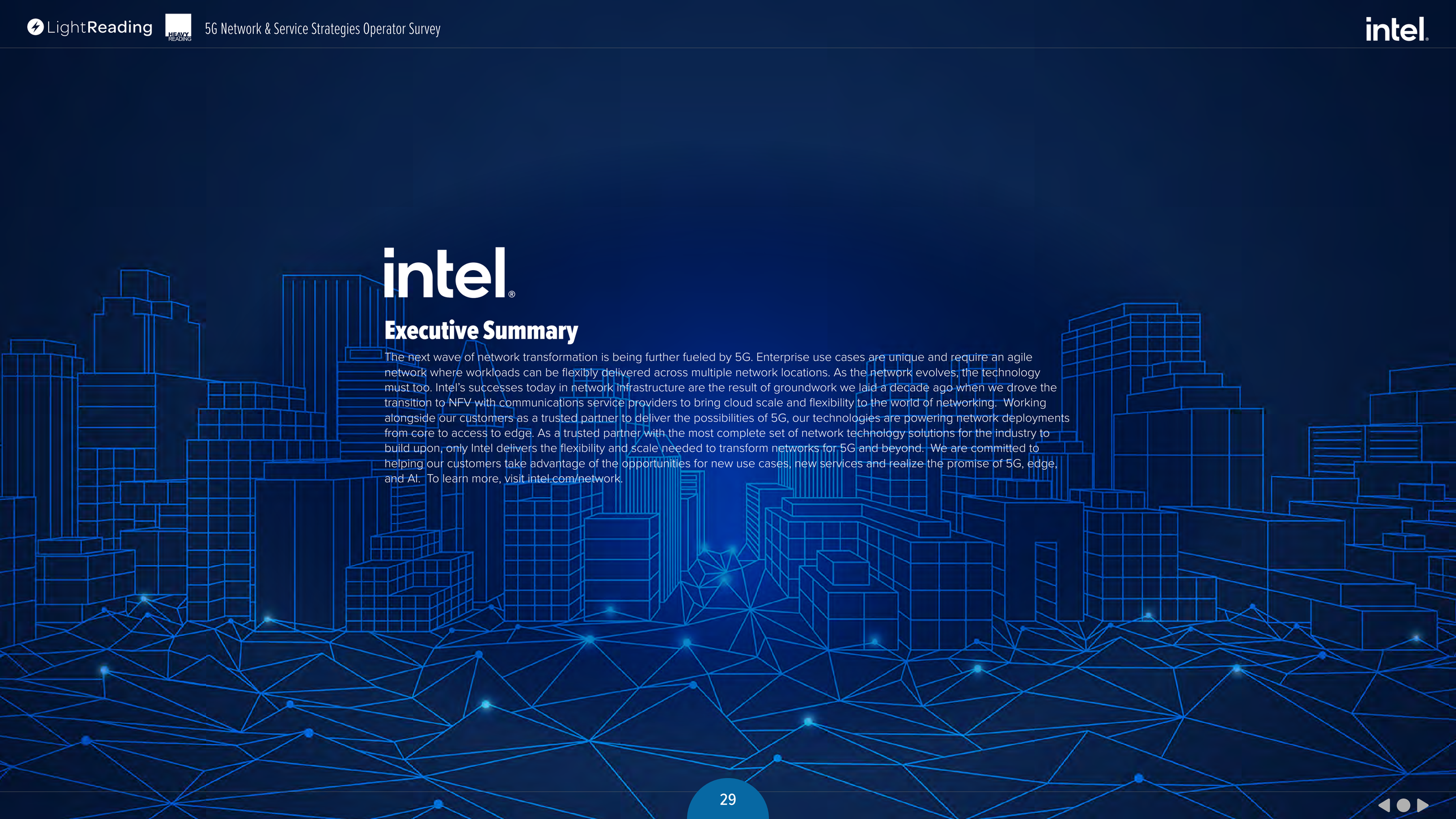
Private mobile networks present opportunities for operators, but also challenges. **Figure 39** shows the biggest perceived barriers to private mobile network deployments based on a weighted average ranking. Cost/budget and complexity top the list of barriers (ranked first and second, respectively) while lack of edge enterprise applications and available devices are the least significant barriers (ranked third and fourth, respectively). Cost and complexity are internal challenges to overcome. Operators seem confident that, if these are addressed, the market of applications and devices will be available to them, and to enterprise customers.

Figure 39:
For your organization, what are the biggest barriers to private mobile network deployments? Please rank the following barriers in order of importance from most significant barrier (1) to least significant (4)?

