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5G Network Strategies

OPERATOR SURVEY 2022

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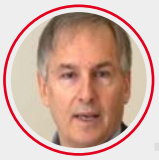
Gabriel leads mobile network research for Heavy Reading. He covers system architecture including RAN, core, and service-layer platforms. Key research topics include 5G RAN, software-based mobile core, and the application of cloud technologies to mobile networking. Gabriel has more than 15 years' experience 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.



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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.

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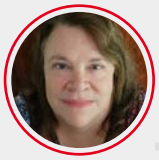
Sterling Perrin is a Senior Principal Analyst within Heavy Reading, which delivers custom research and analysis for the telecommunications industry. His area of coverage is transport, including optical networks, packet networks, and 5G transport.

Sterling has more than 20 years' experience as an industry analyst and a journalist. Prior to Heavy Reading, Sterling served as lead optical networks analyst at IDC. He is a former editor at Telecommunications Magazine. In addition to chairing and moderating Light Reading events, Sterling is a NGON & DCI World Advisory Board member and past member of OFC's N5 Market Watch Committee.



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Jennifer Pigg Clark is Principal Analyst with Heavy Reading covering Cloud Infrastructure and Edge Computing. Clark provides actionable insight into service provider evolution, examining the challenges and opportunities facing communications service providers (CSPs) as they roll out 5G and high-speed broadband access with an increasingly virtualized and cloud native infrastructure. Clark examines the solutions and technology reshaping the telco data center, technologies such as Multi-Access Edge Computing, cloud native infrastructure, open APIs, microservices, container networking, Network Orchestration, Network Functions Virtualization (NFV), and SD-WAN

Clark started her industry research career with the Yankee Group, which was acquired by 451 Research in 2013. She held the role of Sr. Vice President at Yankee Group. Prior to joining Yankee Group, Clark was Manager of Network Planning and Strategy for Wang Laboratories'corporate data network. She began her career at Wang with responsibility for the domestic and international roll-out of Wang's packet network, connecting more than 250 locations in 14 countries. Before joining Wang, she was a member of the IT research and development division of Commercial Union Insurance Companies.

Clark is a highly regarded speaker at industry seminars and conferences and is frequently cited by the commercial and trade press. She has been a guest lecturer at the MIT Sloan School of Management and is a member of the IEEE. She holds a B.A. degree from Mount Holyoke College.

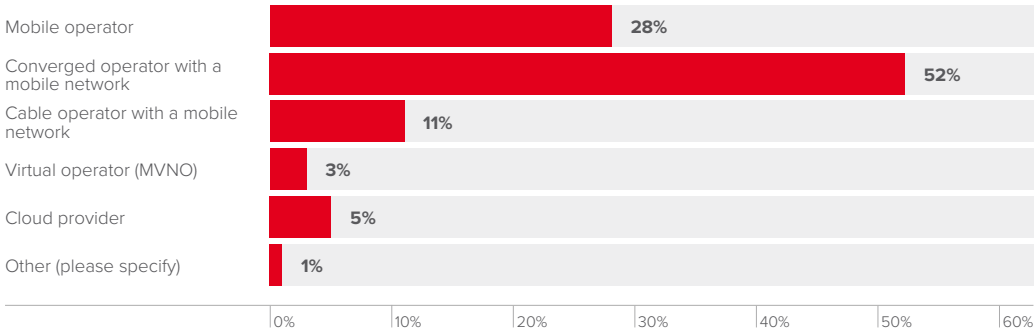
Introduction

This Heavy Reading 2022 5G Network Strategies Operator Survey is designed to provide insight into how 5G networks will evolve as operators and the wider mobile ecosystem continue to invest in 5G technology and services.

This is the fourth annual version of the survey, and it follows almost two full years of disruption caused by the COVID-19 pandemic. Over this period, the sector has proven its value to customers and to society. The fact that operators and technology suppliers were able to maintain or increase investment in 5G networks and deploy at pace through the pandemic is testament to the role of broadband in modern life, from education and healthcare to socializing and entertainment.

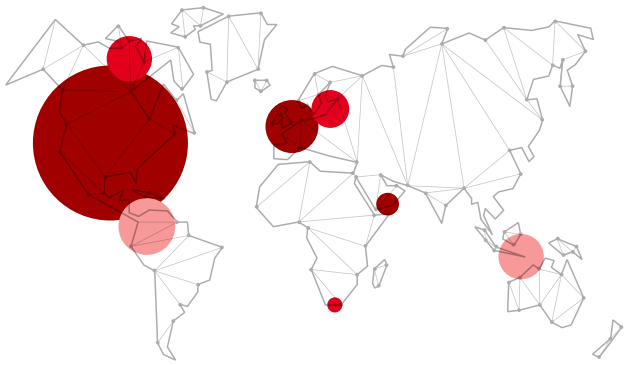
Developed in association with the report sponsors, the online questionnaire was fielded to respondents in the Light Reading service provider database in January 2022. It was open only to employees of telecom operators.

Fig1: What type of telecom service provider do you work for?



Source: Heavy Reading *n=90*

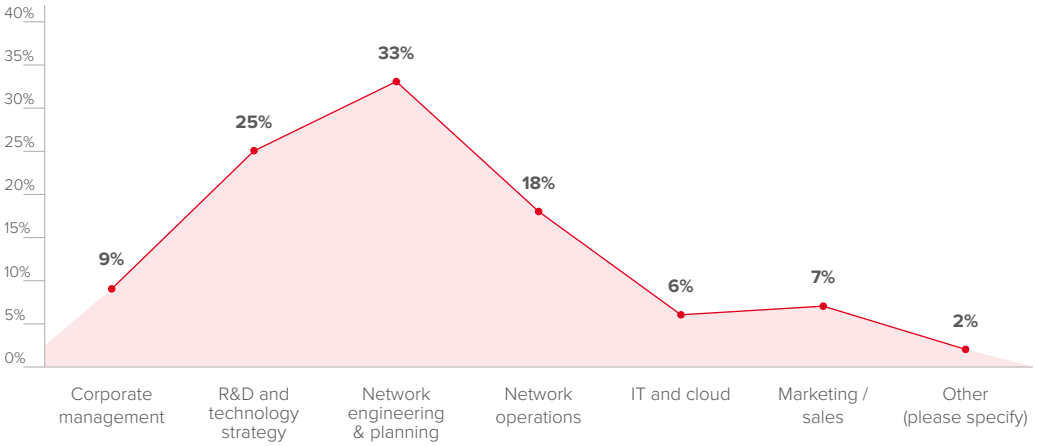
Fig2: In what region is your organization headquartered?



US	41%
Canada	10%
Central/South America (including Mexico & the Caribbean)	12%
Western Europe	11%
Central/Eastern Europe	9%
Asia Pacific (including Australia)	10%
Middle East	5%
Africa	2%

Source: Heavy Reading *n=90*

Fig3: What is your primary job function?



Source: Heavy Reading *n=90*

Fig4: What is your organization's approximate annual revenue?

Less than $250m	14%
$250m–$499m	16%
$500m–$999m	11%
$1bn–$5bn	18%
More than $5bn	41%

Source: Heavy Reading *n=90*

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

- **5G radio access network (RAN) evolution**
- **5G core expansion**
- **5G and edge computing**
- **5G private mobile networks**
- **5G transport networks**
- **5G security**

The questionnaire received between 81 and 90 responses from individuals who self-identified as working for operators. 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 41% of the responses; however, all major global regions are represented.

"This is the fourth annual version of the survey, and it follows almost two full years of disruption caused by the COVID-19 pandemic."

5G: An Important Dance in 2022

Weathering two years of a global pandemic and the resulting business challenges of the crisis, the wireless cellular communications industry, like many others, has seen incredible change over such a short period of time. At the time of this writing in February 2022, 5G networks have delivered on some great advancements in terms of improved speeds for hundreds of millions of people around the world, however there is still much to do to fulfill its promise.

Chris Pearson
President, **5G Americas**

5G will require a lot of work and with the right dance partners in a broad ecosystem of relationships to make it all happen.

First the good news: 5G connections are amid the growth phase of the 'S' curve, as the world continues to rapidly adopt fifth generation wireless cellular devices. As of December 2021, 5G connections reached 438 million worldwide and was on pace to exceed 540 million by the end of the year – and is growing at a fast clip of 19.6 percent **per quarter**.

These 5G connections are forecast to reach 1.3 billion in 2022 and 4.8 billion by 2026.

This powerful growth has been underpinned by strong investments by networks and device makers. In January 2022, there are 203 5G networks around the world and 1,250 announced 5G devices from 180 vendors. All of this makes 5G still the fastest growing generation of wireless cellular communications ever, achieving the remarkable landmark of a half-billion connections in a few quarters, when it took 4G LTE over four years to do the same.

But there is still a lot to be done in terms of deployments, more spectrum allocations and utilization, and more coverage - particularly in regions just starting their 5G journey, like Latin America. The United States faces challenges in ensuring additional spectrum becomes available and the need for regulatory cooperation has been recently highlighted by the issue surrounding C-Band and aviation radio altimeters. Throughout the Caribbean and Latin America, initial 5G networks are being deployed while challenges remain in some areas of regulatory and spectrum policy to help ensure the 5G achieves its promise in the region.

In 5G, we are moving from a deployment phase to an application-services phase. We know that 5G offers much more than broadband for smart phones – but getting the market to realize that will take time. We've reached a period of education, analysis and trials by businesses and enterprises in new products and services that take advantage of 5G throughput, low latency, and mobile device management. Numerous 5G testbeds and technology incubators have been launched, ensuring a healthy pipeline of new products and services built around what 5G can offer. From experiments in agriculture, to robotics in manufacturing, to defense and first responders, large institutional organizations are putting incredible resources into integrating 5G into real-world use cases.

So it is important to realize that 5G's true capabilities revolve around three core competencies: 1) enhanced mobile broadband capable of delivering up to 10 Gbps per second, which is at least ten times faster than 4G LTE 2) ultra-reliable low latency communications with sub-10 millisecond latencies important for highly-synchronized data and real-time video and speech, and 3) massive machine type communications that can control up to a million 5G devices per square kilometer, greatly expanding the capabilities of IoT sensors and devices.

For now, most network operators have only been able to tap the capabilities of enhanced mobile broadband, as 5G global download and peak download speeds have increased dramatically with new 5G deployments. Indeed, dramatic improvements in the 5G video and games experience have been initial early successes, and 5G availability as a percentage of time has improved. But that's just one leg of 5G's three-legged stool.

Ultra-reliable low latency communications (URLLC) appears to be an even brighter area of opportunity, opening up numerous new markets in industries and technologies ranging from healthcare, automotive, unmanned aerial vehicles, extended reality, and industrial automation. Here, the intersection of multi-access edge compute (MEC), which puts great computational power near where the data is being used by the customer, will be critical in shortening the trip time required for data to reach its destination where it can be processed.

However, for URLLC to fully take off, 5G networks will need to implement 5G standalone networks. While 5G standalone network deployments are progressing at a solid but not spectacular rate, there are some great opportunities ahead. In a 5G standalone network (5G SA), both the radio access network (RAN) and the core network (CN) are based on 5G technology. With non-standalone 5G networks (5G NSA), the RAN would be 5G, but it is anchored to a 4G LTE core. Both 5G NSA and the use of Dynamic Spectrum Sharing technologies have provided a bridge for network operators to use, while they prepare their networks for 5G SA. While some network operators have already announced their 5G SA deployments, expect 2022 to be a banner year for additional announcements – and in some cases, new greenfield 5G networks will be built entirely standalone.

> "First the good news: 5G connections are amid the growth phase of the 'S' curve, as the world continues to rapidly adopt fifth generation wireless cellular devices."

In 2022, we look forward to 3GPP's Release-17, which will include a bevy of new capabilities and technologies. There is great opportunity here, but a lot of work still to be done – not only from a standards standpoint, but an implementation standpoint from network operators, as well as equipment and device manufacturers. In 3GPP Release-17, we can look forward to several great advances, including (but not limited to):

- **Support for non-terrestrial networks,** including satellites, high-altitude aircraft, balloons, and unmanned aircraft
- **NR extended reality,** with data throughput rates that could potentially untether VR headsets – providing true mobility
- **Multi-cast broadcast** allowing for powerful communications capabilities for large scale events and for first responders
- **Wireless/wireline convergence** with ways to integrate 5G into the ethernet and Wi-Fi ecosystem
- **Edge computing** in the 5G Core to provide URLLC capabilities that could enhance sophisticated data analytics and AI tools on a hyperscale stack

Each of these new strengths will require concerted effort from our industry to reach out to a broader ecosystem of new partners with specific vertical experience. Every new technology offers vast new ways to integrate more closely with people and systems to an extent that we never have before. Non-terrestrial networks require closer collaboration with satellite and aerospace organizations, while NR extended reality means improved communication with metaverse and gaming companies. Multi-cast/broadcast means deepening relationships with event and venue providers, while wireless/wireline convergence means finding new ways to interact with many of our existing competitors and partners. And with edge computing and the hyperscale cloud on the horizon, a whole new world of full stack capabilities awaits.

As we hit our stride in 2022, it feels like 5G's big coming out party has begun in earnest. There are a lot of dance partners at the ball, so it will be important for our industry to warmly embrace new ideas, new technologies, new applications, and new services. As we arrive to the big dance all dressed up and ready roll, it will take a broad ecosystem of welcoming innovative dance partners to fulfill the promise of 5G.

It's an exciting time for 5G right now. All eyes are on us. Get your dancing shoes on because it's going to be a great time for innovation. ■

About Chris Pearson

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. As President of 5G Americas (formerly called 4G Americas), Mr. Pearson represents the organization's Market Representation interests within the 3rd Generation Partnership Program (3GPP) organization.

ATIS' Next G Alliance Positions North America for the 6G Future

A good roadmap is a must-have for finding the fastest, most efficient way to your destination. Without it, you'll waste time and money meandering. If you arrive too late, you might miss out on everything.

Mike Nawrocki
Managing Director , **ATIS Next G Alliance**

All of that is true not only for people, but also businesses, nations and entire global regions. That's why nearly 18 months ago, North America's wireless operators, vendors and hyperscalers founded the Next G Alliance, whose goal is to advance North American technology leadership in 6G and beyond over the next decade.

Next G Alliance Report: Roadmap to 6G kicks off that journey. Released February 3, it describes the major steps that industry, government and academia will need to take this decade so everything is in place for a successful 6G launch.

It might seem premature to develop a roadmap for the 6G future when most operators are still building out their 5G networks. However, 5G Advanced feature deployments are starting, industrial 4.0 era is in full swing and that is enabling requirements for the next generation – 6G.

Another reason is that 6G should not be viewed as an incremental technological advance. The Next G Alliance is focused well beyond the need for improved speed, efficiency and latency. 6G should be a game changer for society, ensuring North America's economic competitiveness for decades to come while helping to broaden access to education and health care, to name just a few key goals.

That will require a team effort by industry, government and academia — the kind of tight, multifaceted collaboration that takes years to establish. As the Roadmap to 6G notes: "Achieving the goal of 6G leadership will pose additional challenges in areas such as spectrum needs, manufacturing base, workforce skilling, and infrastructure deployment. Recognizing that these foundations take time to establish, one of the primary missions of the Next G Alliance is to bring industry, government and academia to the table to begin working on these policies much earlier in the innovation lifecycle than has been done for previous generations."

> "With 80-plus members, the Next G Alliance has pitched a big tent to accommodate all of the viewpoints necessary to ensure 6G's success."

Addressing the North American 6G Future Now

The Next G Alliance views 6G as more than the incremental advancement of 5G. 6G will require robust North American participation, and the Next G Alliance aims to avoid unseen roadblocks by inviting North American regulators to participate in developing the 6G roadmap now, from the ground up. Spectrum, security and other key regulatory issues are so complex and fundamental that they need attention now, not five or 10 years from now.

