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5G NETWORK & SERVICE STRATEGIES SURVEY REPORT

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INTRODUCTION

The Heavy Reading **5G Network & Service Strategies Operator Survey** is designed to provide the industry with insight into how operators will deploy 5G networks, to identify the services strategies that will drive investment, and to reveal likely timelines for commercialization. The questionnaire, developed in association with sponsors, was fielded to respondents in the Light Reading database in January 2019. The survey was open only to employees of communications service providers.

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

- Deployment Timelines & Services
- Radio Access Network (RAN) Evolution for 5G New Radio (NR)
- Mobile Edge Networking & Cloud
- 5G Transport & Backhaul
- 5G Network Slicing
- 5G Core Network

After removing rogue and non-operator responses, the survey garnered a total of 147 respondents. The demographics are shown in **Figure 1**. The largest respondent groups were technical, engineering, and network operations personnel from large operators in advanced markets. The U.S. was the dominant region, with as many responses as the Rest of World (RoW) combined; however, all major global regions were well represented.

At places in this analysis, Heavy Reading compares responses from different demographic groups. For example, we isolate responses from mobile-only and converged fixed/mobile operators or consider responses from R&D, technology strategy, and engineering roles. Where this is the case, it is noted in the text. The number of respondents is 147 unless otherwise stated. ■

Report Authors

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

Gabriel leads mobile network research for Heavy Reading. Starting from a system architecture perspective, his coverage area includes RAN, core, and service-layer platforms. Key research topics include 5G, LTE Advanced, virtual RAN, software-based mobile core, and the application of cloud technologies to mobile networking.

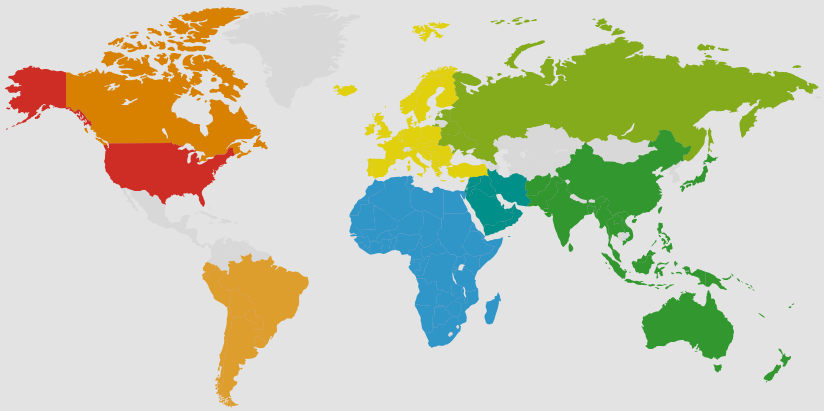
Gabriel is based in London and can be reached at brown@heavyreading.com.

Author: Sterling Perrin
Principal Analyst
Heavy Reading

Sterling has more than 15 years' experience in telecommunications as an industry analyst and journalist. His coverage areas at Heavy Reading are optical networking and SDN. He also authors Heavy Reading's PacketEnabled Optical Networking Market Tracker and Next-Gen Core PacketOptical Market Tracker.

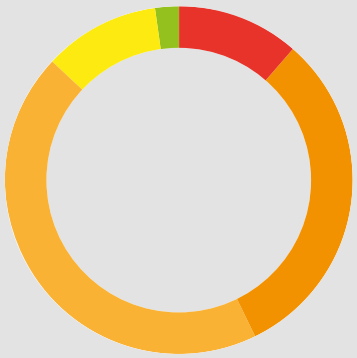
Fig 1: Survey Respondent Demographics

In what region is your organization headquartered?



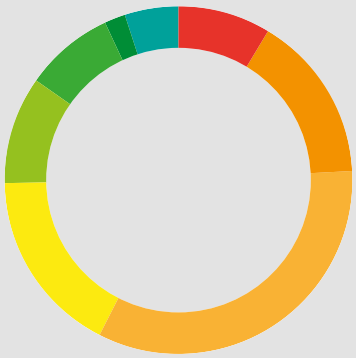
- U.S 48.30%
- Canada 6.80%
- Central/South America 8.20%
- Western Europe 6.80%
- Central/Eastern Europe 8.80%
- Asia/Pacific (including Australia) 16.30%
- Middle East 2.70%
- Africa 2.00%

What type of communications service provider (CSP) do you work for?



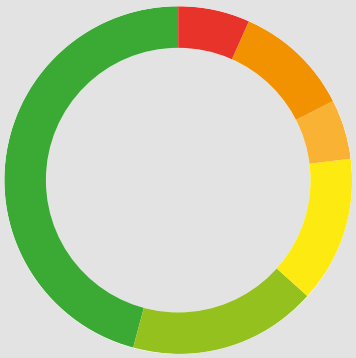
- Fixed network CSP 11.60%
- Mobile network CSP 31.30%
- Converged network CSP (fixed and mobile) 44.20%
- Cable or satellite CSP 10.90%
- Other CSP 2.00%

What is your primary job function?



- Corporate management 8.80%
- R&D or technical strategy 15.60%
- Network planning & engineering 33.30%
- Network operations 17.00%
- IT, data center & cloud domain 10.20%
- Product management, sales & marketing 8.20%
- Product Marketing 2.00%
- Other 4.80%

What are your company's approximate annual revenues?



- Less than $50 million 6.80%
- $50 million to $200 million 10.90%
- $201 million to $500 million 5.40%
- $501 million to $1 billion 13.60%
- $1 billion to $5 billion 17.70%
- More than $5 billion 45.60%

SPECTRUM AND NETWORK DENSITY PAVE THE WAY TO 5G SUCCESS

Chris Pearson

Chris Pearson
President
5G Americas

Chris Pearson is the President of 5G Americas, an industry trade association focused on the development and deployment of 5G and LTE throughout the Americas region. Membership is comprised of leading service providers and manufacturers. As the "voice of 5G and LTE for the Americas," the association contributes to the progress of technology requirements and advocates for regulatory and spectrum policy. 5G Americas is a leading resource for technology information and regularly publishes whitepapers available at www.5gamericas.org.

Transformation and Innovation are the foundation of a technological revolution! This wave of revolution is being embraced by the ICT community in the latest generation of mobile technology. 5G is set to change everything. With growing anticipation, countries around the world are rapidly progressing to address the opportunities of a smart connected world.

The technology advancement is fueled by the convergent work of operators, vendors and regulators, particularly in the U.S., helping to achieve several major milestones toward making 5G a commercial reality. In order to support development and deployment of 5G, the Federal Communication Commission's (FCC) September 2018 ruling helped mobile operators in deploying 5G cell sites more efficiently, more timely and with more predictable costs.