Value	Overall Rank	Ranking Score
Cost/budget	1	232
Complexity	2	219
Lack of edge enterprise applications	3	183
Devices	4	152

Ranking score (The score is calculated by assigning a weight to each rating where the highest priority rating holds the highest weight.)

n=76–80



intel®

Executive Summary

The next wave of network transformation is being further fueled by 5G. Enterprise use cases are unique and require an agile network where workloads can be flexibly delivered across multiple network locations. As the network evolves, the technology must too. Intel's successes today in network infrastructure are the result of groundwork we laid a decade ago when we drove the transition to NFV with communications service providers to bring cloud scale and flexibility to the world of networking. Working alongside our customers as a trusted partner to deliver the possibilities of 5G, our technologies are powering network deployments from core to access to edge. As a trusted partner with the most complete set of network technology solutions for the industry to build upon, only Intel delivers the flexibility and scale needed to transform networks for 5G and beyond. We are committed to helping our customers take advantage of the opportunities for new use cases, new services and realize the promise of 5G, edge, and AI. To learn more, visit intel.com/network.

EMPIRIX

5G Testing and Service Assurance

5G Testing and Service Assurance

By Gabriel Brown, Senior Principal Analyst, Mobile Networks & 5G, Heavy Reading

Service assurance refers to an operator being able to make sure customers experience services at the intended level of quality. This includes ensuring that internal network domains are performing at the level needed to enable end-to-end service. In a 5G network, where more diverse service types are expected, and where performance demands are higher, the capabilities required of service assurance solutions are commensurately greater. Operators will be able to repurpose some of the tools and processes already in use for 4G service assurance; however, the introduction of new technologies, such as 5G NR, 5G core, edge, and cloud, will require them to rethink and rebuild service assurance for the 5G era.

The key findings for this section are as follows:

- Service orchestration and automation, with 42%, is considered more influential on the customer experience than monitoring and troubleshooting, with 30%. This order of priorities may suggest that a new role for service assurance is emerging that is more directly linked to making service offers available to customers; for example, by verifying the service performs as intended as it is deployed in the network and before pushing it live.
- In terms of the decision to implement service assurance for major 5G service types, the large majority of respondents are either in the "planning phase" or "in the process of rolling out" and are not yet live. That there are not major differences between Enhanced Mobile Broadband (eMBB), URLLC, network slicing and IoT indicates that operators are taking a holistic view of their 5G service assurance strategy.
- Operators have a range of requirements for service assurance for network slicing. That there is no lead requirement is revealing because it underlines that service assurance, like a network slice, touches many parts of a network, and many parts of the operating process. It follows that the service assurance solution should be end-to-end and will have diverse requirements.

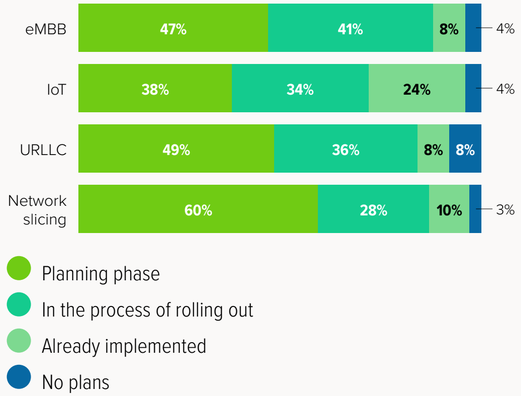
The first question in this section of the survey **(Figure 40)** seeks to understand, at a high level, how service assurance impacts the subscriber experience. It is interesting that monitoring and troubleshooting at 30% places second, because this is the traditional role of service assurance. Instead, "service orchestration & automation" at 42% leads the response. This order of priorities may suggest that a new role for service assurance is emerging that is more directly linked to making service offers available to customers; for example, by verifying the service performs as intended as it is deployed in the network and before pushing it live. This is in line with a view that 5G infrastructure is expected to be more agile, with continuous integration (CI)/continuous delivery (CD) and continuous testing (CT) becoming more important as operators seek to be faster in developing and deploying new services.

Figure 40:
Which of the following is the most influential to the subscriber experience in your 5G network?