Not Just Technology for Technology's Sake

Every generation of mobile technology aims to be faster than its predecessors. But speed should be a means to an end rather than an end in itself. That's why the Next G Alliance roadmap focuses on how 6G can benefit society rather than simply providing terabit speeds or zero latency.

For example, bridging the digital divide eliminates many longstanding barriers to health care and education. Ubiquitous broadband also enables farms to maximize yields to feed more people and empowers cities to tackle chronic problems such as gridlock and the air pollution it creates. 6G also could provide the monitoring capabilities necessary to identify potential emerging force majeure events — and even stop them from happening. For instance, 6G environmental sensors could identify insect beetle infestation so it can be stopped before it leads to deforestation. Saving those trees also could prevent massive forest fires by depriving them of thousands of acres of tinder-dry fuel.

By focusing on these and other "big picture" goals, the Next G Alliance can develop and continually refine a technological and regulatory roadmap capable of achieving them. One potential example is satellite interworking to provide broadband in rural areas. This is fundamentally different than traditional, application-driven approaches such as "8K augmented reality is coming, so 6G needs to support at least a 50 Gbps connection to each user device, with a minimum of 1,000 simultaneous connections per square kilometer."

What Makes the Next G Alliance Unique?

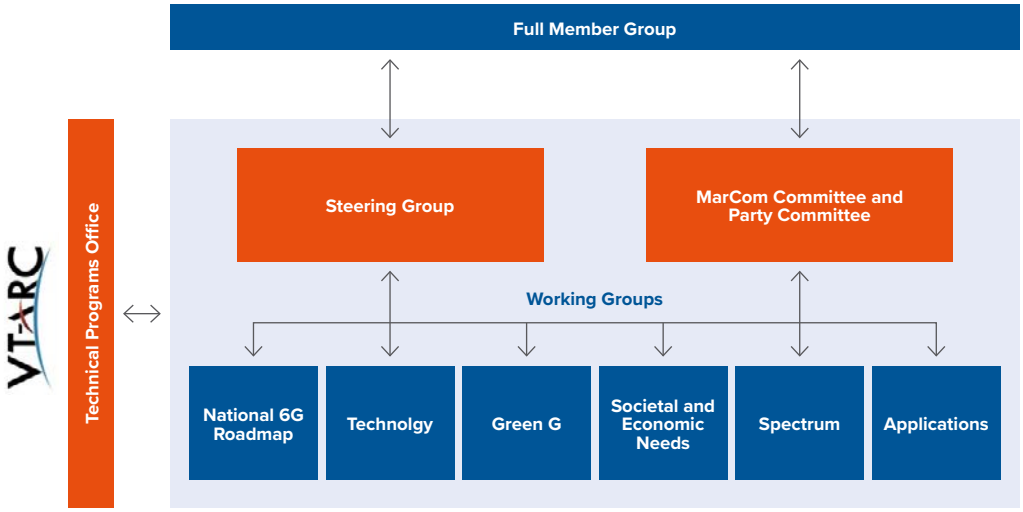
As Figure 5 shows, the Next G Alliance working groups focus on specific aspects and goals, such as spectrum and sustainability. Their input helps ensure that the roadmap takes a holistic view of 6G's development and impact from research to realization in North America.

The diverse working groups highlight how the Next G Alliance differs from 6G initiatives in other countries and regions, such as the European Commission's Hexa-X. Those initiatives often are led by governments, with input from academia, or dominated by a single vendor or operator. With 80-plus members, the Next G Alliance has pitched a big tent to accommodate all of the viewpoints necessary to ensure 6G's success.

Another key difference is that in other countries and regions, 6G initiatives often are preoccupied with technological advances, such as being first in the world with mobile terabit. By comparison, the Next G Alliance focuses on how 6G technology can enable a host of societal benefits, including the environment, education, health care, public safety and more.

Finally, various countries and regions have already announced formal plans of government support for their research and development efforts that will define 6G. They all have the goal of firmly establishing themselves as the epicenter for the next generation of innovation and economic growth. A North American initiative led by industry and with support from government will be essential for balancing the efforts of these other regions and ensure North American 6G leadership. ■

Fig5: Next G Alliance Organizational Structure



VIAVI Solutions

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

5G RAN Evolution

The rapid deployment of 5G RAN is underway in all global regions. According to Omdia, the overall RAN equipment market set a record high of $45bn in 2021, of which over 60% was 5G, and it is set for another strong year in 2022.

The rate at which 5G new radio (NR) network equipment is deployed, how different frequency bands are combined, and the extent to which technologies such as massive multiple input, multiple output (MIMO) are integrated into the overall RAN architecture have a direct impact on the customer experience. These factors also affect the economics of mobile data and therefore the mobile ecosystem as a whole.

Key takeaways

- Standalone (SA)-capable 5G RAN with 54% of the responses will be the focus of operator investment over the next three years, ahead of private networks (23%), edge computing (20%), and network slicing (2%). This indicates operators are committed to moving to SA in the 5G RAN and are not content to remain in non-standalone (NSA) mode for the medium term. However, in something of a surprise, close to half of respondents prioritized another option; clearly, these operators see other opportunities for 5G network investment.
- The outlook for massive MIMO is positive. Operators will focus investment on high traffic areas, rather than nationwide deployments, over the next two years. 60% of respondents expect to deploy massive MIMO on less than 25% of their cell sites, whereas only 19% expect to deploy massive MIMO on more than half of their sites. As a rule of thumb, the busiest 20% of sites in a network carry 80% of the traffic, and so this focused deployment is logical.
- Operators view open RAN has having great potential but cannot wait for the technology to mature before they determine 5G RAN strategies. A third (31%) of respondents say open RAN will be “critical – it’s a strategic priority” over the next three years, up from 18% in the 2021 survey, which reflects increasing confidence in the technology. The largest respondent group, however, is the 51% that say open RAN will be “important” over that timeframe. The “somewhat important” group has shrunk from 28% in 2021 to 14% in 2022.

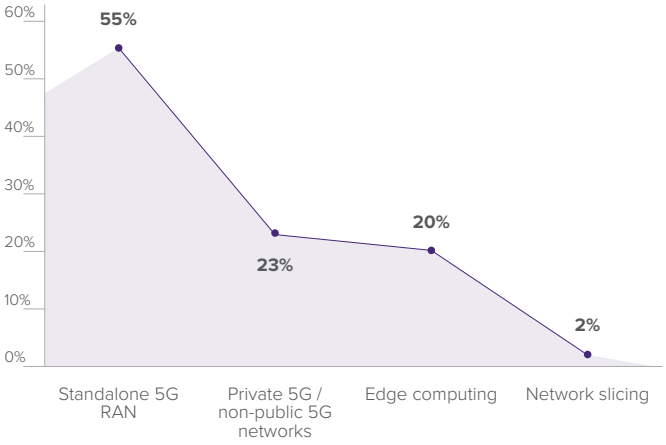
Mobile operators have great demands on their capex budgets and face difficult decisions on how to prioritize investment. The first question (Figure 6) seeks to understand the relative importance of four major areas of investment in the 5G network: standalone 5G RAN, private networks, edge computing, and network slicing.

The lead response is "standalone 5G RAN" with 54%, far ahead of the other options. Rather than asking about RAN in general (which is always the largest area of investment), the question asked specifically about RAN investment related to "SA 5G," which is the capability to support users on a 5G core and RAN without any dependency on 4G. SA 5G requires excellent coverage and uplink performance in the service area (as good as or better than 4G) and therefore requires an excellent RAN. This result shows that many operators appear committed to moving to SA and are not content to remain in NSA mode for the medium term.

It is, however, interesting and something of a surprise that close to half of respondents selected another option. For these respondents, the implication may be that the move to SA is less urgent or that SA may not be needed across a large part of the network's coverage area over the next three years. And clearly, these operators see other opportunities for 5G network investment; edge (20%) and private /non-public 5G networks (23%) score well—both these topics are addressed in dedicated sections later in this report.

That network slicing (2%) scores lowest is not a surprise. The very low score perhaps indicates limited enthusiasm for this technology capability. However, it is difficult to interpret this result because network slicing is dependent on a 5G core and SA operation—thus, by definition, it comes in a later phase.

Fig6: Where does your company anticipate making the greatest investment over the next three years?



Source: Heavy Reading *n=90*

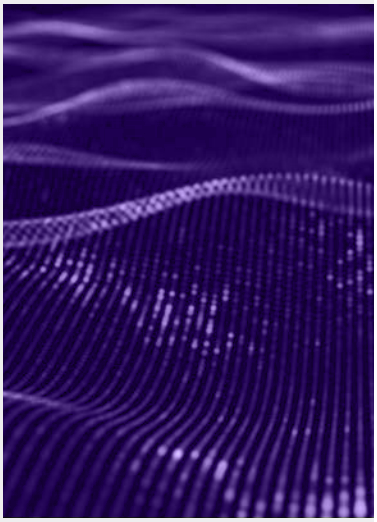
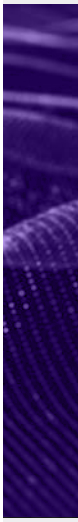


Fig7: What percentage of your cell sites do you expect to deploy massive MIMO by the end of 2023?

Less than 10%	**18%**
10–25%	**42%**
26–50%	**21%**
51–75%	**9%**
More than 75%	**10%**

Source: Heavy Reading *n=90*



For this reason, readers should avoid the conclusion that network slicing is unimportant. Other questions on network slicing provide more insight into this topic later in this report.

Massive MIMO is an important technology for mid-band 5G RAN. It enables operators to extend cell edge performance, making it possible to deploy mid-band time-division duplexing (TDD) frequencies on the existing cell site grid, and therefore reduces civil works costs considerably. It also increases peak rates to offer faster end-user downlink speeds (to enable high bandwidth applications) and increases the capacity of the cell to allow operators and support new business models such as unmetered usage or fixed wireless access. However, there is a higher processing requirement for massive MIMO equipment relative to standard MIMO systems, as well as increased power consumption and site engineering costs (e.g., for weight and wind load).

The survey response (Figure 7) shows how operators are thinking about the deployment of massive MIMO, expressed as a percentage of RAN sites. In general, the outlook is positive on massive MIMO. However, consistent with last year, deployments will be targeted at high traffic areas rather than networkwide.

A decent 19% of respondents expect to deploy massive MIMO on more than 51% of their sites before the end of 2023. A solid 21% will deploy on between 26% and 50% of their sites, representing an ambitious quasi-nationwide buildout focused on cities and towns. The largest group (42%) expect to focus on the high demand areas that are covered by 10–25% of their sites, followed by 18% focused on less than 10% of their sites. Given this technology is most appropriate in areas of high demand density, such as urban centers, it makes sense to focus on these areas first. (As a rule of thumb, the busiest 20% of sites in a network carry 80% of the traffic.)

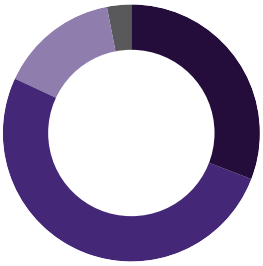
Open RAN has the potential to change how RANs are designed, built, and operated. By using open interfaces between subsystems and by disaggregating baseband software and hardware, there is an opportunity to increase competition and innovation. The introduction of a service management and orchestration framework should also enable more efficient and dynamic RAN operations. However, there are challenges with this new approach to RAN.

The results in Figure 8 show a third (31%) of respondents say open RAN is "critical" and "a strategic priority," up from 18% in the 2021 survey. This probably reflects both increasing confidence in the technology and the high profile of open RAN in industry media. The largest respondent group is the 51% that say open RAN will be "important" over the next three years. The "somewhat important" group has shrunk from 28% in 2021 to 14% in 2022.

Overall, the primary analysis is that operators view open RAN as having great potential and are increasingly confident the technology will prove itself. However, operators cannot wait for open RAN to mature before they determine 5G RAN strategies, and they cannot depend on it to develop sufficiently to replace vendor-integrated solutions within a three-year timeframe. In the meantime, therefore, they will press ahead with classic vendor-integrated RAN deployments.

The next question (Figure 9) seeks to understand how quickly open RAN may be deployed through the end of 2023. The results are, in Heavy Reading's view, probably overly optimistic in this timeframe. First, there is a good deal of realism in the sense that a majority expect less than 25% of their sites will use open RAN by end of 2023. However, the 20% that expect between 26% and 50% of sites to use open RAN is hard to square with the current rate of adoption and looks "toppy"; the 12% that expect more than 51% of sites to be open RAN can only logically represent greenfield operators.

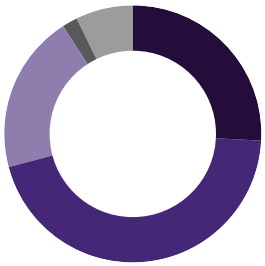
Fig8: How important will open RAN be to your network in the next three years?



Critical – it's a strategic priority	31%
Important	51%
Somewhat important – but not a priority	15%
Not important at all	3%

Source: Heavy Reading *n=90*

Fig9: What percentage of your cell sites will utilize an open RAN architecture by the end of 2023?



Less than 10%	26%
10–25%	45%
26–50%	20%
51–75%	2%
More than 75%	7%

Source: Heavy Reading *n=90*

"Mobile operators have great demands on their capex budgets and face difficult decisions on how to prioritize investment."

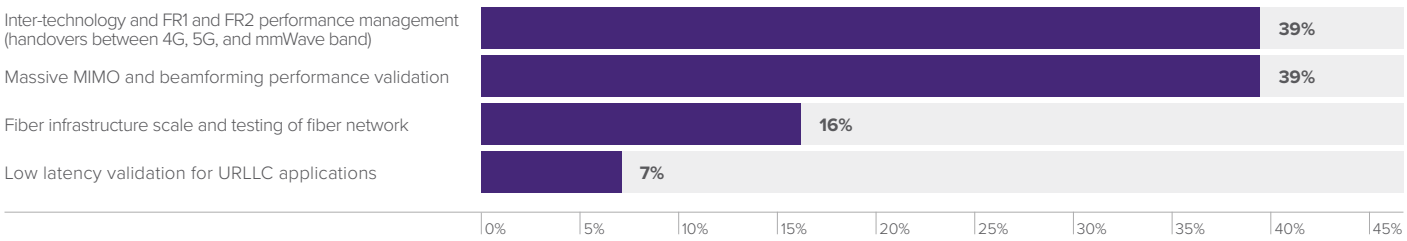
The largest group is the 45% that expect between 10% and 25% of their sites to use open RAN by 2023. This is plausible but would require operators to rapidly accelerate the current rate of adoption. The appropriate interpretation of this result, in Heavy Reading's view, is therefore that it shows a positive sentiment toward open RAN.

The final question in this section covers 5G RAN field testing.

Testing deployed equipment is required through the RAN lifecycle, from acceptance testing to ongoing performance monitoring. Figure 10 asks which aspect of 5G field testing is of greatest concern to operators. In common with previous years, the response is split evenly between "massive MIMO and beamforming performance validation" (39%) and "inter-technology and FR1 and FR2 performance management" (39%).

> "The apparent low level of concern about testing for ultra-reliable low latency communication (URLLC) applications (7%) may indicate not that this is a solved problem, but rather, that it is less of an issue for most operators because they are not yet close to offering these very demanding services commercially."

Fig10: What aspect of 5G field testing is your greatest concern?