Here are key highlights from the FCC ruling:

- When processing applications such as zoning requests and managing deployments in public rights-of-way deployments, state and local governments must make their fees transparent and reasonably priced. This helps address the red tape and bureaucratic uncertainty that frequently delayed 2G, 3G and 4G deployments and often resulted in surprise costs.

- The FCC created 60- and 90-day "shot clocks" that state and local governments must follow when reviewing applications for small cells. These ensure that mobile operators and site companies have predictable regulatory timetables when developing and executing their buildout plans.

- State and local governments now have FCC guidance for determining when their aesthetic and undergrounding requirements are onerous to the point of effectively prohibiting 5G sites.

By addressing these and other regulatory roadblocks, the FCC placed the U.S. on a path toward creating 3 million jobs and $500 billion in economic growth that Accenture expects 5G to enable. Also, more than twenty states have done their part by providing similar guidance to encourage the development and deployment of smart cities and rural connectivity through 5G networks.

Yet, there is much work left to be done. The U.S. and the rest of Americas risk falling behind other countries—not just in terms of 5G coverage and subscriptions, but also in respect to the economic and societal benefits that 5G will enable.

Ample Spectrum and Unprecedented Network Density are Key

Twenty years ago, practically every industry presentation had a "hockey stick" slide predicting that mobile data traffic would skyrocket. Precisely that happened and the trend shows no signs of abating. AT&T, for example, says its data traffic increased more than 360,000 percent from 2007-2017.

According to the 5G Americas' white paper, LTE to 5G: The Global Impact of Wireless Innovation by Rysavy Research released in 2018, 5G uses spectrum much more efficiently than 4G. But that will go only so far in enabling operators to keep up with customer demand. Operators require increased spectrum to efficiently deploy 5G and to deliver its transformational capabilities. This is a key reason for which 5G Americas and its operator and vendor members are encouraging the FCC and National Telecommunications and Information Association (NTIA) to study, allocate and auction various low, mid and high bands.

In essence, these U.S. agencies are laying the foundation for a futuristic connected smart and enabled country. Even though the U.S. is a leader in identifying and allocating millimeter wave (mmWave) high band spectrum, it needs to continue the leadership approach by being responsive and providing more spectrum below 6 GHz. Many countries are competing to lead the world in 5G are rampantly allocating and auctioning both mmWave and mid-band spectrum for 5G.

"Our chief responsibility will be finding enough spectrum to support competitive, ubiquitous and secure 5G in America," NTIA Assistant Secretary of Commerce for Communications and Information David J. Redl said in April 2018. "To get there, we need to have spectrum available across the low, mid and high bands. We have been very successful in leveraging existing interagency processes to assess which bands can be opened up – from the low bands all the way up through the millimeter wave range, and beyond."

Chronic spectrum shortage is one reason that 5G became the first cellular technology to use mmWave spectrum bands. FCC's September 2018 ruling proved to be a crucial milestone because the ultra-high frequencies are deemed significant for 5G. However, the higher the frequency, the shorter the distance a cellular communications signal will travel. Thus, to provide seamless 5G coverage in cities and suburbs using mmWave bands, mobile operators need a much higher density of cell sites than they did previously for LTE at lower spectrum bands. The FCC's cell site streamlining ruling ensures that operators are enabled to deploy 5G sites faster than they could under most pre-existing traditional state and local regulations. Cell sites are critical to providing good coverage for customers.

Build It and They Will Come—Again

Spectrum and network density are principle ingredients for 5G success -- and that success provides for innovation to ignite positive change in our society. Tremendous growth came about because 4G changed the connected society by enabling new businesses and new ways for people to communicate. With 5G, the changes will be many times greater. For example, taking a look in the future:

- Data will continue its' tremendous growth. In Cisco's November 2018 VNI report they forecast that global data traffic will grow at a CAGR or 46 percent between 2017 and 2022, reaching 77.5 exabytes per month by 2022

- New business models will develop. Consider all the household brands that were founded after the first commercial 4G networks in the U.S. were launched in 2010, such as Instagram, Lyft and Snapchat. These are multi-billion-dollar companies built on the ubiquitous broadband connectivity that 4G enables, and also examples of how businesses and consumers are increasingly making mobile their primary connection.

- Wireless will be the future. In 2017, wired devices were already less than half of all global IP traffic, according to Cisco's Visual Networking Index. By 2022, mobile and other wireless traffic will grow to 71 percent. Connected devices will provide automation and smart everything – smart cities, homes, factories.

5G will innovate all areas of our lives. Whether through smart factories and industrial automation, smart cities, Ultra-Reliable Low-Latency Critical Communications (URLLC), Vehicle-to-Everything (V2X) communication, wearables, Virtual Reality and Augmented Reality, enhanced security -- no one knows what will be the next Instagram, Lyft and Snapchat of the next decade.

But if history is our guide, 5G will be critical to enabling all of them. That is a connected future being built by innovative operators around the world today – for the benefit of society tomorrow! ■

DEPLOYMENT TIMELINES & SERVICES

Author: Gabriel Brown, Principal Analyst - Mobile Networks & 5G, Heavy Reading

When 5G will be deployed commercially and how fast it becomes a mass-market service is of great interest to all parts of the mobile industry value chain.

THE KEY FINDINGS FOR THIS SECTION ARE AS FOLLOWS:

On a 2-year view, the largest group of respondents **(33%)** say "faster end user speeds" is the primary driver for 5G, followed by "system capacity and efficiency" **(27%)**. Over a 5-year view, the ability to "address new markets & services" climbs from last place to first place in the ranking, with **47%** of the response, significantly above all other scores.

A majority of respondents expect to launch 5G in the 2018-2020 period **(69%)**, which is in line with operator statements in advanced markets. In terms of the mass market, however, the majority **(59%)** sees 2021-2023 as most likely timeframe for commercial services.

Heavy Reading asked when operators think more than 25% of their subscriber base will have a 5G device. Only **12%** think this will happen by 2020. The ramp up appears to start in the 2021-2022 period **(33%)**. However, the majority of respondents **(55%)** do not think this will occur until 2023 or later (**40%** 2023-2024 and **15%** 2025 or later).

Heavy Reading asked operator respondents to identify the primary drivers for 5G deployment over 2- and 5-year time horizons. On a 2-year view, the largest group (33%) say "faster end user speeds" is the primary driver for 5G, followed by "system capacity and efficiency" (27%) and "competitive reasons" (23%).

This indicates the major selling point for 5G in the first few years will be faster mobile broadband. The ability to offer faster downlink data rates is marketable and contributes to the operator's competitiveness. Initially, then, the basic service stays familiar (mobile broadband), but performance and efficiency improve.