- **42%** Service orchestration and automation
- **30%** Monitoring, troubleshooting and automated operations
- **15%** Predictive and prescriptive machine enhanced analytics
- **14%** Billing, rating and policy orchestration

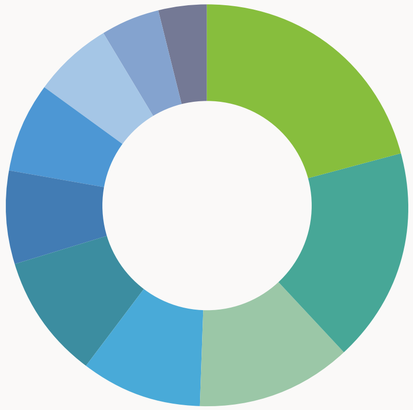
The next question asks when does the respondent's organization intend to implement service assurance for four major 5G service types. The large majority of respondents in each case are either in the "planning phase" or in the "process of rolling out," as shown in **Figure 41**. That there are not major differences between eMBB, URLLC, network slicing, and IoT perhaps indicates that operators are taking a holistic view of their 5G service assurance strategy. In the "already implemented" category, IoT scores highest, with 24%. This perhaps reflects that IoT is a deployed service in the form of narrowband IoT (NB-IoT) and enhanced machine-type communication (eMTC) in 4G networks, and that both of these cellular IoT technologies carry forward and are considered to be 5G IoT solutions in the 3GPP and IMT 2020 definitions of 5G.

Figure 41:
When does your organization intend to implement service assurance for the following?



In terms of business justification for service assurance, **Figure 42** shows a very mixed picture. There is no clear lead reason and probably the best explanation is that service assurance is required across the board. The slight advantage for "improve operational efficiency" (21%) and "reduce customer churn through better service quality" (17%) probably reflects that these are the two areas Heavy Reading would have expected to score highly. The fact that they do not lead by a more significant margin underlines the point that operators will take a holistic view.

Figure 42:
What is the most important business justification for your organization's service assurance initiatives over the next three years?



- **21%** Improve operational efficiency 21%
- **17%** Reduce customer churn through better service quality
- **12%** Identify new revenue streams 12%
- **10%** Improve net retention rates for enterprise customers
- **10%** Improve SLA oversight and compliance
- **7%** Single source of truth data lakes for centralized intelligence
- **7%** Leverage data analytics for automated root cause and remediation
- **6%** Enhance ecosystem collaboration and trust
- **5%** Reduce network trouble tickets
- **4%** Break silos and reduce tool-sprawl

The same pattern of looking at service assurance holistically is seen when the survey asks, in **Figure 43**, which factors are most important when selecting a service assurance vendor. "Easy to deploy, orchestrate, and operate" leads with 30% for obvious reasons. However, the difference from the other factors is relatively modest. It is perhaps a surprise that end-of-life (EOL) concerns are not a greater factor considering that the vendor landscape for service assurance is fragmented and that one might expect consolidation at some stage to force portfolio rationalization. However, this is the lowest scoring concern and may reflect that operators have good vendor relationships and are comfortable with their roadmaps, and/or that they feel confident about being able to change suppliers in different domains.

Figure 43:
Which of the following is most important when selecting a service assurance vendor?

- **30%** Easy to deploy, orchestrate, and operate supporting industry standards
- **16%** Software-based and no proprietary appliance dependencies
- **12%** Modular design that promotes incremental buy and deploy vs. monolithic, static provisioning
- **11%** Supports DevOps (CI/CD) for faster time-to-market
- **10%** Future-proof technology
- **9%** Enhance effectiveness of data analytics
- **6%** EOL concerns
- **6%** Eliminates data fragmentation and silos

Network slicing is one of the defining features of 5G and introduces many new requirements on service assurance. In the first instance, slices are end-to-end and, therefore, cross multiple network domains (RAN, core, transport, cloud, etc.). In the second, network slices are often regarded as being useful for better than best-effort services, such as services with an associated service-level agreement (SLA). For example, if a customer wants, and pays for, a highly reliable guaranteed bit-rate service, this will require the operator to provide reporting to show the SLA is being met.

Figure 44 asks which aspect of service assurance is most critical to support network slicing. Consistent with responses to the above questions, operators have a range of requirements. Again, there is no clear first-place preference. This is revealing because it underlines that service assurance, like a network slice, touches many parts of a network, and many parts of the operating process. It follows that the service assurance solution should be end-to-end and will have diverse requirements.

Figure 44:
When considering service assurance solutions, which of these is most critical for supporting 5G network slicing?