Source: Heavy Reading *n=88*

Concern about fiber infrastructure testing (16%) is at the same level as in prior years, even as operators become more familiar with 5G backhaul deployment and more comfortable with their field test processes. Conversely, the apparent low level of concern about testing for ultra-reliable low latency communication (URLLC) applications (7%) may indicate not that this is a solved problem, but rather, that it is less of an issue for most operators because they are not yet close to offering these very demanding services commercially. ■

VIAVI Solutions

Executive Summary

With 200-plus networks in service at the beginning of 2022, 5G now supports billions of subscribers. The diversity of applications – including consumer, industrial and IoT – requires a more adaptive and intelligent radio access network (RAN), based on multi-access edge computing (MEC), disaggregation, open networking, and evolution to the cloud.

To support massive volumes of data over swathes of spectrum to multitudes of users at challenging latencies, different logical functions will need to be flexibly placed at different physical locations and coordinated by a new RAN Intelligent Controller (RIC). 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. And with core functions such as the user plane moving to the RAN, the RAN is indeed starting to look like the new core. This complexity means that quality of experience will increasingly be dependent on: network validation to confirm interoperability and performance of multi-vendor architectures; service assurance to meet subscriber-level KPIs; all connected intelligently via the cloud to speed and even automate network adaptation and service enablement.

ORACLE
Communications

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

5G Core Expansion

The packet core manages sessions, mobility, authentication, and policy in a mobile network. It connects externally to the internet and cloud providers and directly into enterprise networks. The large majority of the 5G networks launched to date use a 5G RAN connected to a 4G core in NSA mode. 5G core deployments started in 2020 and gained momentum in 2021.

By November 2021, at least 19 operators in 15 countries had launched public 5G SA networks, according to the Global Mobile Suppliers Association (GSA), and 94 operators in 48 countries had either invested in trials or had planned/actual deployments. This equates to 20% of the 469 operators known to be investing in 5G as now active in 5G core trials or deployment. This is a decent number, but the growth potential is clear.

Deployment of the 5G core affects devices, RAN, transport, and telco cloud strategies. It will, therefore, be a multiyear process to scale to the global mass market. Ultimately, the 5G core is expected to be an enabler of new service types—such as network slicing, edge applications, and URLLC—that are not possible or practical with a 4G core.

Key takeaways

- Operators will make use of new 5G core capabilities to offer specialized enterprise services, but to a limited extent over the next two years. The largest response is the 36% that will provide only "standardized 5G services to all enterprise verticals." The next largest is the 26% that will provide specialized services to just "a couple of verticals." In third is the more ambitious but still cautious "3–5 verticals" (28%). Those expecting to provide specialized services for "most of the verticals" in their markets only account for 10% of the responses. No doubt, the timeframe plays a part on this result—for operators that are only now deploying a 5G core, focusing on a small number of lead verticals over the next two years makes sense.
- Network analytics (most important) and network slicing (second most important) are the most useful capabilities of 5G core when it comes to offering specialized services. The fourth-place ranking for exposing network APIs raises an eyebrow in the sense that the "5G network platform" is often presented as "API-driven." This result does not undermine the view that network service APIs are useful, but it does indicate that this model is relatively immature.
- Operators will make widespread use of continuous integration/deployment/testing (CI/CD/CT) pipelines to operate 5G core networks. Most respondents expect to make either monthly (29%) or quarterly (35%) updates to 5G core network functions. This represents a much higher update frequency than is normal today, but does not mean operators will be making frequent, fine-grained updates to the production network. Reflecting the risk and consequences of service disruption, only a few (12%) expect to make daily updates to the 5G core.

With so much potential growth in 5G core network deployments, the first question in this section seeks to understand operator purchasing preferences. Figure 11 shows four different 5G core procurement models ranked in order and displayed using a weighted average score. The first two choices are close: in first place is "assembling 5G core components and operated internally by the operator" with a score of 235. Historically, this is the most common model for Tier 1 operators that have strong internal skills and integration capabilities. In second place is "purchasing a pre-integrated 5G core solution and operated internally by the operator" with a score of 218. This again is a common model in 4G core, especially for midsize and smaller operators, and it is no surprise to see it score highly for 5G.

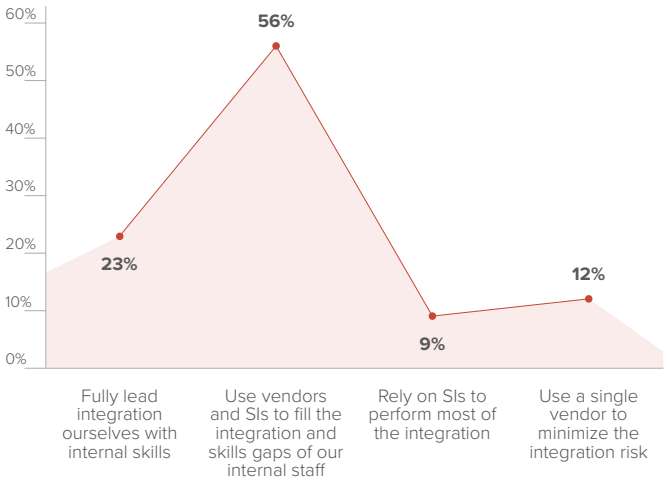
Fig11: What 5G core network procurement models are most important to achieving your business objectives? (Rank in order where 1 = most likely)

Source: Heavy Reading *(n=79–82)*

There is relatively less enthusiasm for the two core as-a-service models. This may come as a surprise in the sense that "as-a-service" is now the predominant model for enterprise software. In the public network mobile core, however, the demands of data sovereignty and requirements for reliability and performance make operators risk-averse. The core is critical to service availability and, as shown by the survey, most operators continue to prefer full control and will retain this infrastructure in-house.

Operators generally use a multi-vendor strategy for the mobile core network. The classic model is to select a lead vendor and integrator and use other vendors to support specific parts of the system where best-in-breed is required. Figure 12 shows this will probably also be the case in 5G core. Only 12% said they would "use a single vendor minimize integration risk," confirming the multi-vendor 5G core thesis. Only 9% will "rely on [systems integrators] SIs to perform most of the integration," confirming operators also expect to be involved in the details of the 5G core integration. The question then is: How involved do they want to be?

Fig12: How will your company integrate and support a multi-vendor 5G core network?



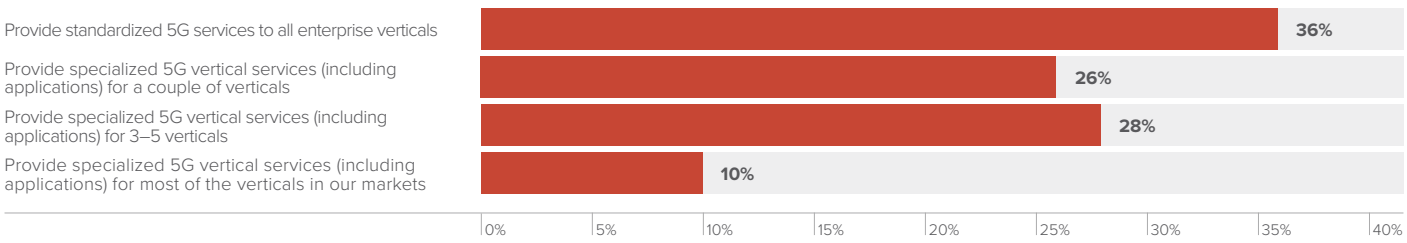
Source: Heavy Reading *n=87*

A quarter (23%) expect to "fully lead integration"—a decent number—and this group is clearly confident in its internal capabilities. The lead result is the 56% that expect to "use vendors and SIs to fill the integration and skills gaps of our internal staff." This suggests that a multi-vendor strategy supported by external integration services will prevail in 5G core but underlines that operators will remain in charge and will lead the project in-house.

The most important advance in 5G is to enable services that are not possible or practical on a 4G network, such as network slicing, low latency applications, or edge services. A 5G core gives operators greater capability to configure services for specific use cases or customers. Figure 13 gives an indication of the extent to which operators expect to take advantage of this ability over the next two years (a short timeframe) to offer specialized enterprise services.

> "Deployment of the 5G core affects devices, RAN, transport, and telco cloud strategies. It will, therefore, be a multiyear process to scale to the global mass market."

Fig13: How will your company offer 5G services to the enterprise market in the next two years?



Source: Heavy Reading *n=87*

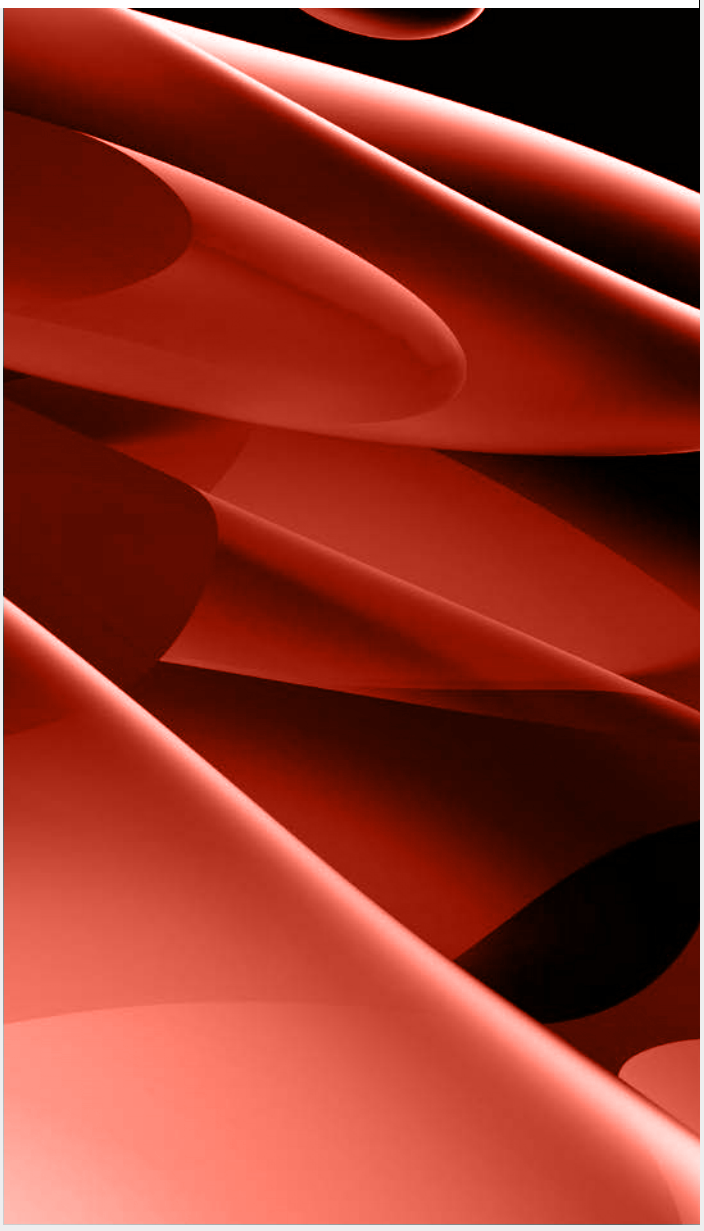
The overall analysis is that operators will make use of the new capability but to a limited extent. Most do not expect to offer many specialized service types. The largest single group is the 36% that will provide only "standardized 5G services to all enterprise verticals." The next largest group will provide specialized services just "a couple of verticals" (26%). In third is the more ambitious "3–5 verticals" (28%).

Those expecting to provide specialized services for "most of the verticals" in their markets account for only 10% of the responses. No doubt, the two-year timeframe in the question plays a part in this result. Two years for operators that are only now deploying a 5G core does not give much time to develop, test, and commercialize a service. Focusing on a small number of lead verticals makes sense over this time horizon.

5G core networks are deployed as a set of "cloud native" applications on software-defined infrastructure. Part of the drive for a cloud native core network is to introduce a more automated operating model and greater ability to reconfigure the core in software to meet changing requirements or enable new services. Updating the core network is the job of a CI/CD/CT pipeline (or management and orchestration system). Figure 14 shows how frequently operators expect to deliver upgrades to core network functions using CI/CD/CT.

Most interesting is that respondents expect to make monthly (29%) or quarterly (35%) updates and that relatively few (12%) will be making daily updates. This shows that operators will not be running highly dynamic networks with very frequent, fine-grained updates to the production core and instead will schedule updates over longer planning periods. It is the case, however, that the results for monthly or quarterly updates indicate a much higher update frequency than is normal today.

Possible reasons for not making frequent daily updates are because this will not significantly improve the customer experience and because the risk to service availability due to misconfigured core software is high.



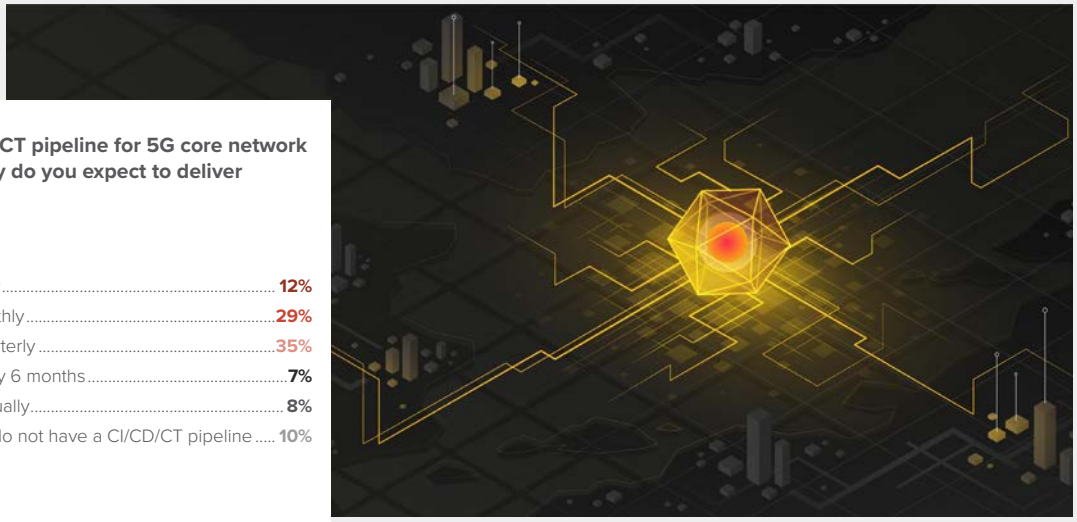
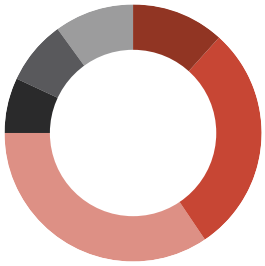


Fig14: If your company has a CI/CD/CT pipeline for 5G core network lifecycle automation, how frequently do you expect to deliver upgrades to network functions?



Daily	12%
Monthly	29%
Quarterly	35%
Every 6 months	7%
Annually	8%
We do not have a CI/CD/CT pipeline	10%

Source: Heavy Reading *n=87*

The consequences of outages in the mobile core are serious and the impact is often networkwide, which drives operators to be cautious about frequent in-service network updates.