Over a 5-year view, the finding is very different. The ability to "address new markets & services" climbs from last place to first place in the ranking, with 47% of the response, significantly above all other scores. This indicates operators remain committed to the vision of 5G as an enabler of new services and business models across diverse industry sectors. They do not expect this to materialize at the start of 5G, but over the medium term. This result emphasizes that 5G should be viewed in terms of the 10-year, or longer, technology cycle typically associated with a new "G" **(Fig 2).**

After years of build-up, anticipation for 5G is at its height. The first precommercial mobile networks are now operational in the U.S. and South Korea, and a significant number of operators in advanced markets have publicly stated their intention to launch service in 2019. This question asks about timelines for initial commercial services and mass-market 5G services to distinguish between the excitement of service launch and the availability to a wider customer base.

A majority of respondents expect to launch 5G in the 2018-2020 period (69%), which is in line with operator statements in advanced markets. In terms of the mass market, however, the majority (59%) sees 2021-2023 as most likely timeframe for commercial services. Note that 2021-2023 scores as high as 71% in RoW (not reflected in the figure), indicating that U.S. respondents are more bullish than their international peers **(Fig 3).**

Across all demographic categories, smart cities are identified as the most attractive use case for 5G, far ahead of other options presented. This is consistent with previous Heavy Reading 5G surveys. One reason for this may be that smart cities encompass a wide range of use cases and applications – in many ways, they embody the 5G promise – and are therefore a safe choice for respondents. >

Fig 2 - What will be your company's primary driver in deploying 5G networks, in 2 years and in 5 years?

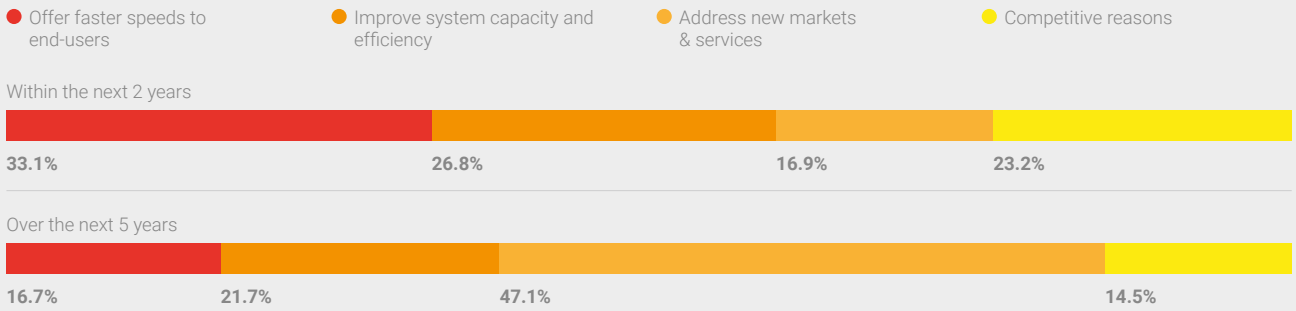


Fig 3 - When will your company launch 5G as a commercial proposition?

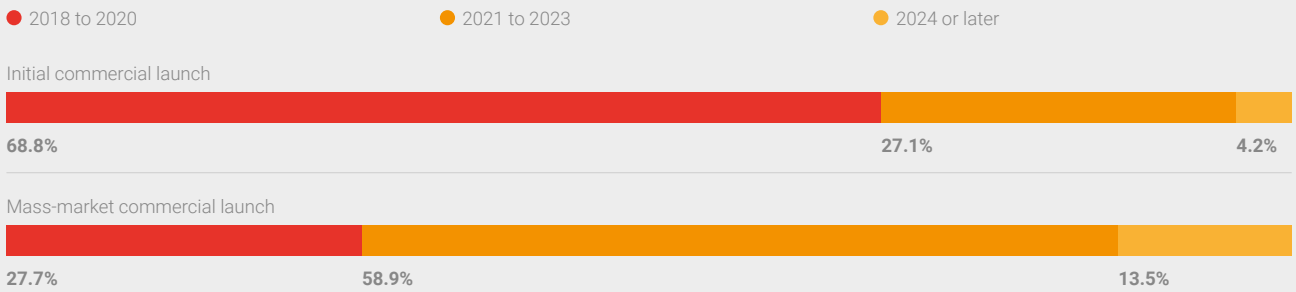
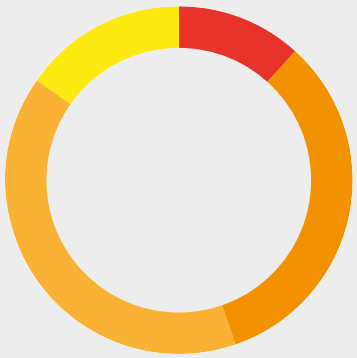


Fig 5 - By what year do you estimate more than 25% of your subscriber base will have a 5G compatible device?



- 2020 ..... **11.70%**
- 2021 to 2022 ..... **33.10%**
- 2023 to 2024 ..... **40.00%**
- 2025 or later **15.20%**