- **25%** Real-time, end-to-end service assurance across the entire slice(s)
- **20%** End-to-end visibility and correlation of multiple data sources within a slice
- **17%** Zero-touch deployment, operations and closed-loop automation
- **16%** Support for industry standard, open APIs for seamless integration
- **11%** Cloud-native architecture for on-demand deployment, agility and scaling
- **11%** AI/ ML driven predictive analytics

EMPIRIX

Executive Summary

Launching 5G Standalone requires cloud-native assurance solutions that provide visibility and insight into the new Service-Based Architecture (SBA), technologies, interfaces, protocols and distributed cloud infrastructure.

This drives the optimization of customer, service and network experiences during the pre-launch preparation, launch and operation lifecycle which requires unified, correlated, end-to-end and highly granular visibility, monitoring, analytics and troubleshooting across subscribers, devices, applications, services and networks with drill-down to individual call/data sessions and deep packet analysis.

Empirix is a leading provider of customer experience assurance for the 5G era, empowering CSPs to deliver high quality digital experiences with the world's first cloud-native, by design, service assurance solution, KLERITY™, enabling capabilities such as:

5G SA Pre-Launch Preparation: technology evaluation, traffic insights and call flow visualizations for SBA and CUPS, network function vendor benchmarking, interoperability testing, performance/ quality management, and in-depth troubleshooting

5G SA Launch and Operations: proactive operations, SLA management of uRLLC, eMBB and mMTC KPIs and KQIs, advanced Root Cause Analysis of subscriber and protocol issues, network slice assurance and monetization, and support of private 5G and Industrial IoT.

KLERITY is available with a subscription model that reduces TCO by up to 40% versus traditional assurance systems.

Contact info@empirix.com for more information or to schedule a demonstration.

Red Hat

Securing 5G Edge and Endpoints

Securing 5G Edge and Endpoints

By Jim Hodges, Research Director Cloud and Security, Heavy Reading

The delivery of low latency, high value 5G services at the edge introduces additional infrastructure and endpoint security requirements. This section documents the capabilities and strategies that operators plan to deploy at the edge to meet these new security demands.

The key findings for this section are as follows:

- An effective 5G security strategy requires trust in both platforms and the software capabilities that run on them. Accordingly, trusted hardware ranked highly as a "critical" security capability for both 5G infrastructure in general (60%) and at the edge (68%).
- Operators plan to run advanced policy and trust-based security capabilities on these hardware platforms. "Critical" software priorities at the edge include establishing a strong root of trust for remote devices under management (63%) and enforcing a global security policy and posture (62%).
- Overall, operators are confident that their hardware and software strategies will enable them to secure edge infrastructure and end points. For example, 63–76% of operators believe they have in place a mature and scalable security strategy (63%) that is equipped with the resources and skillsets (76%) to support the new requirements associated with distributed infrastructure (72%).

In response to a fluid and dynamic threat landscape, operators pragmatically realize they must rely on a number of security capabilities to secure their 5G infrastructure. Of these, as shown in **Figure 45**, the leading "critical" capabilities are identity and access management (69%), trusted hardware (60%), and isolation and policy enforcement (54%). The input confirms that an effective 5G security strategy requires policy-based tools to support key functions, such as identity management hosted on trusted hardware platforms.

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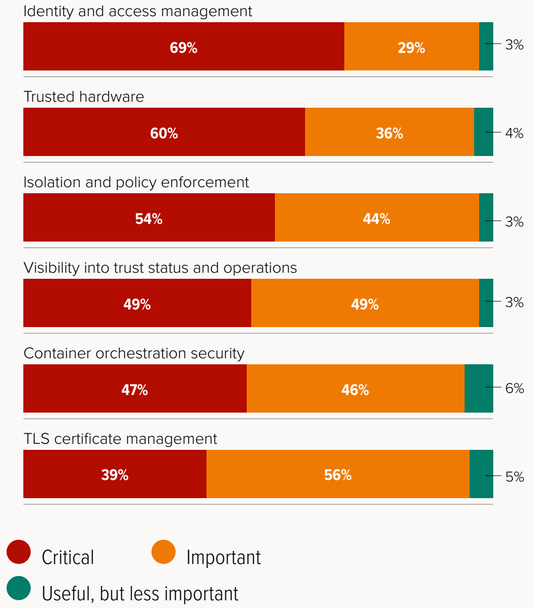
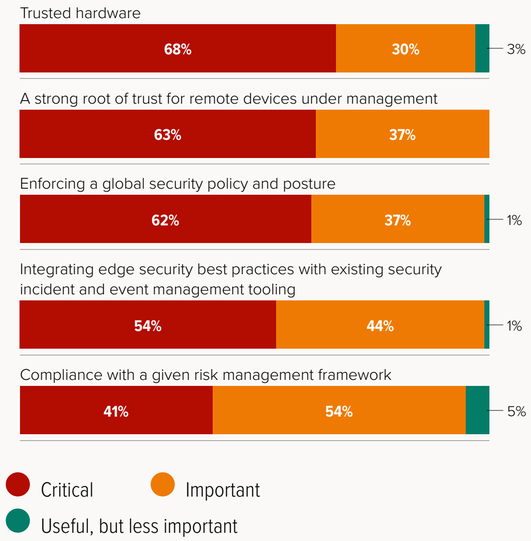
Figure 45:
How important are the following capabilities for securing 5G infrastructure at your organization?