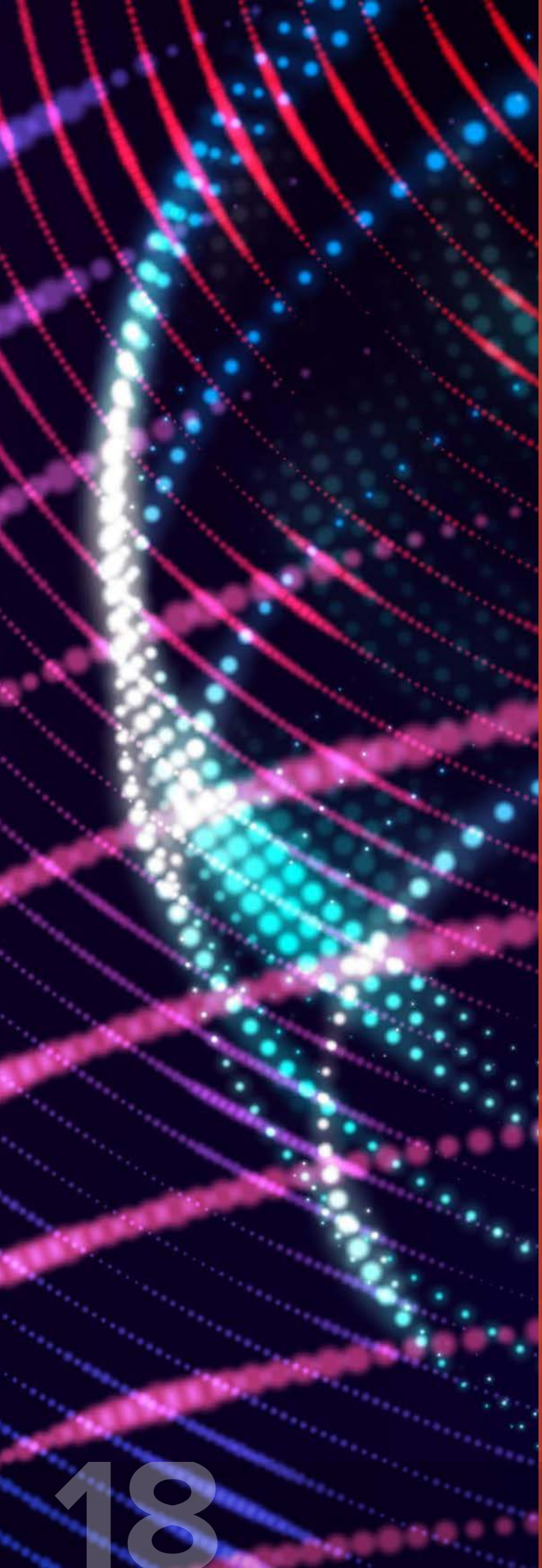
Figure 15 shows how operators rank five different core network capabilities that enable them to offer differentiated services. The chart uses a weighted average score. In first place is "using network analytics to improve customer experience or generate new offers" with a score of 281. In second, with a score of 258, is "offer tailored network services to specific verticals through network slicing." It is interesting that this "slicing" option secured the highest number of "1= most important" scores, but also a larger number of "4–5 less important" scores, indicating polarized opinion.

It is logical that using automation to create more efficient network operators scores lowest because the impact of efficient operations on services is indirect. The relatively low score for "exposing network APIs" is more surprising in the sense that the "5G network platform" is often presented as "API-driven" and the ability to offer advanced services often linked to integration of the network with third-party cloud applications. This fourth-place ranking does not undermine that view, but it does indicate that this model is relatively immature. ■

Fig15: What capabilities does your company see as most important in achieving a differentiated service offering? (Rank in order where 1 = most likely)

Source: Heavy Reading *n=87*

"By November 2021, at least 19 operators in 15 countries had launched public 5G SA networks, according to the Global Mobile Suppliers Association (GSA), and 94 operators in 48 countries had either invested in trials or had planned/actual deployments."



ORACLE
Communications

Executive Summary

At Oracle we have learned to think of everything as code, to drive automation into every process, and to see the world through data. We are helping operators to embark on that journey of embracing cloud native in several different dimensions. First, we bring fully cloud native capabilities in the functionalities we deliver to carriers. We have deep expertise in not only building cloud-native applications but also operating them in a DevOps model, offering CSPs more deployment options as they migrate applications to containers and Kubernetes.

We are a Platinum member of the Cloud Native Computing Foundation (CNCF), furthering our commitment to open source serverless platforms. We know that the only way for operators to meet the velocity and diversity of demand is through network automation which can only be managed with data-centric analysis and decision-making. Realizing the full potential of the fourth industrial revolution will require new business models delivered across robust supply, application and production ecosystems tied together with common data and connectivity solutions. To prepare, we have invested in a cloud-native, microservices-based 5G core with slicing support, which can be deployed on private or public cloud platforms. Furthermore, our rich consulting services help carriers towards every step of their 5G core deployment journey.

Red Hat

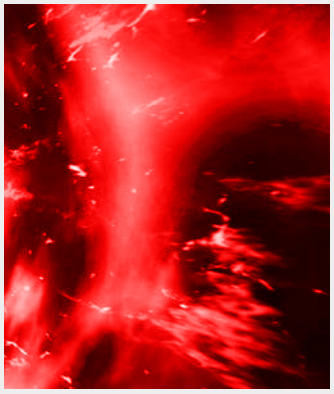
Jennifer Clark
Principal Analyst, Edge Computing
& Cloud Infrastructure
Heavy Reading

5G and Edge Computing

Edge computing is a focal point of innovation for operators and their partners. The survey results show that multi-access edge compute (MEC) deployments are accelerating and that operators need to build roadmaps that emphasize support for new applications and services that do not overleverage partnerships with the hyperscalers.

Key takeaways

- Early edge deployments are largely focused on overall improved network costs and performance, not on creating new revenue streams and enabling new applications.
- The current MEC market favors the manufacturing and healthcare verticals. However, respondents predict a rapid uptick over the next 24 months in the deployment of edge services to the retail, media and entertainment, and transportation & logistics verticals.
- The deployment of MEC combined with a move to containers are very complex transitions and somewhat outside the current skill set of the operators. This is making partnering with the hyperscalers an increasingly attractive (if hazardous) shortcut.



The drivers of edge computing deployment can be divided by those that improve performance and operational costs and those that enable new applications and revenue streams. The respondent pool, regardless of company size (over or under $5bn in annual revenue) or location (US vs. Rest of World [RoW] based) selected "reduce bandwidth use/cost" as the top driver for edge computing (Figure 16). Related drivers of "improve application performance in general" and "improved resilience" were much more important to smaller operators than to Heavy Reading's over $5bn segment. All three drivers translate to money in the pocket of the operators—the first by the more efficient use of bandwidth, the other two by providing consistency in performance—thereby lowering pay-outs for service-level agreement (SLA) breaches. This perspective has been reinforced by one-on-one conversations with the operators, which shared that their early MEC rollouts were aimed not so much at reducing latency for some demanding applications, but at establishing consistent delay and jitter for all applications. From this perspective, early MEC implementations are acting as a pressure valve. They are helping to absorb sudden demands on the network and, as one Tier 1 operator commented, they are giving their enterprise customers some "extra runway" to handle ever increasing network loads.

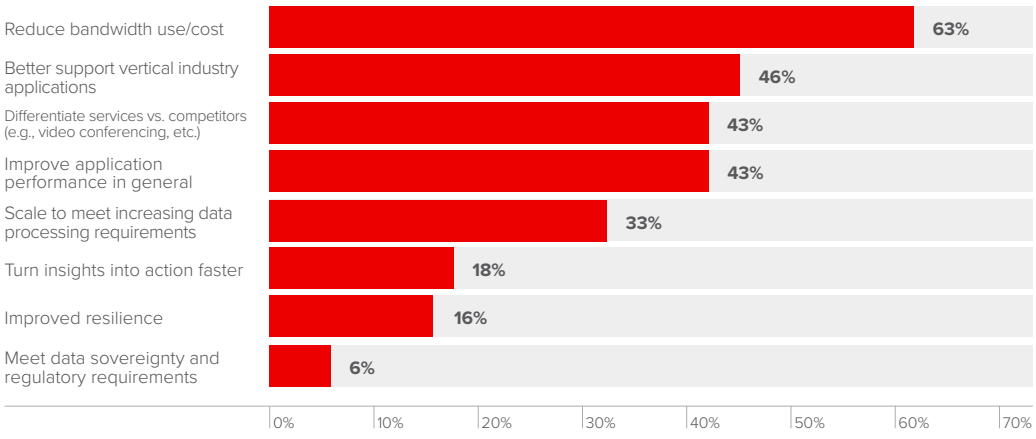
The largest operators showed much greater interest in drivers that enabled new revenue streams (as opposed to lower costs). "Differentiate services vs. competitors" is far more important to the largest operators (65% vs. 28% for respondents with annual revenue of under $5bn). Heavy Reading posits that the "competitors" these Tier 1 operators are responding to are not only other telcos, but also hyperscalers (the ultimate "frenemies" as both partners and competitors).

"Meet data sovereignty and regulatory requirements" claims the "also ran" spot in this survey. However, it can provide low hanging fruit for the operators, particularly in some heavily regulated healthcare, defense, and government applications.

According to Figure 17, healthcare, automotive, financial services, and manufacturing respondents have the greatest percentages of current implementations. "Automotive" clearly does not refer to fully autonomous vehicles on public highways. Rather, it is a catchall for a variety of auto-centric applications: insurance, Internet of Things (IoT) cameras and devices, onboard entertainment, and campus autonomous vehicles, with some manufacturing and fully autonomous driving trials and proofs of concepts (PoCs) thrown in. The media & entertainment vertical shows the largest growth spurt over the next 24 months, followed by retail and transportation & logistics.

In terms of regional differences, areas outside the US are less interested in the financial vertical—33% with "no near-term plans"—but show a heightened focus on deploying MEC services within the next 24 month in both the healthcare (59%) and transportation & logistics (71%) verticals. These verticals can be heavily subsidized outside of the US and frequently bubble to the top in Heavy Reading's edge surveys, particularly when the spotlight is on Europe.

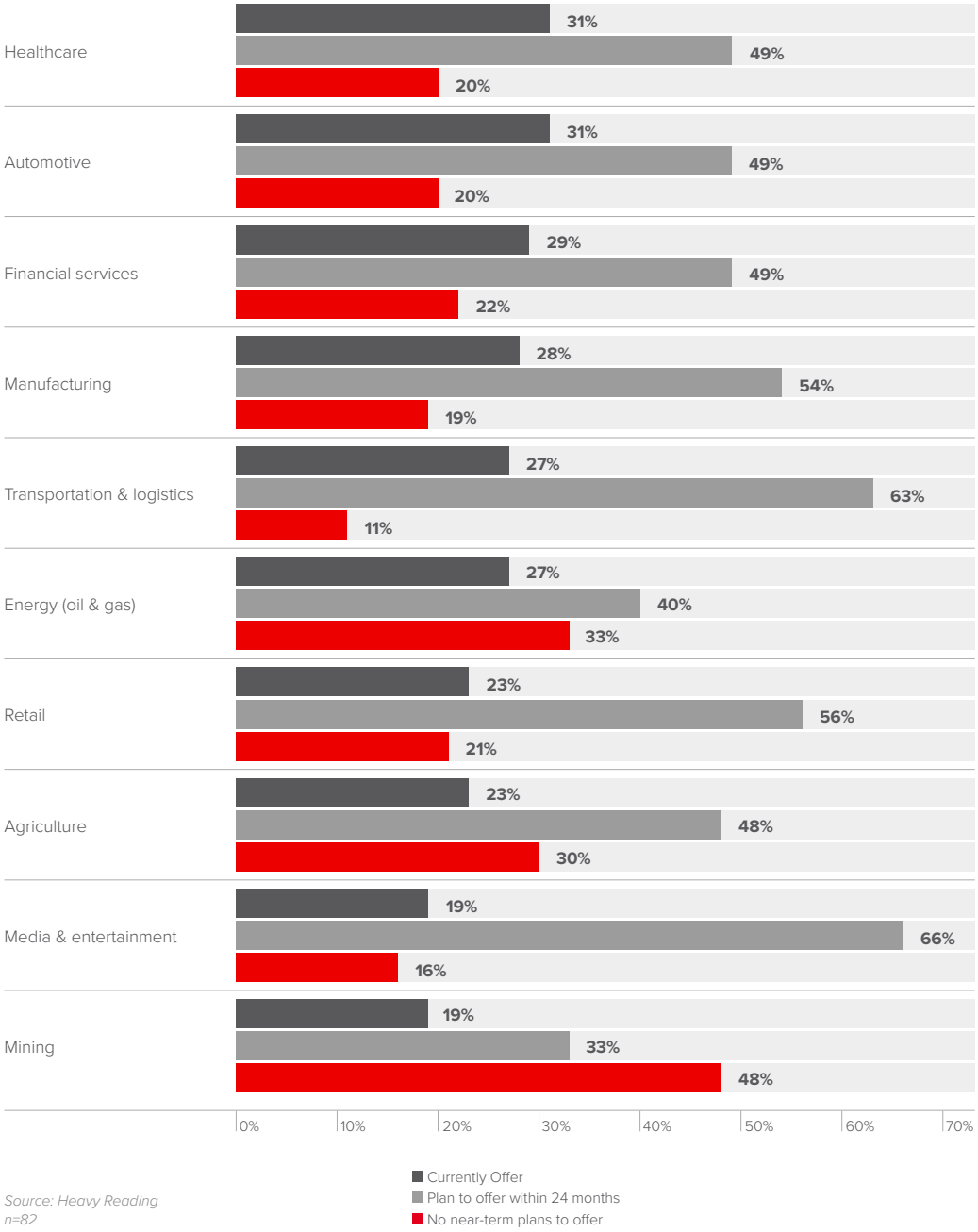
Fig16: What are your top motivators for moving workloads to the edge? (Select all that apply.)



Source: Heavy Reading *n=87*

"Survey results show that multi-access edge compute (MEC) deployments are accelerating and that operators need to build roadmaps that emphasize support for new applications and services"

Fig17: When will your organization start to offer 5G edge services for the following industries/use cases?



Source: Heavy Reading
n=82

While mining shows the greatest percentage (almost half) of respondents with "no near-term plans" to deploy MEC, these responses are heavily weighted toward smaller operators (61% vs. 25% for >$5bn operators) and operators outside of the US (66% RoW vs. 21% US). However, the demographic spread for the related vertical of energy is different. Heavy Reading believes this is because US Tier 1 operators, in particular, have been targeting mining operations for private 5G and view MEC as a key enabler of private 5G.

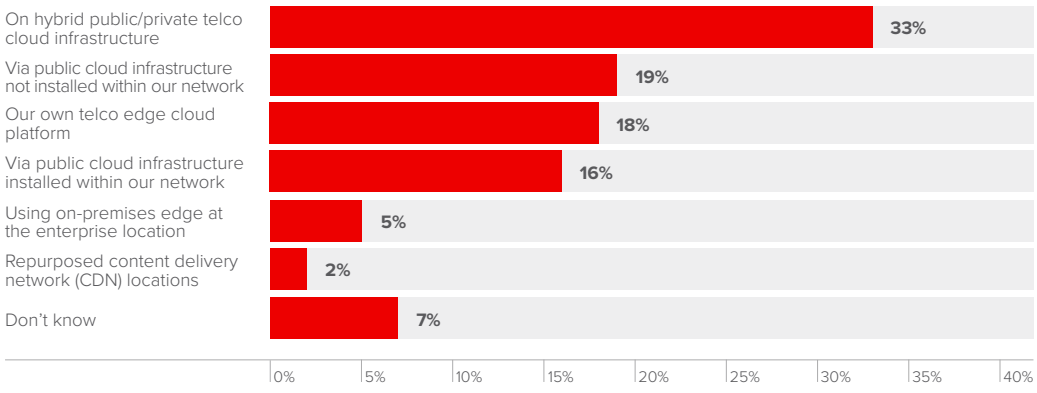
Edge services can be offered via a variety of deployment models with varying degrees of ownership, control, and geographic reach. As shown in Figure 18, a "hybrid public/private telco cloud infrastructure," giving CPSs the most attractive combination of both control and reach, garners a third of survey responses overall. However, when looking only at the largest operators (>$5bn in revenue), that percentage grows to almost 50%. The next two deployment models fall precipitously to around 15%. The remaining choices for these Tier 1 operators are in the single digits—as they are with the overall survey respondents.