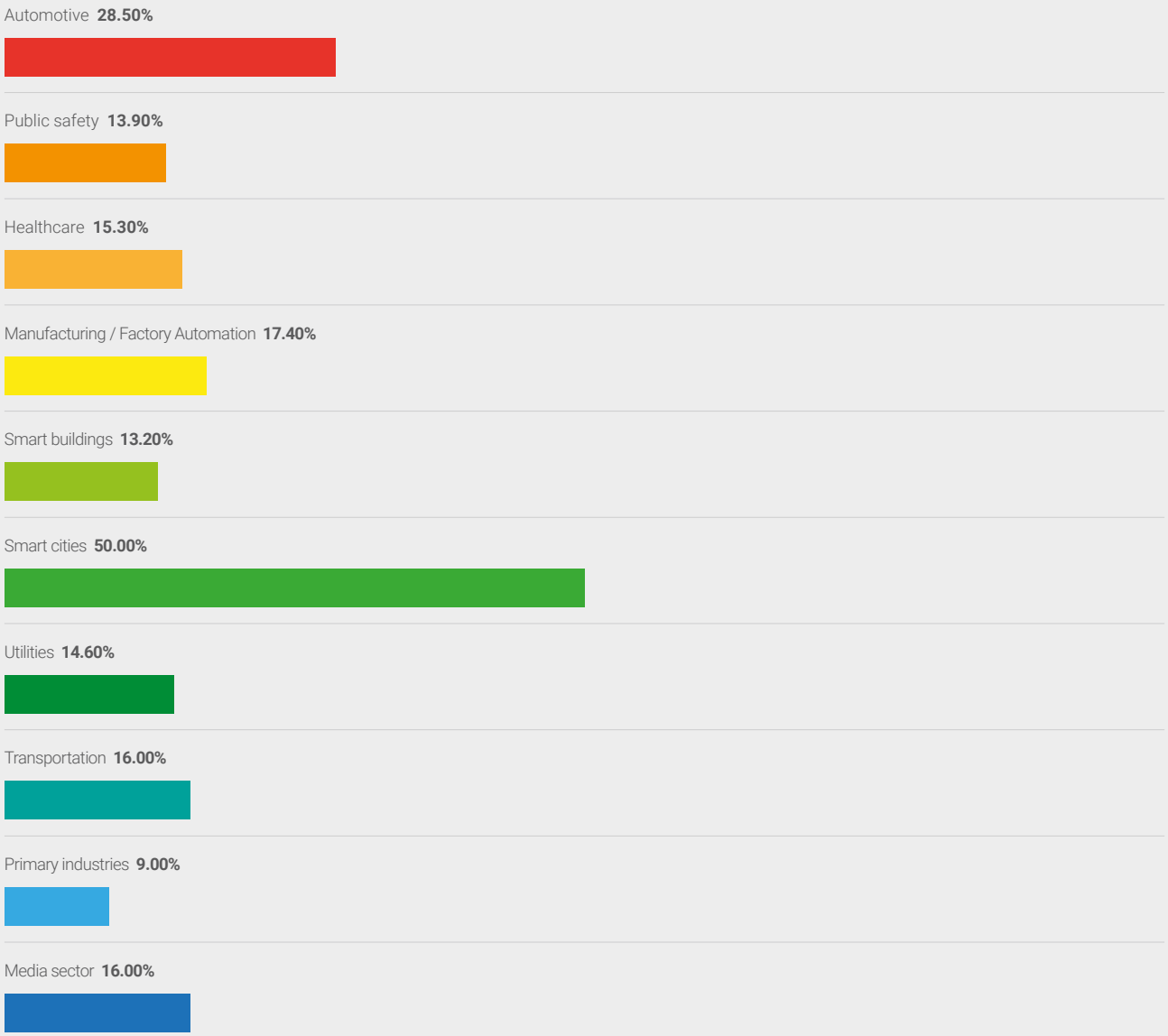
In second place, by a clear distance, is automotive. This makes sense in that many automotive applications can be uniquely served by mobile networks – there is no alternative connectivity on the highway **(Fig 4)**

Following the question about mass-market 5G, Heavy Reading asked when operators think more than 25% of their subscriber base will have a 5G device. Only 12% think this will happen by 2020. The ramp up appears to start in the 2021-2022 period (33%). However, the majority of respondents (55%) do not think this will occur until 2023 or later (40% 2023-2024 and 15% 2025 or later). Again, consistent with the prior finding, U.S. respondents are more bullish, with 52% expecting this threshold to be reached by 2023, versus 37% in RoW.

One factor to keep in mind is the lengthening replacement cycle for smartphones in most developed markets. It will be interesting to see to what extent 5G drives an acceleration in handset upgrades.

First- and second-gen devices tend to come with compromises (e.g., on power consumption, cost, and bugs). One might also expect the iPhone to add 5G later than challenger handset vendors – particularly the Chinese OEMs targeting the mid-range. On the other side, if 5G devices are mainly about modem upgrades, the timeline is tied to the performance, maturity, and availability of the chipset **(Fig 5)** ■

Fig 4 - Which market segments do you think are most attractive for 5G?



RAN EVOLUTION FOR 5G NR

Author: Gabriel Brown, Principal Analyst - Mobile Networks & 5G, Heavy Reading

How quickly operators deploy 5G coverage is of critical importance. Without coverage, services cannot be delivered and there is less incentive for consumers to upgrade devices. Heavy Reading expects operators to leverage their existing cell site footprint as much as possible and notes that 5G RAN products are being designed to enable site reuse

THE KEY FINDINGS FOR THIS SECTION ARE AS FOLLOWS:

43% of respondents think between 26% and 50% of their existing RAN footprint will have been upgraded to 5G in by the end of 2021.

Mid-band spectrum between 2 GHz and 6 GHz will be most popular for 5G deployment in the next 3 years, with **81%** of respondents selecting this option. This aligns with a view that mid-band Time Division Duplex (TDD) spectrum is the sweet spot for 5G, combining wide channel widths, technology maturity, spectrum availability, and decent coverage.

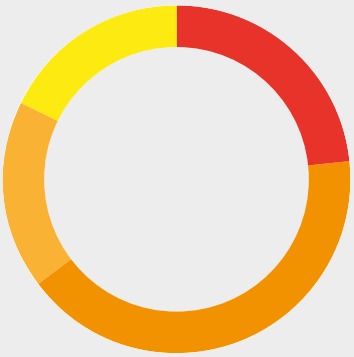
Operators clearly think that RAN densification is needed for 5G; however, the largest number (**52%**) say this will be "carefully targeted." A large **38%** say "significant densification in key areas" will be needed. Only **2%** say extreme densification is on the cards.

The response to the question “How much of your RAN footprint will be running 5G access, within the next three years (i.e. by the end of 2021)?” was somewhat cautious. 40% say they think less than 25% of their RAN footprint will have been upgraded in this timeframe, and 43% think between 26% and 50% of their RAN will support 5G in this timeframe.

This response could be interpreted as sensible and pragmatic; perhaps operators would like to avoid overhyping the rollout. It could, for example, reflect a view that 5G will be introduced for capacity relief in urban centers initially and then extended in line with traffic demand over time.

There is also a more bullish view contained within the survey data. If only the 17 responses from individuals working in technology strategy at large mobile-only operators are considered, the figure below shows that a majority expect to have deployed 5G on more than 25% of their footprint by 2021. This may be ambitious, but it is plausible where operators deploy 5G in low and mid-bands and where they are able to upgrade Long-Term Evolution (LTE) RAN in software to dual-mode LTE-NR operation **(Fig 6).**

Fig 6 - How much of your RAN footprint will be running 5G access, within the next three years (i.e. by the end of 2021)?



- Less than 25% **23.5%**
- 26 - 50% **41.2%**
- 51 - 75% **17.6%**
- More than 75% **17.6%**

Mid-band spectrum between 2 GHz and 6 GHz contains the most popular frequencies for 5G in the next 3 years, with 81% selecting this option versus 42% for above 6 GHz and 28% for below 2 GHz. This aligns with a view that mid-band TDD spectrum around 3.5 GHz (and perhaps at 4.5 GHz, 2.6 GHz, and 2.3 GHz) is the sweet spot for 5G, combining wide channel widths (relative to LTE), technology maturity, spectrum availability, and decent coverage **(Fig 7).**

This preference for mid-band holds across all demographics and regional segmentation of the data, with some uptick for millimeter wave (mmWave) in the U.S. versus RoW. Note also that this was a “select all that apply” answer that generated 217 responses from 147 respondents. Thus, quite a number of operators expect to deploy in multiple bands. >

Fig 7 - Which frequency bands do you expect to deploy 5G NR, within the next three years?