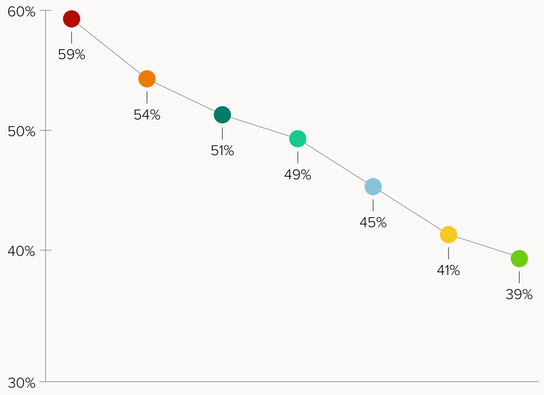
Trusted hardware is also a top consideration at the edge. As shown in **Figure 46**, it is, in fact, the leading "critical" capability (68%). In addition, software capabilities, such as management of remote devices, also attained a high "critical" ranking (63%), followed closely by enforcement of a global security policy and posture (62%).

Figure 46:
How important are the following capabilities for securing edge infrastructure at your organization?



As the 5G cloud evolves, so must 5G security strategies. To meet these needs, as **Figure 47** shows, operators are focusing on several capabilities. Of these, the top three leading capabilities are policy-based compliance scanning (59%), consistent infrastructure provisioning of physical and virtual network functions (54%), and more frequent vulnerability checks, remediation, and patching (51%). The fourth-place ranking of automated management of public key infrastructure (49%) reinforces that automation will be a vital element of future security models.

Figure 47:
As 5G emerges, with more edge activity and smart end-user devices, how does your organization plan to evolve its security strategy?



- **59%** Policy (industry, regulatory, and/or organization) compliance scanning
- **54%** Consistent infrastructure provisioning for physical and virtual network functions
- **51%** More frequent vulnerability checks, remediation, and patching
- **49%** Automated management of public key infrastructure
- **45%** Using a standard, operating environment for software
- **41%** Encryption of data in motion
- **39%** Encryption of data at rest

Since the launch of commercial 5G NSA took place in 2019, operators have had more than two years to prepare and execute their 5G security strategies. As **Figure 48** shows, approximately two years on, 63%–76% of operators believe that they have made considerable progress. For example, 63% of operators believe they have in place a mature and scalable security strategy that is equipped with the resources and skillsets (76%) to support the new requirements associated with distributed infrastructure (72%) and to secure 5G network slices (71%).

In addition, 68% agree that their security strategy supports the ability to implement zero-trust principles. This level of readiness was not unexpected, given 5G's broad appeal and reach, but one interesting data point was the higher than anticipated number of operators (71%) that agreed that their security strategies already extend to running services in public clouds, despite the limited number of commercial implementations.

Figure 48:
How important are the following capabilities for securing 5G infrastructure at your organization?

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Executive Summary

You are only as secure as your weakest link. As application environments evolve, security teams are increasingly challenged to keep up with the changing risks, compliance requirements, tools, and architectural changes introduced by these innovations. Traditional perimeter-based network security is no longer effective on its own. Security should be implemented within each layer of the application and infrastructure stack. Automation is a critical part of scaling how the organization addresses security and compliance monitoring.

Red Hat wants to help you have confidence as you adopt a continuous security strategy to maintain security and regulatory compliance, while helping your business remain competitive, flexible, and adaptable. Red Hat provides telco-grade technologies to build, manage, and automate hybrid clouds more securely as part of a layered, defense-in-depth security strategy, and our broad partner ecosystem extends these capabilities even further. You can take advantage of the capabilities at each layer in your environment, including operating systems, container platforms, automation tools, Software-as-a-Service (SaaS) assets, and cloud services. Visit redhat.com/security to learn more about Red Hat's commitment to protecting your environments and the data and privacy of your customers.