Operators with annual revenue of under $5bn divide their responses almost equally between the first four responses, with little variation between the US and RoW. The reluctance to deal with hyperscalers that was seen from some regions outside the US in earlier surveys has dissipated as operators have been seduced by the ease with which they are able to get an edge service up and running in their own region and beyond.

Heavy Reading was surprised to see any operator claim that the primary edge deployment model would be on-premises edge at the enterprise location. The four respondents that made this selection are all mobile or converged operators from both the US and RoW. Three of the four have revenue of over $5bn. The most logical explanation is that these edge deployments are in a private 5G network or were driven by a specific IoT enterprise app.

The two respondents that decided on the practical strategy of leveraging repurposed content delivery network (CDN) locations were a cable operator and a mobile virtual network operator/enabler (MVNO/MVNE).

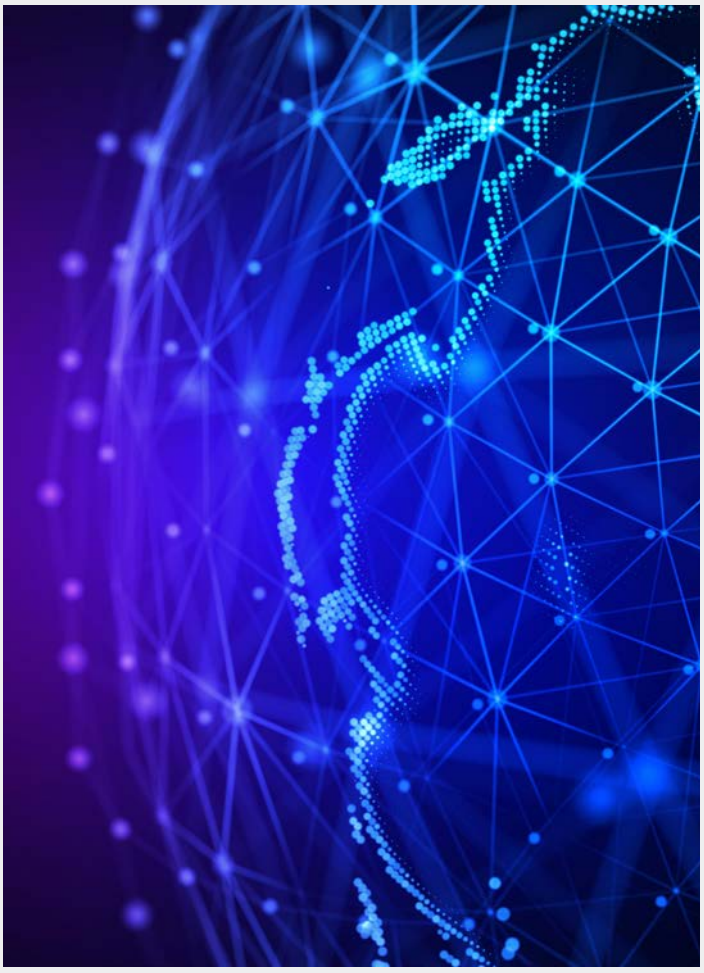
Fig18: How will your organization primarily offer edge services?



Source: Heavy Reading *n=84*

The use of containers enables enterprises to build and run highly scalable and flexible applications for deployment at the edge and/or in a public, private, or hybrid cloud. Key benefits of containers/microservices include the following:

- Lower total cost of ownership (TCO), enabling users to deploy only what is needed, rather than entire monolithic network functions.
- Faster time to market (TTM) for new services and applications.
- Ability to decouple the application from the infrastructure, simplify application development, and enable applications to run in a highly distributed fashion.
- Increased cadence of small and regular updates to applications enabled by the microservices/containerized architecture and the use of CI/CD.



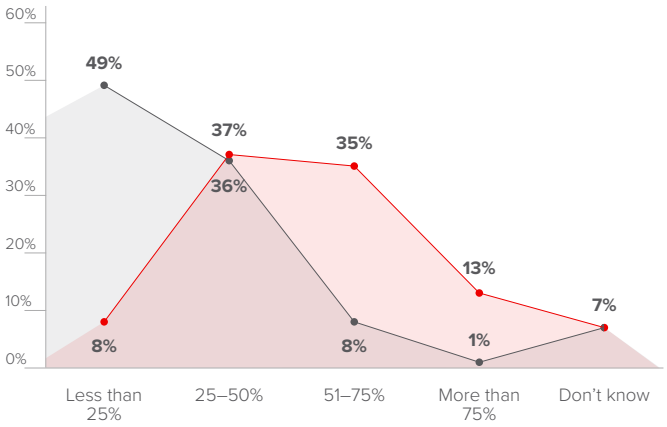
As compelling as these benefits may seem, the transition to containers and containerized network functions (CNFs) from virtual machines (VMs) and virtual network functions (VNFs) is much more complex than the transition from appliance-based network functions to network functions virtualization (NFV) and VMs. Containers and cloud native represent a fundamental change in the way operators design, deploy, and manage applications and services. With this in mind, it is not surprising that almost half of respondents claim that less than 25% of their edge cloud workloads are containerized today (Figure 19). It is encouraging that over 50% of respondents expect 51% or more of their workloads to be containerized by 2025. Heavy Reading notes some acceleration of container adoption predicted by the very large operators and US operators, but the numbers are statistically similar to the survey base overall.

When examining the factors that are limiting edge deployment (Figure 20), the most interesting detail to note from the data is that there is only a 6-percentage-point difference between the number one limiting factor, "cost and complexity of infrastructure," and the fourth factor, "integration/ compatibility between ecosystem components." And each of the four factors was identified as a barrier by around half of the respondents. These top four factors combine to form a significant barrier to deployment. It is this barrier that is encouraging operators to partner with the hyperscalers for their MEC deployments: because it is easier.

They are not expecting to reduce TCO, as has been pointed out in other recent MEC surveys.

Limited customer demand, pulling in a third of respondents, is concerning, but the percentages are predictably lower (hovering around 20%) for larger operators and US operators. ■

Fig19: What percentage of your edge cloud workloads is containerized now or will be by 2025?



Source: Heavy Reading *n=84*

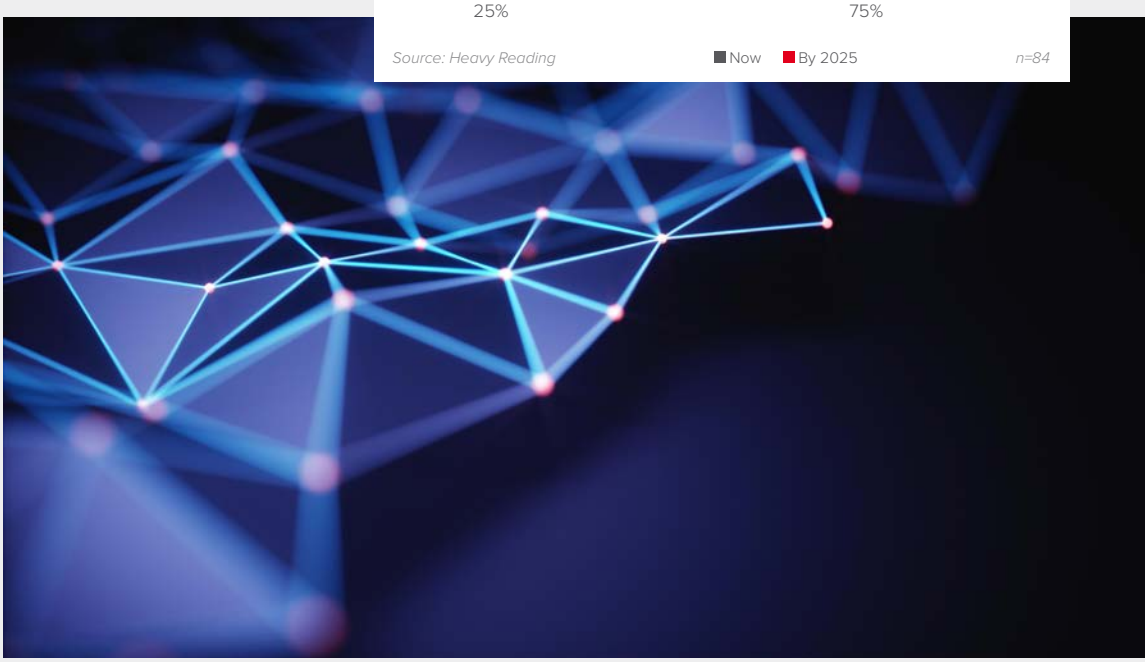
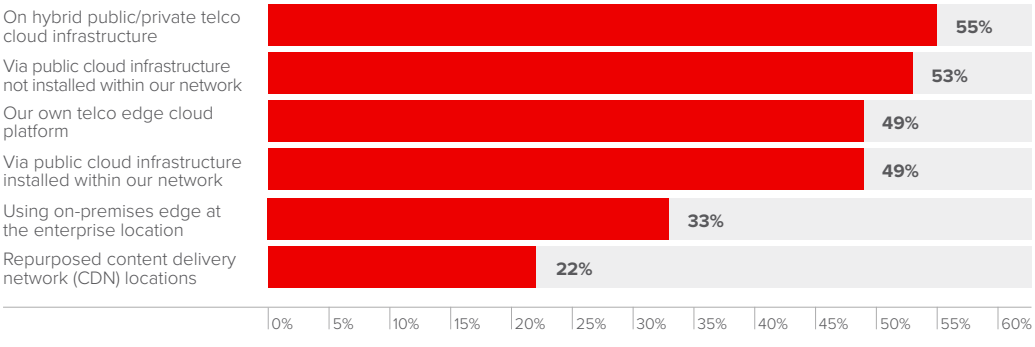


Fig20: What is most limiting your 5G and edge cloud deployment? (Select three)



Source: Heavy Reading *n=82*

Executive Summary

Digital service providers (DSPs) 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 for their radio access networks (RANs) allows them to quickly scale to dynamically meet changing demand. With multi-access edge computing (MEC), service providers can deliver innovative, latency-sensitive services and applications for enterprise customers, and capture new revenues.

DSP 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 flexibility to develop and deploy with speed and ease in any cloud you choose. Together with our ecosystem partners, we help customers make the most of 5G opportunities with pre-integrated offers to build out services with confidence and without fear of lock-in. For the foreseeable future, digital service providers will have many different kinds of workloads in multicloud environments. Our telco-grade hybrid cloud solutions provide a consistent, predictable foundation that lets service providers move between clouds as strategic, business, or technology needs evolve. Partnering with Red Hat, DSPs can provide the experience that customers expect, and address cost, resilience and regulatory requirements.

ACCEDIAN

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Mobile Networks & 5G
Heavy Reading

5G Private Mobile Networks

Private mobile networks are in a growth phase. There are now more than 1,000 deployments listed in the Omdia Private Network Intelligence Service, with 350 new networks added in 2021. The increase is driven by large enterprises seeking to use this technology, often in association with edge cloud, to redesign and optimize operational processes or introduce new operating models. There is activity across a wide variety of industries and in the government/public sector.

LTE is still the lead technology for private mobile networks today, but 5G is being adopted rapidly. If the ecosystem continues to develop, 5G could become a mainstream option from 2023 onwards. 3GPP Release 16 introduced non-public networks (NPNs) to the 5G system architecture, and there is a well-developed program to continue to evolve private 5G in the standards process.

Key takeaways

- The private 5G network market is now truly underway. A majority of respondents are either already (37%) deploying trial and small-scale networks or will be later in 2022 (31%). However, a majority also do not expect 5G to be "mainstream" until 2023 (35%) or later (14% in 2024; 17% in 2025). This is a reminder that, although 5G is now part of the commercial private mobile network market, the ecosystem is not yet fully formed.
- There is broad-based demand for private 5G across diverse industrial sectors. The top three sectors are manufacturing (48%), automotive (41%), and healthcare (39%), with several other sectors also well represented. The focus on manufacturing is understandable given it has a high profile in operator and vendor marketing and in media coverage of private 5G. It also has demanding performance requirements that 5G has been designed to address.
- In terms of business models, operator respondents expect their company to take a leading role in on-premises private networks. 33% expect to "directly provide network design and installation services," and 30% expect to "directly provide an overall managed services solution." The remaining 37% show there is some diversity of thought and ambition in the operator community about how telcos should participate in this market to best support customers.

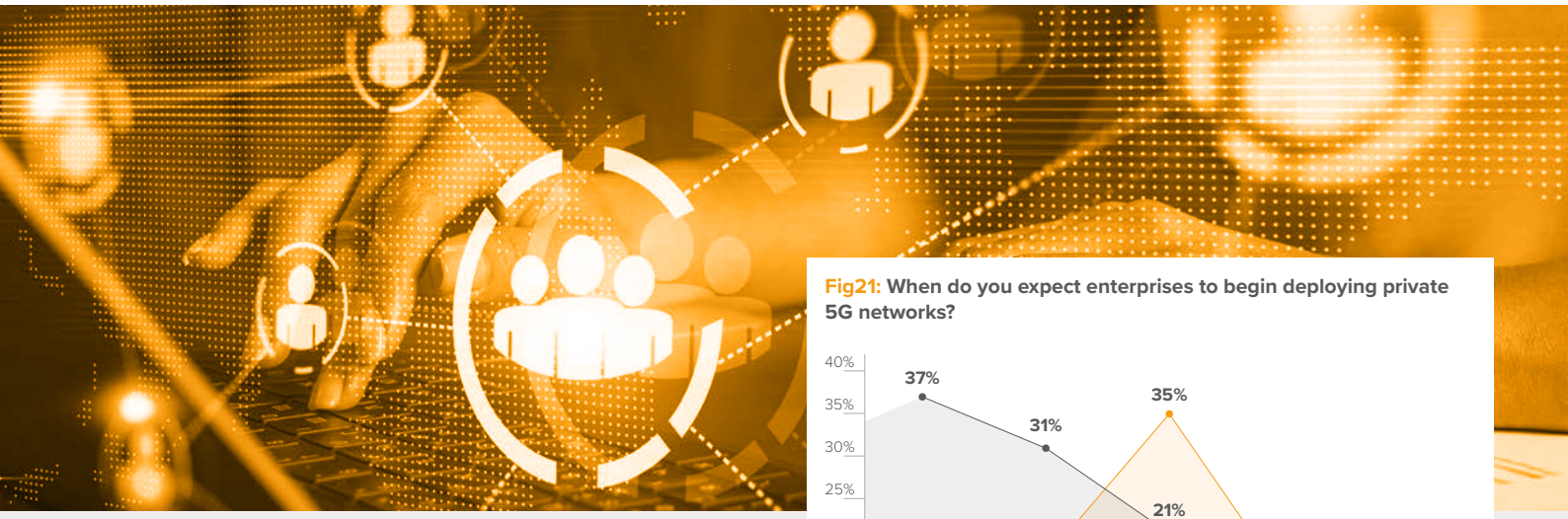
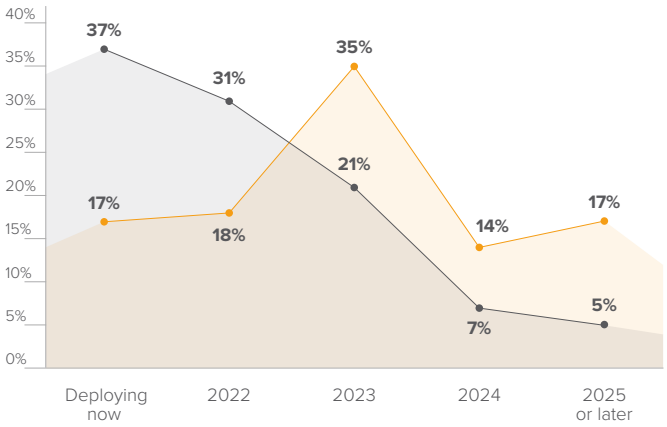


Fig21: When do you expect enterprises to begin deploying private 5G networks?