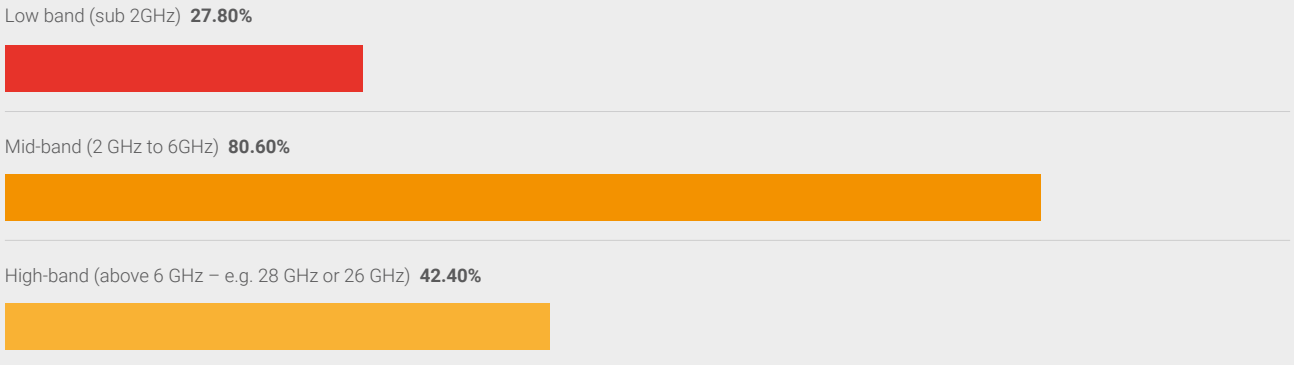
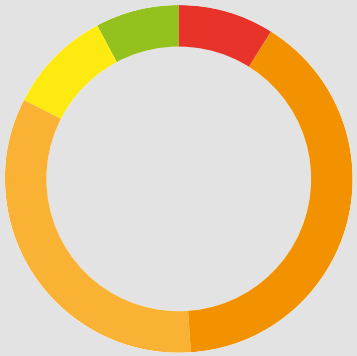
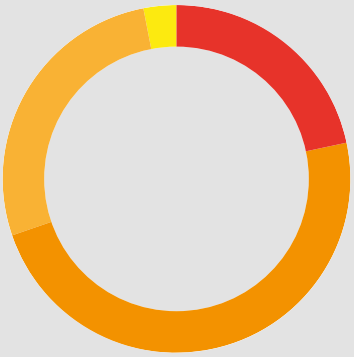


Fig 8 - What percentage of your sites (or cell sectors?) do you expect to migrate to Massive MIMO?



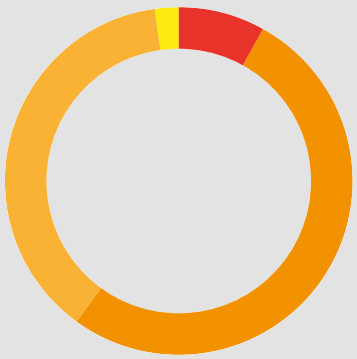
- Less than 10% **9.00%**
- 10 - 25% **40.00%**
- 26 - 50% **33.80%**
- 51 - 75% **9.70%**
- More than 75% **7.60%**

Fig 9 - What type of 5G base station model will be most widely used in your network?



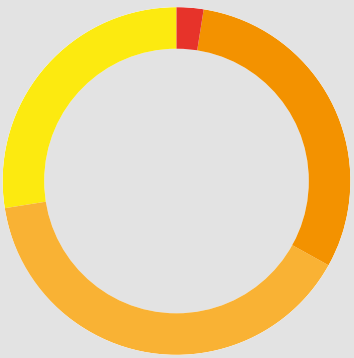
- Traditional Macro BTS **21.70%**
- Integrated RU/DU with separate CU **48.30%**
- Disaggregated base station with separate RRU + CU + DU **27.30%**
- Other (specify) **2.80%**

Fig 10 - Do you plan to densify your network with small cells to support 5G?



- No, not necessary **8.30%**
- Some densification, but carefully targeted **51.70%**
- Significant densification in key areas **37.90%**
- Extreme densification **2.10%**

Fig 11 - When do you expect mmWave technology to be mature enough to support mass market mobile broadband?



- Within 1 year **2.70%**
- Within 2 years **30.10%**
- Within 3 years **39.70%**
- More than 3 years **27.40%**

Massive multiple input, multiple output (MIMO) is one of the most important enabling technologies for 5G RAN. To determine how widely it might be deployed, Heavy Reading asked what percentage of the operator's sites it would expect to migrate to this new antenna technology. Just over half the of respondents (51%) say they would upgrade more than 25% of their sites to massive MIMO. However, only a relatively small number thought this would extend to more than 50% of their sites (18% of responses in total). The clustering of responses between 10% and 50% of sites is not very precise, but it does give a feel for the expected deployment of massive MIMO radio in the macro RAN. Given that massive MIMO is more useful in higher bands and wider channel widths and is less suitable for narrow channels at low bands, this result appears reasonable, especially if mmWave is discounted (mmWave uses massive MIMO by default) **(Fig 8).**

The 5G RAN architecture offers the potential for disaggregated base station equipment and novel deployment options in place of the traditional macro base station model. This is an exciting area with lots of potential. Nevertheless, Heavy Reading is surprised to see only 22% of respondents expect to use the traditional model in their 5G deployment because disaggregated RAN is still relatively new technology that is not yet available at scale from the major vendors. It is coming, but is not quite there yet. These results therefore make more sense if we think of them in terms of the models that operators might aspire to deploy. When looking at the responses from mobile-only operators in technical roles, the number expecting to use traditional macro base stations jumps to 41% **(Fig 9).**

Densification is important to meet demand in areas of high traffic density – for example, urban centers – and small

cells are a solution. However, they are also expensive in terms of site permissions, transport, site rental, equipment, maintenance, and so on. Operators only like to densify using small cells when they have a clear cost-benefit analysis to show it is worthwhile.

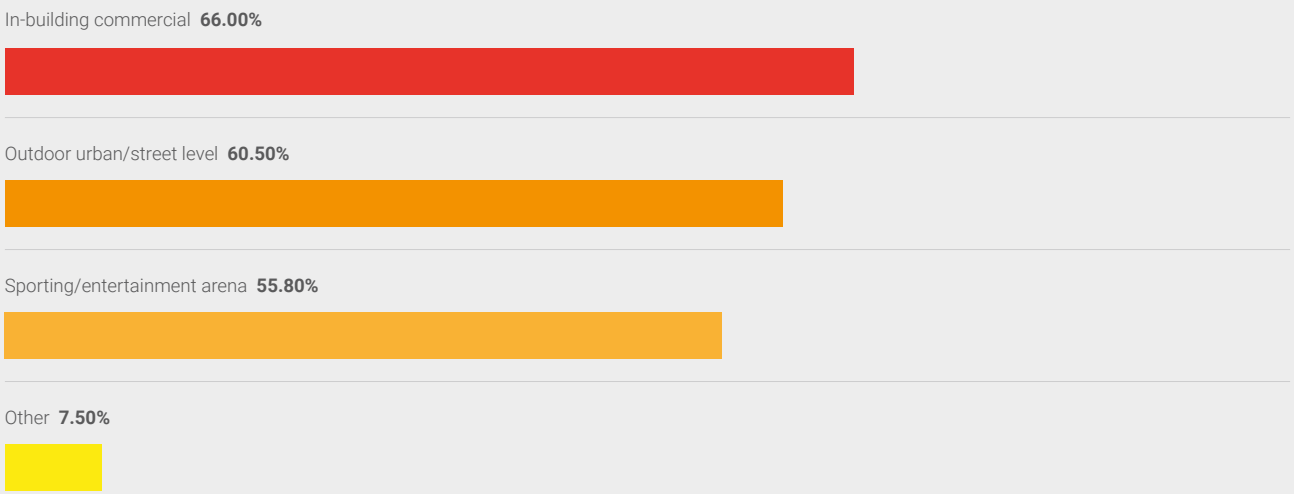
Responses to this question show that operators clearly think that densification is needed for 5G; however, the largest number (52%) say this will be "carefully targeted." A large 38% say "significant densification in key areas" will be needed, but only 2% say extreme densification is on the cards **(Fig 10).**

A major (potential) breakthrough in mobile systems is the ability to use mmWave spectrum. This is nothing less than a once-in-a-generation game changer. To date, mmWave has been used for fixed wireless access, wireless backhaul, and satellite systems; extending it to mobile is a new order of challenge. In this context, it is extremely interesting that AT&T has already launched precommercial mobile 5G using mmWave.

This question asks specifically about mass-market use of the technology for mobile. A solid 33% think the technology will be mature enough within 2 years (numbers are higher in the U.S. and lower in RoW). 40% think it will take longer than 2 years, but less than 3, and a not insignificant 27% think it will take more than 3 years **(Fig 11).**

In terms of where operators will use mmWave, quite a spread of environments will be targeted, without large differences in response to the options presented in the question. Note that this was a "select all that apply" question, which generated 279 responses from the 147 survey takers. This indicates that operators see mmWave technology as broadly applicable and not relegated to niche status **(Fig 12)** ■

Fig 12 - What deployment environments will be targeted for 5G mmWave bands (26-39 GHz)?



MOBILE EDGE NETWORKING & CLOUD

Author: Gabriel Brown, Principal Analyst - Mobile Networks & 5G, Heavy Reading

Edge networking and edge cloud are closely associated with 5G. It will be either impossible or very difficult to deliver advanced low latency 5G services without hosting application logic much closer to the user than is the case in today's centralized cloud architectures. In other cases, such as related to content delivery, there are potential economic and user experience benefits to edge cloud.

THE KEY FINDINGS FOR THIS SECTION ARE AS FOLLOWS:

Operators see opportunities for edge in their businesses, but understand that it is a wider movement, not restricted to telecom, that they can take advantage of. It is part of 5G, but not limited to 5G.

Operators think of edge services as incorporating input from a broad ecosystem of participants. **44%** of respondents say edge will enable a new category of apps that can be offered across operators; a lower **15%** think these edge applications would be specific to individual operators.

Only **10%** say they will launch edge services in 2019, but **35%** are already engaging with vendors and are in the process of moving toward proofs of concept (PoCs) and trials. That **41%** are still in the education phase and have not taken specific actions should temper hype for the near-term deployment and operation of edge, at scale, in mobile operator networks.

In this question, Heavy Reading wanted to understand how operators think about edge as relates to mobile networks in general and 5G specifically. Clearly, edge is not considered only, or even mainly, a 5G capability because just 14% say they associate it with "a set of 5G features."

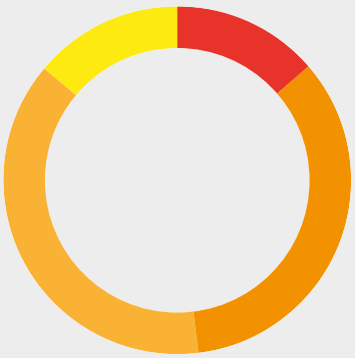
The two much larger responses, with 35% and 38%, respectively, think it is either an important new aspect of cloud or an opportunity to create a new set of low latency applications. From an operator respondent base, this response feels about right – they see opportunities for their business but understand that edge is also a wider movement they can take advantage of. It is not limited to 5G **(Fig 13).**

According to the survey response, Internet of Things (IoT) services and general enterprise apps will be the first to take advantage of edge to contribute to operator revenue. This aligns with some of the high density requirements of low power IoT (such as narrowband-IoT [NB-IoT] in 4G and 5G networks) and chimes with the prevailing market narrative. It can also speak to the low latency industrial IoT in applications such as factory automation. In general, however, more demanding services are expected to take longer to mature into revenue-generating services. For these services, the figure indicates 2020 or 2021 and beyond is an appropriate timeframe to think about. Again, RoW is considerably more cautious than U.S. on how quickly these services will mature **(Fig 14).**

This question attempts to understand if operators think edge-enabled applications will be unique to their networks and business plans, enhancements to today's applications, or a new category of applications that can be offered across operators.

This latter option has the strongest support at 44%, with a not insignificant 31% saying it will be a hybrid of the options – some unique, some aligned with cloud providers, and some in a new category of cross-operator edge apps. >

Fig 13 - How do you believe is the Edge best defined (as it pertains to cellular infrastructure and services)?



- A set of 5G features **13.80%**
- An important new aspect of cloud computing **34.50%**
- An opportunity to create a new set of applications because of lower latency **37.90%**
- We're not sure **13.80%**

Fig 14 - When will the following Edge services materially impact mobile operator revenue?