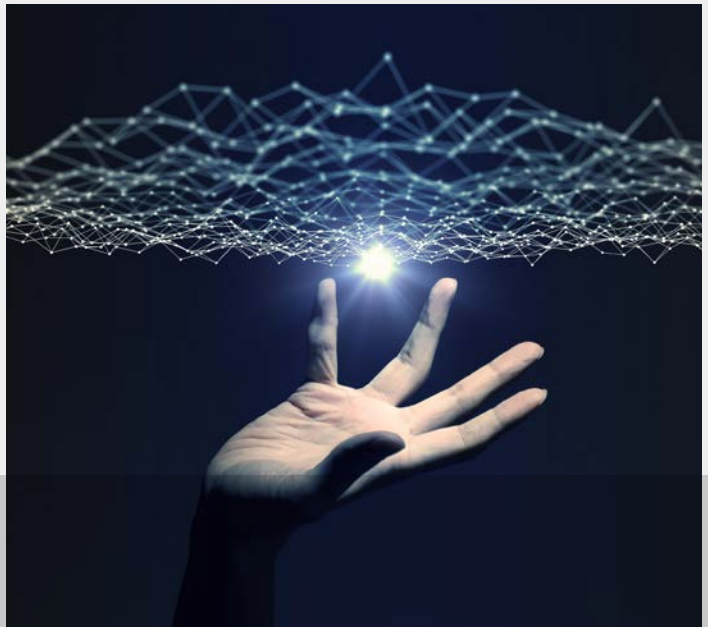
Source: Heavy Reading n=85

The timescale for the adoption of private 5G networks is an important issue. Public 5G networks launched in April 2019 and had been commercially live for almost three years at the time of this survey (January 2022). There are examples of private 5G network trials over the same period, but only a few commercial deployments. The lag between public and private commercialization is due to several factors, including the following:

- Because private 5G will use the SA architecture.
- Because many of the advanced capabilities than make private 5G valuable are dependent on Release 16 specifications.
- Because LTE offers a more mature enterprise ecosystem, including devices, applications, and integrators.

The first question in this section seeks insight into operator expectations for private 5G deployment timelines. For small-scale and trial networks, Figure 21 shows a majority of respondents are either already in deployment (37%) or will be later in 2022 (31%). The key finding, therefore, is that private 5G is now truly underway. In terms of "mainstream" 5G private networks, 17% are already in deployment and 18% will be later this year. This underlines that 5G technology is now part of the commercial private mobile network market and is set for rapid growth.

It is also the case that a majority do not expect 5G to be mainstream until 2023 (35%) or later (14% in 2024; 17% in 2025). This is an important reminder that this market is not yet fully formed and not yet quite ready to scale. Alongside the need for Release 16 capabilities, better support for IoT, and so on, the private network market needs well-formed ecosystems that can provide enterprises with sector-specific pre-integrated solutions with long-term support. Products developed for the consumer market help generate volume to support the enterprise market, but the technology must be adapted for the private network context. A further factor is that the timelines for operational transformation in the target verticals must also be accommodated and this, in turn, will affect the timeline to mainstream adoption.



Respondent views of the industrial sectors that will lead in the adoption of 5G private networks are shown in Figure 22. The 84 respondents made 246 selections for an average of three selections each (the maximum allowed by the question). The top three sectors are manufacturing (48%), automotive (41%), and healthcare (39%), with several other sectors also well represented. The primary finding, therefore, is that demand is broad-based.

The focus on manufacturing is understandable. This sector has a high profile in operator and vendor marketing and in media coverage of private 5G. It also has demanding performance requirements that 5G has been designed to address—for example, related to robotic motion control, time-sensitive networking (TSN), and augmented/virtual reality (AR/VR) applications.

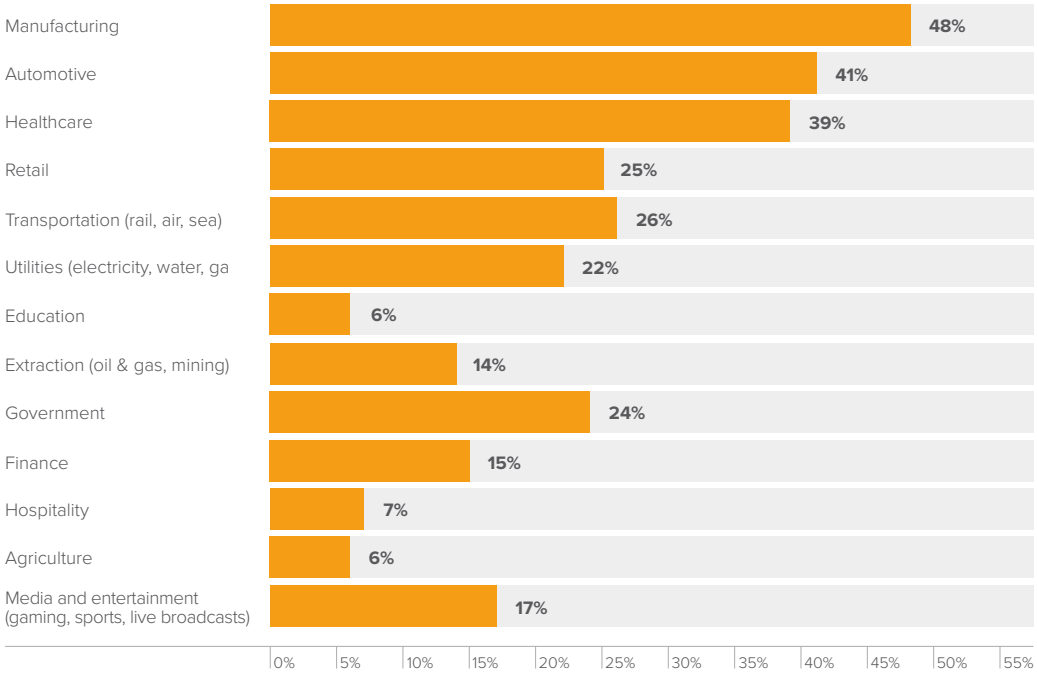
The high score for automotive is curious—unless the strong vote refers to automotive manufacturing (see above)—because most vehicles need wide-area coverage that can only practically be provided by the public network. A possible explanation is that respondents had in mind VPNs provided by 5G network slices. A number of automotive companies are currently working with operators on just this type of network slice solution to support connected vehicles on the public network.

It is a surprise that the extractive industries (mining, oil & gas) did not score higher, as this sector is a bedrock customer for the private network business today, and these are generally high end bespoke solutions that will benefit from advanced 5G capabilities. By contrast, it makes sense that agriculture may be a slow adopter, given that many of the applications in this sector require low cost sensors that are not yet available on 5G or are currently too expensive and consume too much power.

The classic triumvirate of data rates (44%), capacity (45%), and coverage (49%) rank as the top benefits of 5G cellular technology for private networks, as shown in Figure 23. Given this is the view of 84 operator respondents, no explanation is necessary. Better mobility (25%) might have been expected to score higher because this is a capability in which 3GPP mobile technologies excel.

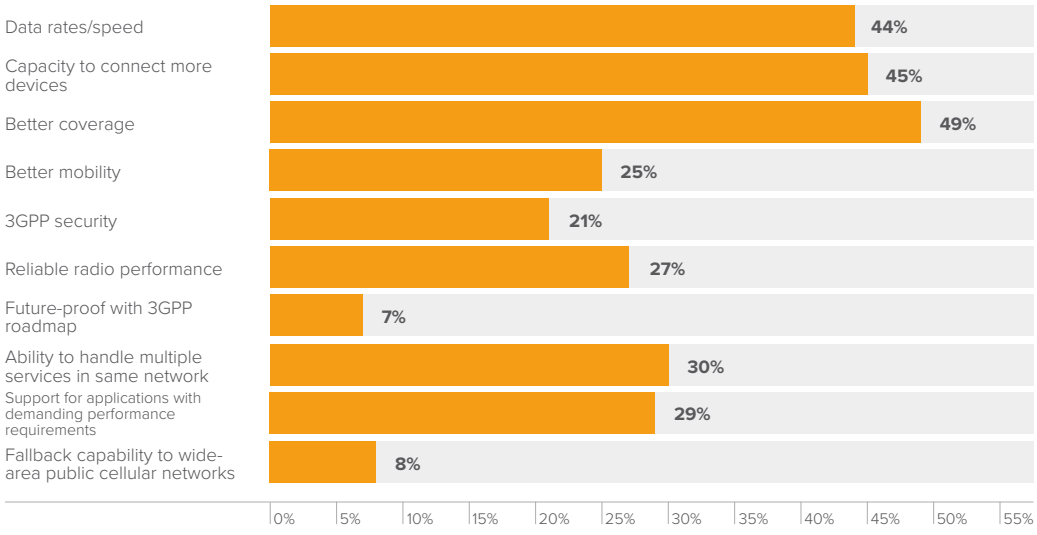
It is notable that the top challenge identified for private 5G is "integrated application, network and security monitoring" (46%), as shown in Figure 24.

Fig22: Which industries will most likely implement private 5G networks? (Select three)



Source: Heavy Reading *n=84*

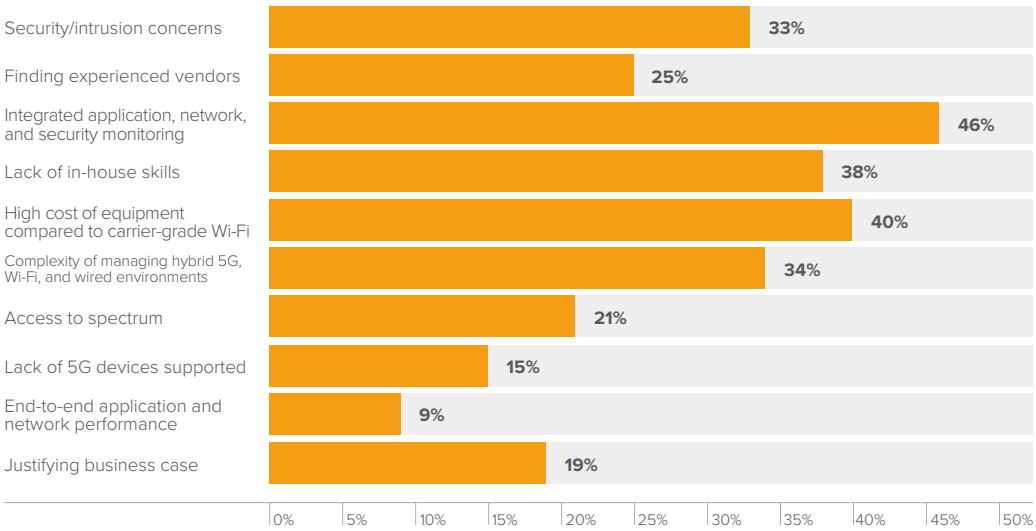
Fig23: What are the top benefits to using private 5G network technologies over other solutions? (Select three)



Source: Heavy Reading *n=84*

"There are now more than 1,000 deployments listed in the Omdia Private Network Intelligence Service, with 350 new networks added in 2021."

Fig24: What are the top challenges enterprises face when deploying private 5G networks? (Select three)



Source: Heavy Reading *n=84*

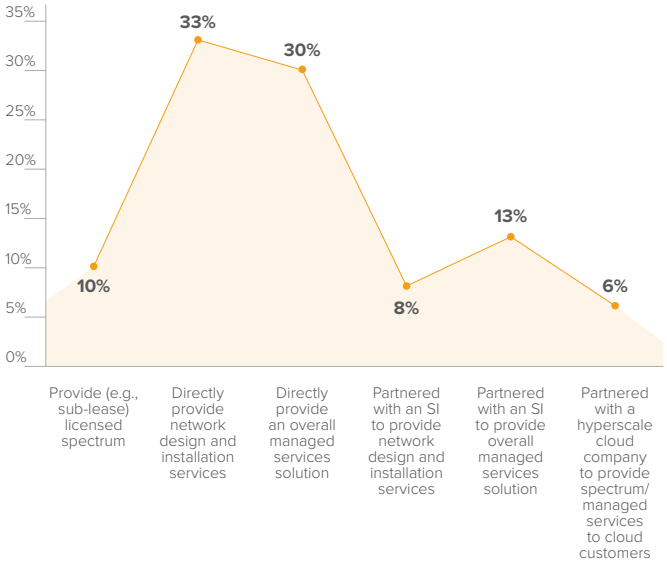
This is obviously important to private networks, but to see it rank as the top challenge merits investigation. Possible reasons could relate to the likelihood that organizations are using private 5G to process mission-critical operational data and assuring and monitoring these flows could make the difference between the uptime and shutdown of a key production process. In the same vein, "security/intrusions concerns" rank high on the list of challenges at 33%.

Private mobile systems are generally more expensive than Wi-Fi to deploy and operate. It is a slight surprise, therefore, that cost of equipment ranked second (40%) and not first in the list of challenges, but this perhaps indicates that this market will be driven by value-based pricing and business outcomes. "Complexity of managing hybrid 5G, Wi-Fi, and wired environments" comes in a close third with 34%.

The role of telecom operators in private networks and the associated business model is hotly debated. One view is that private networks are better delivered by specialist enterprise vendors, SIs, and operations technology companies and that public network expertise does not transfer well to this environment. Another is that operators have exclusive use licensed spectrum (important for more critical applications), experience building and operating networks, and access to a deep ecosystem of equipment and device suppliers and therefore are the best type of company to support customers over the long term.

For the operators that responded to this survey, it is not a surprise that most of them see their company taking a leading role in on-premises private networks. Figure 25 shows that 33% expect to "directly provide network design and installation services" and 30% expect to "directly provide an overall managed services solution." What is perhaps more interesting is that these two scores are not higher. The remaining 37% show there is some diversity of thought and ambition in the operator community about how they should participate in this market to best support customers. ■

Fig25: What is the primary role your organization will play in private networks deployed on-premises for/by enterprises?



Source: Heavy Reading *n=85*

ACCEDIAN

Executive Summary

Accedian-sponsored research along with active proof of concepts with manufacturing consortium Encode and the Icade real estate project find an appetite for 5G across many industries.

An impressive 75% of manufacturers say 5G is a key enabler of digital transformation. The manufacturing, transport, healthcare and financial sectors in particular are aspiring to transform their businesses with 5G.

A network that provides for consistent, high-quality, and resilient services — is an absolute necessity in today's hyperconnected business environment. However, there is a complex balance of risks and deployment choices that businesses need to make as they move forward with 5G. Private 5G networks must integrate with existing networks and business processes, keep data secure, and support ultra-reliable and low-latency applications.

CSPs can become strategic partners to organizations by offering private 5G networks as a managed service. Taking responsibility for managing performance and resolving issues reduces the cost burden on enterprises with limited technical resources, while creating new revenue streams.

Accedian is a leader in performance analytics, cybersecurity threat detection and end user experience solutions for both service providers and enterprises.

Accedian Skylight enables granular and accurate real-time visibility, anomaly detection, and analytics on the performance of private 5G networks and applications.