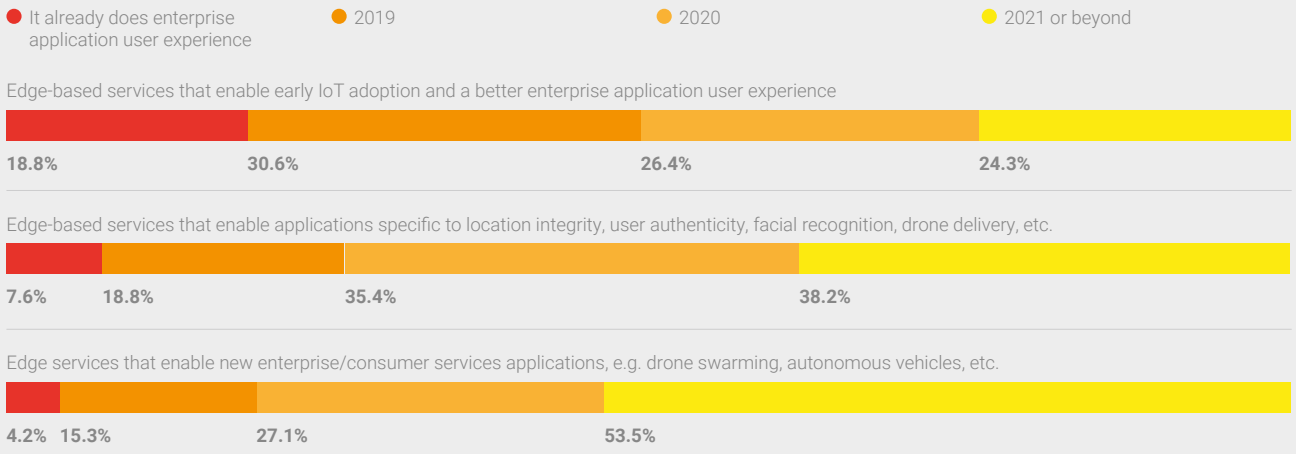
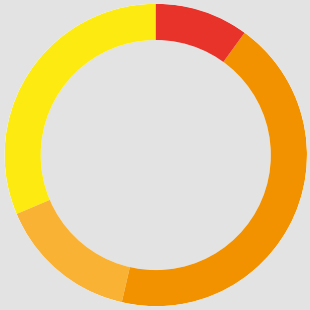
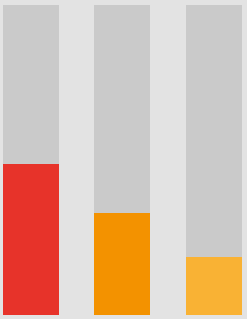


Fig 15 - How do you believe the Edge platform will affect application development?



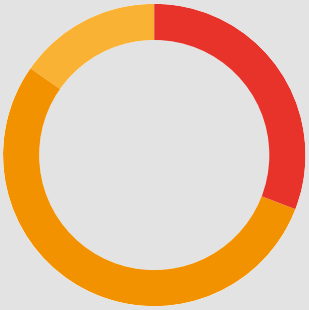
- The same applications we use today will be enhanced for the Edge **10.20%**
- Edge will enable the creation of new sets of standardized applications, suitable for a new App Store **43.50%**
- Edge applications will be unique to the goals of individual mobile operators **15.00%**
- It will be a hybrid of all these approaches **31.30%**

Fig 16 - How will you leverage integrators for your Edge deployment? (select all that apply)



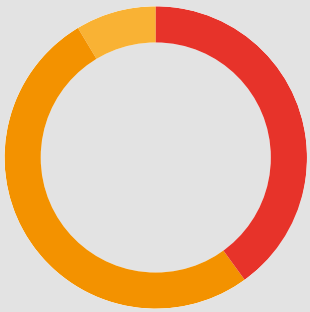
- Primarily use existing vendors & integrator partners..... **102**
- Primarily use new integrator partners..... **69**
- Primarily use internal enterprise resources..... **39**

Fig 17 - How vital is Edge computing to your network evolution strategy?



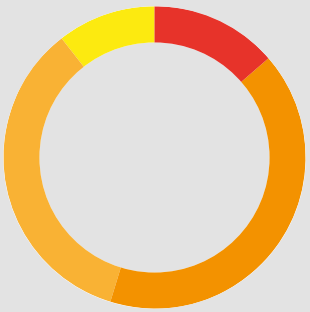
- It's critical to our strategy..... **31.00%**
- It's important - we will leverage some edge resources to ensure experience delivery..... **53.80%**
- Minor impact only - we do not see the Edge as a necessary factor to our execution **15.20%**

Fig 18 - How important is Edge computing to the strategy of your future business?



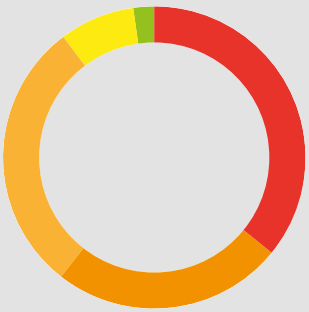
- It's critical - it will ensure our service differentiation to our customers **40.10%**
- It's important – primarily to our internal capabilities and efficiency **51.40%**
- It's not important at all..... **8.50%**

Fig 19 - As an operator, which best represents your current interest and progress in Edge computing?



- No formal discussion or planning within our strategic network evolution strategy..... **13.70%**
- Internal education is ongoing, but no specific actions have been taken **41.10%**
- We are engaging with key vendors and have, or are in process of moving to a PoC and or trials **34.90%**
- We will launch capabilities in 2019 and expand services opportunistically..... **10.30%**

Fig 20 - Which ecosystem segment do you believe will be most important towards the creation of new revenue services from Edge services?



- Network operators **36.30%**
- Public Cloud providers..... **24.70%**
- Application developers..... **29.50%**
- Device manufacturers..... **8.20%**
- Other..... **1.40%**

The implication is that the market should think about edge as enabling a new category of services that incorporates input from a broad ecosystem of participants **(Fig 15).** That the edge is part of broader ecosystem is confirmed by response to the next question on systems integration. A large majority (69%) of respondents say they primarily use existing vendors and integrator partners for their edge deployment. New integrator partners also score highly at 47%; it therefore is likely that some combination of these will prevail.

Internal company resources scored less highly at 27%. And in contrast to some other questions, U.S. respondents are less bullish about their internal integration capabilities, with just 20% selecting this option versus 33% for RoW **(Fig 16).** The edge is not only about services that can be consumed by end users. It also has a role in network strategy – for example, it could be used to run RAN and core virtual network functions (VNFs) at edge cloud facilities in future distributed network architectures. In the survey, 31% say this is more than important – it is "critical" – and 54% say its "important." This is strong, if somewhat qualified, support for the idea of the edge cloud for operator networking **(Fig 17).**

Asking about the importance of edge to business strategy delivered the same kind of result, with slightly more emphasis on "critical" at 40%. Given that operators' business success is tightly linked to network strategy and that the survey was taken primarily by network designers, engineers, and planners working at operators, the similarity in response to the prior question is to be expected **(Fig 18)**.