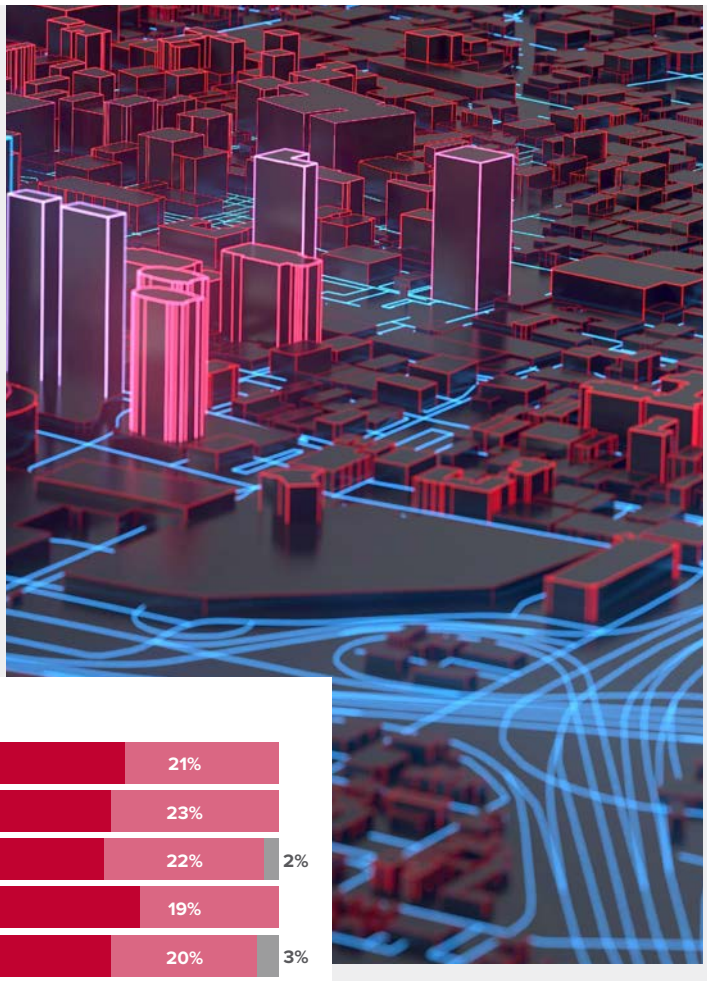
Sterling Perrin
Senior Principal Analyst,
Optical Networks & Transport
Heavy Reading

5G Transport Networks

5G deployment drivers are shifting as the focus moves beyond just faster speeds (primarily for consumer markets) to also include new markets and new services (heavily targeting enterprises). The shift to advanced 5G services has big implications for not just the radio network, but also the supporting transport network, including fronthaul, midhaul, and backhaul—collectively called "xhaul."

Key takeaways

- Outdoor/mountable deployments top the list of 5G transport priorities in this year's survey, selected as "critical" by 24% of operators surveyed. The result points to the importance of small cells in 5G deployment plans, in which equipment will be placed on street poles and on buildings that are closest to users. Following in priority are segment routing ("critical" for 23%) and TSN ("critical" for 22%). While TSN has registered consistently high interest in past surveys, Heavy Reading notes that segment routing has climbed up the priority list.
- Survey data shows solid interest in fronthaul connectivity for RAN centralization globally. Over two-thirds (68%) of operators surveyed expect at least 25% of their macro cell sites to contain fronthaul connectivity by the end of 2024. At 44%, a plurality of respondents anticipate from 25% to 49% of their macro cells will contain fronthaul links within three years' time. Still, and as expected, far fewer operators anticipate "fronthaul everywhere" architectures. Just 24% of respondents believe more than half of their macros will connect with fronthaul by 2024.
- End-to-end network slicing is an important goal for many operators, but it will not be implemented across the network all at once. Slicing in the 3GPP mobile network is the first priority, with 39% of operators surveyed expecting to implement network slicing in the mobile core and/or RAN by the end of 2023. Slicing timelines in the transport network lag well behind the 3GPP mobile network, with just 24% of respondents expecting soft slicing implementation by the end of 2023.



Heavy Reading has been tracking the evolution of 5G transport technologies for several years, including in previous editions of this project. This year's survey yields some changes and new findings. As shown in Figure 26, topping the rankings of critical 5G transport technologies are outdoor deployments (selected as "critical" by 24% of respondents), segment routing ("critical" for 23%), and TSN ("critical" for 22%).

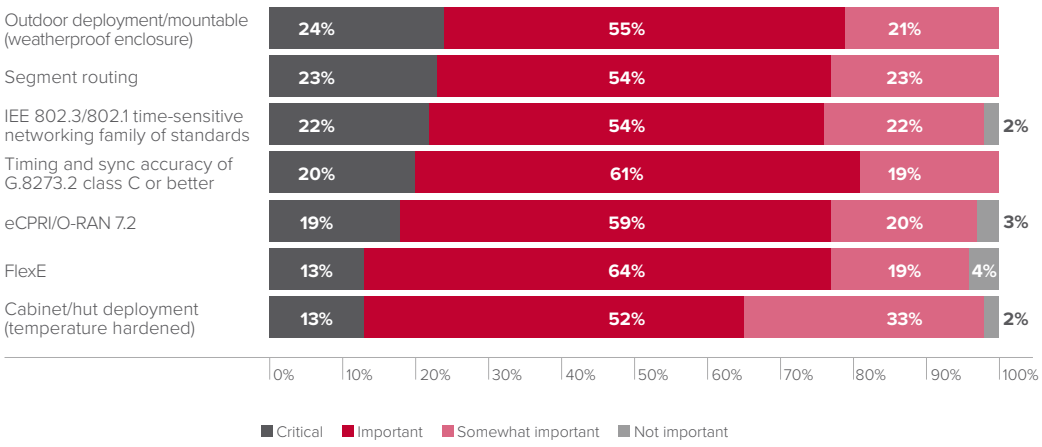
Timing and synchronization accuracy and eCPRI/O-RAN 7.2 occupy the middle rung in terms of significance, selected as "critical" by 20% and 19% of operators surveyed, respectively. Lastly, on the bottom rung are FlexE and cabinet/hut deployments, each selected as "critical" by just 13% of operators.

Interestingly, the two equipment housing options bookend the operators' priorities list—with outdoor/mountable deployments at the top and cabinet deployments at the bottom. The results perhaps point to the importance of small cells in 5G deployment plans, in which equipment will be placed on street poles and buildings that are closest to users.

The high prioritization of segment routing is also a surprise in this year's survey, as the technology option ranked lower in the 2021 edition. Segment routing is eyed as an important option for network slicing in the transport network. This soft slicing option is typically envisioned to work in combination with Ethernet VPNs (EVPNs) to target different granularities of services. On the other hand, the hard slicing option, FlexE, ranks last on the priorities list—indicating that hard slicing will be used far less frequently than soft slicing.

As expected, time remains crucial in 5G, whether it is the IEEE TSN family of standards used to prioritize packetized fronthaul and URLLC enterprise traffic or G.8273 class C timing and synchronization to meet strict timing requirements for clocks in 5G, particularly for fronthaul.

Fig26: How important are the following to your 5G transport platforms?



Source: Heavy Reading *n=84*

> "The shift to advanced 5G services has big implications for not just the radio network, but also the supporting transport network, including fronthaul, midhaul, and backhaul—collectively called "xhaul."

Fronthaul connectivity supports centralized RAN architectures in which operators seek the efficiencies that come from centralized (i.e., pooled) baseband resources and tight coordination across radios. Centralization can also be implemented in conjunction with RAN virtualization (or cloud RAN).

Heavy Reading survey data continues to show solid interest in fronthaul connectivity for RAN centralization globally. Figure 27 shows over two-thirds (68%) of operators surveyed expect at least 25% of their macro cell sites to contain fronthaul connectivity by the end of 2024. At 44%, a plurality of respondents anticipate from 25% to 49% of their macro cells will contain fronthaul links within three years' time. As expected, far fewer operators anticipate "fronthaul everywhere" strategies. Just 24% of respondents believe more than half of their macros will connect with fronthaul by 2024.

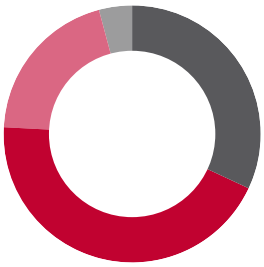
An important point to note is that RAN centralization plans vary significantly by geographic region, with US operators leading the charge. Parsing the data by geography, 82% of US respondents expect at least 25% of their macro cell sites to use fronthaul connectivity by year-end 2024, compared to just 59% of their RoW counterparts—representing a significant spread of 23 percentage points.

Network slicing is an important capability of the 5G system, and transport slicing will be required for end-to-end slicing to become reality. As noted earlier, transport slicing comes in two broad categories—soft slicing and hard slicing—and each has its own set of techniques. To gain a better understanding of slicing priorities, Heavy Reading asked operators to identify timelines for various network slicing approaches.

As shown in Figure 28, slicing in the 3GPP mobile network domain is the first priority in terms of timelines. 39% of operators surveyed expect to implement network slicing in the mobile core and/or RAN by the end of 2023, well ahead of any of the other options listed. (Note that the question did not ask respondents to distinguish between mobile core and RAN.)

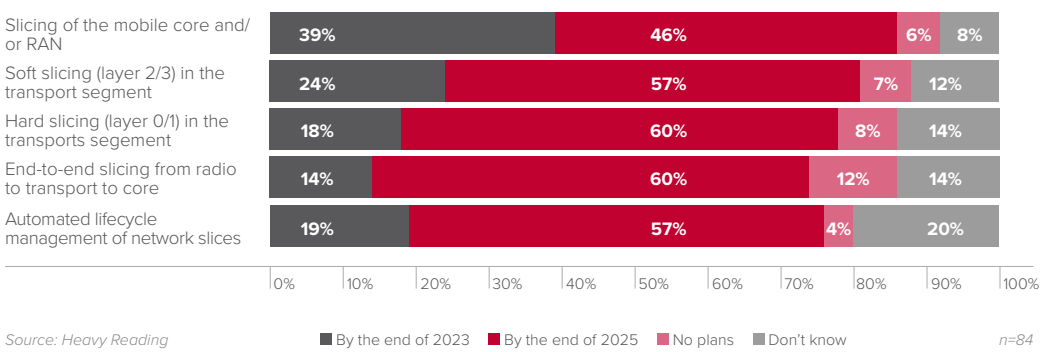
Slicing timelines in the transport network lag well behind the mobile network, with just 24% of respondents expecting soft slicing implementation by the end of 2023 and fewer still (only 18%) expecting hard slicing during that timeframe. The gap between mobile network slicing and transport network slicing is important because both mobile and transport slicing will be required for an end-to-end sliced network. Just 14% of operators surveyed believe end-to-end slicing will be in place by 2023.

Fig27: What percentage of your company's 5G macro cell sites is expected to contain fronthaul functionality by the end of 2024?



Source: Heavy Reading *n=84*

Fig28: Which approaches to network slicing is your organization considering, and when?



Source: Heavy Reading *n=84*

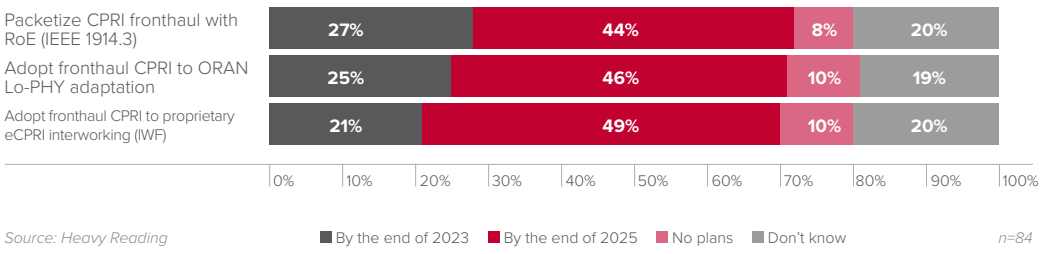
For the longer term, results are more encouraging, as operators expect transport slicing deployments to advance rapidly between the years 2024 and 2025 (especially for soft slicing). As a result, nearly three-quarters (74%) of operator respondents expect end-to-end network slicing in their networks by year-end 2025.

Because of the massive installed base of legacy CPRI connections, efficiently handling a mix of both eCPRI and legacy CPRI traffic will be required for most operators building fronthaul connectivity for 5G. Operators have several CPRI transport options available to them, including packetized fronthaul using IEEE 1914.3 Radio over Ethernet (RoE), O-RAN-compliant CPRI to eCPRI conversion, and proprietary CPRI to eCPRI conversion.

Survey results indicate that through 2023, and even through 2025, all three approaches will be used for CPRI (Figure 29). In the near term, RoE has a slight adoption edge over CPRI to eCPRI conversion (with 27% expecting RoE by 2023 vs. 25% expecting O-RAN). However, by 2025, respondents expect RoE and O-RAN adoption in equal measure (with each approach selected by 71% of respondents).

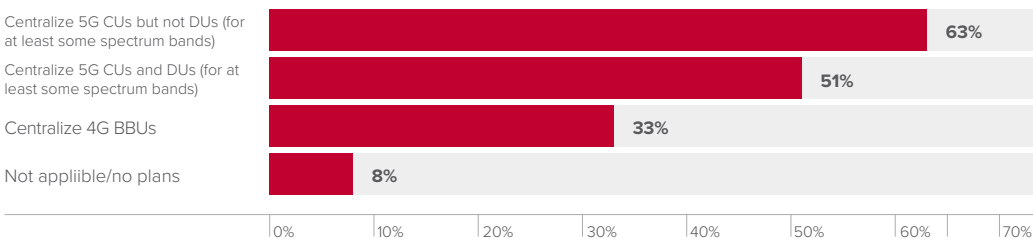
Interestingly, operators also expect to adopt proprietary CPRI to eCPRI interworking in virtually equal proportion, with 70% of respondents expecting proprietary interworking adoption by year-end 2025. Despite the industry attention that O-RAN receives, operators will continue to rely significantly on vendor-specific implementations for fronthaul, at least over the next four years.

Fig29: Which approaches to CPRI fronthaul are you considering adopting, and when?



Source: Heavy Reading *n=84*

Fig30: Which centralized RAN architectures do you plan to deploy within in the next three years? (Select all that apply)



Source: Heavy Reading *n=84*

Several options exist for RAN centralization. Full centralization of the baseband components requires fronthaul connectivity with CPRI and eCPRI, but a partial centralization of only the centralized unit (CU) function results in a midhaul transport segment handled by Ethernet. Additionally, some operators are choosing to centralize their 4G RANs along with 5G.

Over the next three years, the most popular option will be CU-only centralization with a distributed unit (DU), selected by nearly two-thirds (63%) of operator respondents (Figure 30). One key appeal of this centralization approach is that it eliminates the requirement for fronthaul—which, despite its benefits, is the most challenging segment to build. Still, full centralization is also expected to be popular, as CU and DU centralization was selected by 51% of the survey group. A significant minority of the survey group is also interested in centralizing the 4G RAN, with this option selected by one-third (33%) of operators.

As with other aspects of RAN centralization highlighted in this survey, differences exist when comparing US and RoW results. Most notably, US operator interest in CU-only centralization is much higher compared to RoW operators. 71% of US respondents selected CU-only centralization versus 57% in RoW—a 14-percentage-point difference. ■

ciena

Executive Summary

Ciena (NYSE: CIEN) is a networking systems, services and software company. We provide solutions that help our customers create the Adaptive NetworkTM in response to the constantly changing demands of their end-users. By delivering best-in-class networking technology through high-touch consultative relationships, we build the world's most agile networks with automation, openness and scale.

Jim Hodges
Research Director, Cloud,
and Security
Heavy Reading

5G Security

Many mobile operators are now well into the execution phase of commercializing their 5G core and RAN networks. One of the key considerations in this execution process is the definition and implementation of the unique 5G security capabilities vital to support cloud native services in centralized and edge cloud configurations.

Key takeaways

- Mobile operators, US operators especially, are confident that they have in place effective security strategies that will enable them to support and secure 5G services.
- These strategies rely on several foundational capabilities to secure 5G infrastructure and devices. Leading the way here are “trusted hardware” (46%) and “identity and access management” (43%) for infrastructure security. Trusted hardware is also considered a critical component for securing edge infrastructure (48%) and even device endpoints (46%).
- The survey respondents believe that as edge deployments scale, they will need to evolve their security strategies and focus on “policy compliance scanning” (66%), “implementing zero-trust principles” (59%), and “encryption of data at rest” (50%).

While operators' 5G security strategies will vary due to specific regional market and threat requirements, as Figure 31 documents, globally some common capabilities will play a strategic role in the execution.

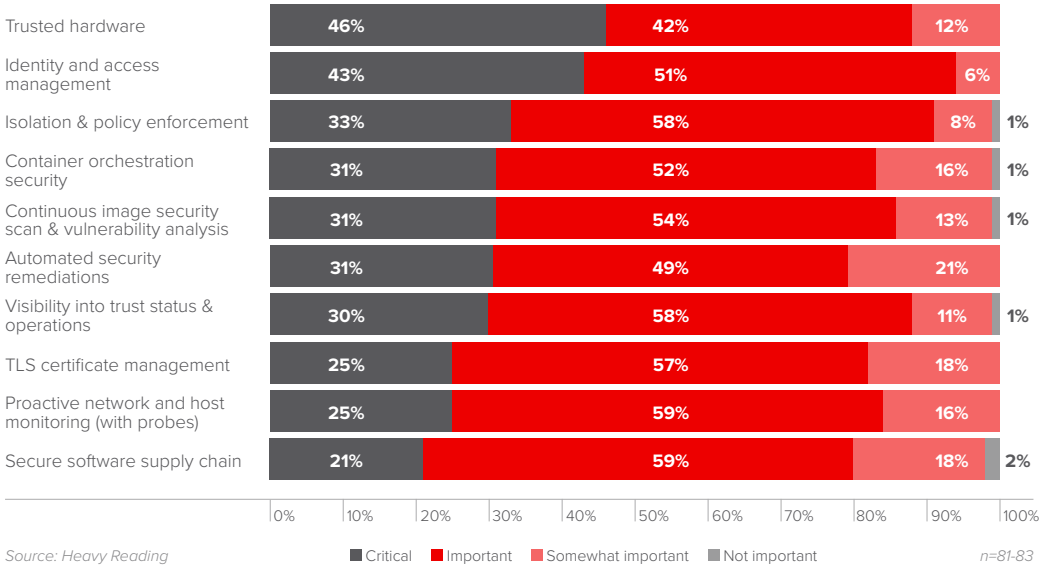
Of these, the two that stand out based on "critical" inputs are the well-established security fundamentals of "trusted hardware" (46%) and "identity and access management" (43%).

Other newer capabilities bundled in the 30–33% range, such as "isolation & policy enforcement" (33%), "container orchestration security" (31%), "continuous image security scan & vulnerability analysis" (31%), "automated security remediations" (31%), and "visibility into trust status & operations" (30%), also resonated with the survey respondents. These results confirm that orchestration, policy, and automation are also key components.

One consideration that a mobile operator must address in its security strategy is prioritizing the specific security capabilities that will be most important for securing edge infrastructure. As Figure 32 shows, based on "critical" inputs, the top three capabilities are not that different from the capabilities documented directly above.

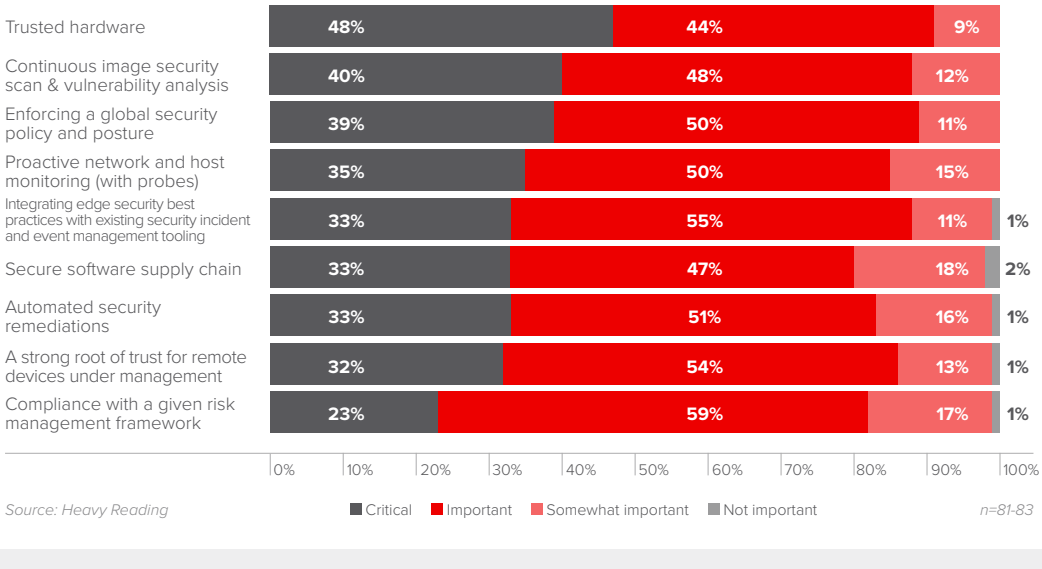
This includes "trusted hardware" (48%) attaining the highest ranking. Other capabilities of note include the second-place scoring of "continuous image security scan & vulnerability analysis" (40%), which moved up from its fourth-place ranking in Figure 31, and "enforcing a global security policy and posture" (39%).

Fig31: How important are the following capabilities for securing 5G infrastructure at your company?



Source: Heavy Reading *n=81-83*

Fig32: How important are the following capabilities for securing edge infrastructure at your company?



Source: Heavy Reading *n=81-83*

Consistent with the previous figure inputs, several capabilities fell into a narrow data range (32–35%). "Proactive network and host monitoring (with probes)" (35%) leads the pack, followed closely by "integrating edge security best practices," "secure software supply chain," and "automated security remediations" (all 33%).

Based on these two inputs, it is clear that 5G security will rely on a number of important capabilities both in the core and at the edge. Leading the way are trusted hardware and capabilities that enable the ability to support continuous image scanning and adaptive and automated policy control.

"Many mobile operators are now well into the execution phase of commercializing their 5G core and RAN networks."

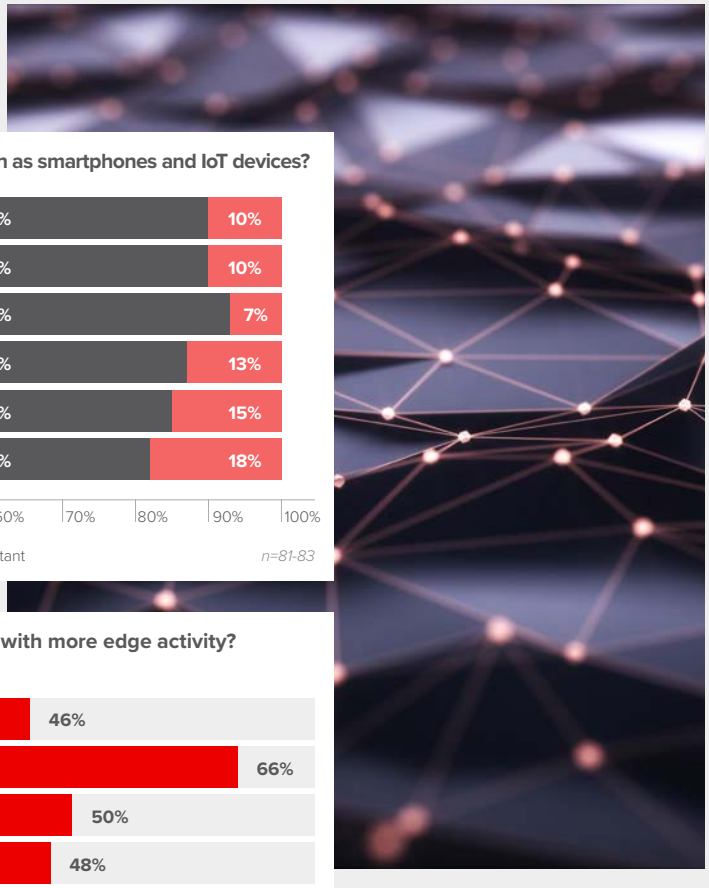
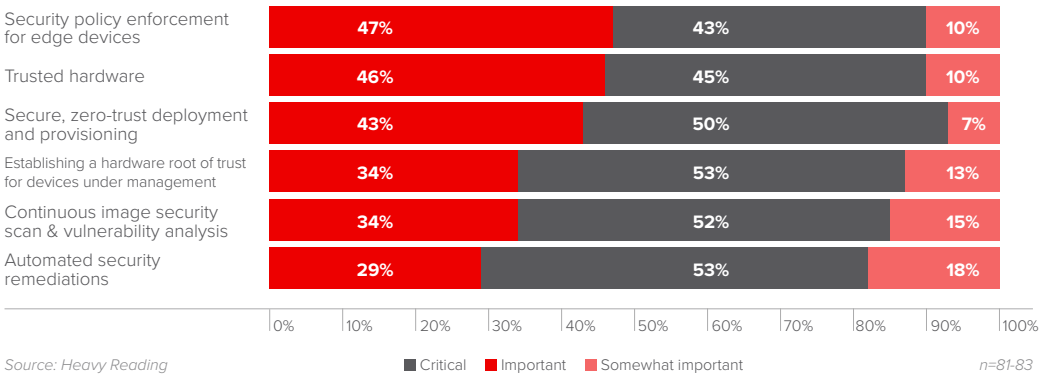
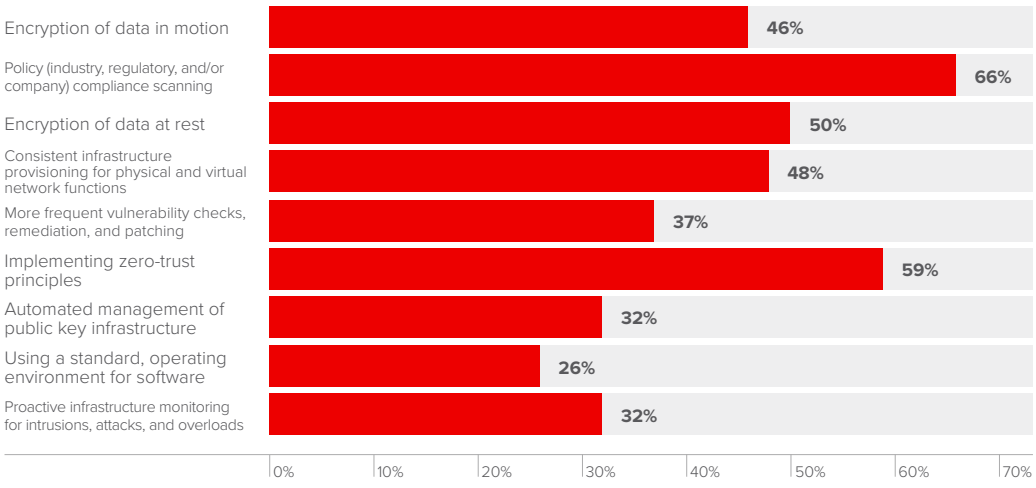


Fig33: How important are the following capabilities for securing endpoints, such as smartphones and IoT devices?



Source: Heavy Reading *n=81-83*

Fig34: How will your company evolve its security strategy, as 5G emerges with more edge activity?
(Select all that apply)



Source: Heavy Reading *n=82*

All generations of mobile technology have introduced new types of mobile devices with new form factors, enhanced performance metrics, and storage capabilities. 5G will not disappoint in this regard with the ability to support ultra-low latency cloud native services. However, with these new capabilities comes a greater risk that these new devices can be "weaponized" to support cyber-attacks. This applies to not only smartphones, but also IoT devices that will be crucial to fuel machine-to-machine (M2M) service innovation.

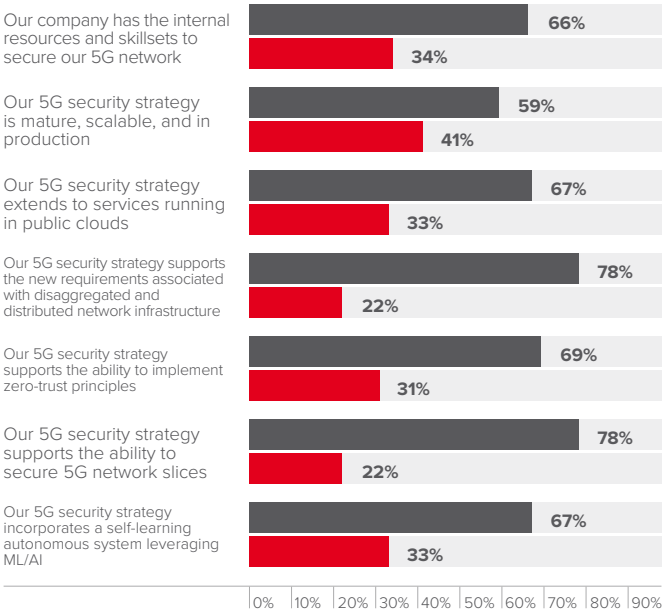
To address these new device-centric threats, mobile operators will also need to support new capabilities to secure these devices. As Figure 33 illustrates and as seen with infrastructure, based on "critical" inputs, policy-related capability, specifically "security policy enforcement for edge devices" (47%), is a top consideration.

"Trusted hardware" (46%), consistent with previous input, scored highly, attaining a second-place ranking. In third place with a score of 43% is "secure, zero-trust deployment and provisioning," which, in Heavy Reading's opinion, reinforces the importance of adopting zero-trust provisioning for cloud networks.

The next question in the survey provided additional granular security insights into the impact of the evolution and adoption of 5G services at the edge. As Figure 34 illustrates, there are several top-of-mind concerns. Of these, "policy compliance scanning" attained the highest ranking (66%), followed closely by "implementing zero-trust principles" (59%) and then "encryption of data at rest" (50%).

Other capabilities of note include "consistent infrastructure provisioning for physical and virtual network functions" (48%) and "encryption of data in motion" (46%). Heavy Reading views this data as reinforcing the importance of zero-trust principles and the value of policy-based scanning, as well as confirming the value of data encryption at the edge.

Fig35: Do you agree or disagree with the following statements?



Source: Heavy Reading

The final question of this section assessed overall operator 5G-related security confidence and strategy readiness. As Figure 35 shows, despite the challenges, 78% of the respondents believe that their "5G security strategy supports the new requirements associated with disaggregated and distributed network infrastructure" and will even support "the ability to secure 5G network slices" (78%).

They also are confident that their 5G strategy will support all-important zero-trust principles (69%) and will incorporate a "self-learning autonomous system leveraging [machine learning/ artificial intelligence] ML/AI" (67%) and even "services running in public clouds" (67%).

The one area where respondents' confidence is lower relates to the maturity of their security strategy and ability to scale and be production-ready (59%). Unlike the other questions in this section in which the data trends between the US and RoW respondents were quite similar, a greater number of US respondents agree that their 5G security strategies were mature, scalable, and in production compared to their RoW counterparts (US =76%; RoW = 48%). One factor likely influencing the variance is that 88% of US respondents agree that they have the internal resources and skill sets to secure their 5G network compared to only 51% of RoW respondents. As a result, a lower percentage of RoW operators agree they are ready to implement zero-trust principles (US = 79%; RoW = 63%) and 5G network slices (US = 88%; RoW = 71%). ■

> "Mobile operators, US operators especially, are confident that they have in place effective security strategies that will enable them to support and secure 5G services."

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.