After asking about edge in theory, the following question sought to ascertain how much progress operators have made toward implementing and using edge capabilities in practice. With only 10% saying they will launch services in 2019, it is fair to say the market is in the early phases of development. However, a solid 35% are now engaging with vendors and are in the process of moving toward PoCs and trials – this obviously does not guarantee commercial deployment but does show progress. That 41% are still in the education phase and have not taken specific actions should also temper hype for the near-term deployment and operation of edge at scale in mobile operator networks. This is consistent with revenue opportunities being a few years out, as identified in a prior question **(Fig 19).**

Having identified that respondents, in aggregate, view a broad ecosystem as important to edge application development in a prior question, it is not a surprise to see that echoed when they are asked which part of the ecosystem will be most important to generating new revenue from edge. In simple terms, developers, public cloud, and operators look to have almost equal influence. Perhaps it is a slight surprise that device makers did not score highly, given handsets are by some definitions part of the "far edge." The implication is that respondents believe that edge-enabled services will be, or should be, transparent to devices. This type of decoupling would make it easier to develop the market; without tight dependencies on device operating systems or handset replacement cycles, progress could be faster. It is, however, an operator-centric view of edge **(Fig 20)** ■

MobiledgeX

MobiledgeX is a new U.S. company founded by Deutsche Telekom January 1, 2018. MobiledgeX was one of the outcomes of an extensive two-year study of edge computing that Deutsche Telekom performed internally. That study strongly suggested that edge computing could benefit device makers, application developers, public clouds as well as all mobile operators, given that mobile networks already have a computational control plane at the edge of the network. MobiledgeX is not only "free" for mobile operators, but it also creates new business opportunities from companies outside the mobile network industry that want to leverage the unique assets enabled by mobility.

MobiledgeX recently announced its 1.0 product release which is already live in production networks in Germany and Poland. The MobiledgeX services are deployed on "Cloudlets" that run on existing mobile operator physical or virtual infrastructure. MobiledgeX has created an SDK to adapt mobile applications to integrate with these services. When such an application is used, the MobiledgeX global control system deploys the application backend elements to the closest Cloudlet available, based on the application user's location.

MobiledgeX is deploying edge computing today within 4G/LTE infrastructures using an expanding, global federation of mobile operator partners, and emphasizing the importance of building an edge now (not waiting for 5G) in order to gain experience with the many nascent opportunities earlier. MobiledgeX advocates and promotes the value of edge as an internal tool, giving mobile operators a functional platform far more agile than traditional cellular infrastructure.

5G TRANSPORT NETWORKS

Author: Sterling Perrin, Principal Analyst - Optical Networking & Transport, Heavy Reading

While 5G trials and initial commercial rollouts may not strain the transport network, significant architecture changes are required to roll out 5G services at scale. 5G targets a tenfold increase in capacity, and this increase at the radio reverberates throughout the access network. Without proper planning, the transport network becomes the bottleneck. Beyond capacity, new use cases such as massive machine-type communications (mMTC) and ultra-reliable low latency communications (URLLC) create new requirements and thresholds for latency, reliability, scalability, cost, and other factors. In this section, Heavy Reading delves into operator plans and expectations for transport networks supporting 5G, including upgrade timelines, architecture preferences, and top inhibitors that must be addressed for mass deployments

THE KEY FINDINGS FOR THIS SECTION ARE AS FOLLOWS:

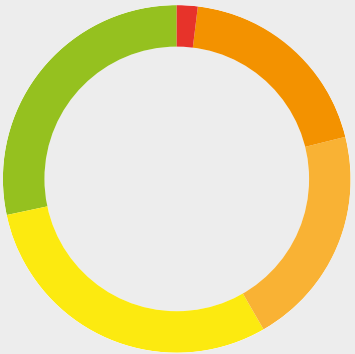
At **34%**, a plurality of survey respondents say that their 5G transport network upgrades are already taking place, with an additional **18%** reporting upgrades will begin by the end of 2019. A full **77%** of operators report that their 5G transport network upgrades will be underway by 2020. And just **20%** expect to upgrade in 2021 or later.

For planned 5G transport networks, operators selected an average mix of **63%** fiber, **32%** wireless, and **5%** other media (such as coax). Interestingly, the physical media mix for planned networks is not that different from their current networks, though fiber ticks up slightly. Also interesting is the large role of wireless connectivity in both current and planned transport networks.

Dual challenges rise to the top in inhibiting operators from building out their 5G transport networks. The high costs of fiber deployments and the high costs/ limited availability of spectrum licenses for wireless transport were each selected as a top inhibitor by **61%** of the survey group.

5G promises an order of magnitude increase in bandwidth delivered to end devices. It is not surprising, then, that network operator backhaul capacities must also increase to meet these end device needs. While 1 Gbit/s backhaul has been the standard data rate for 4G networks, expectations for 5G are much greater.

Fig 21 - What is your organization's expected backhaul capacity needed for a 5G NR macro cell site in the next 3-5 years?



- Less than 1 Gbps **2.10%**
- 1-3 Gbps **19.20%**
- 3-5 Gbps **20.50%**
- 5-10 Gbps **30.10%**
- More than 10 Gbps **28.10%**

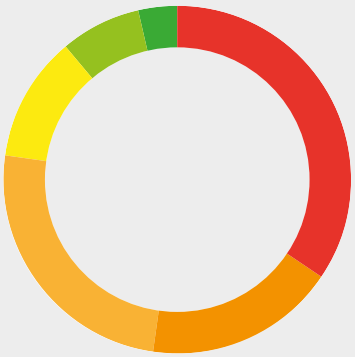
In Heavy Reading's survey, 79% of operator respondents expect 3 Gbit/s or higher backhaul capacity in the next 3-5 years. At 30%, the greatest share of respondents report that they expect 5 Gbit/s to 10 Gbit/s backhaul capacities, while 28% expect greater than 10 Gbit/s backhaul capacity will be needed in the 3-year timeframe. Backhaul expectations for U.S. respondents were more aggressive than the overall survey group. For the U.S., 38% report that they expect greater than 10 Gbit/s backhaul capacity will be needed at macro sites in the next 3-5 years **(Fig 21).**

Conventional wisdom states that transport networks must be upgraded prior to large-scale 5G commercial launches or the transport network will itself become the bottleneck. The survey results reinforce this assessment. At 34%, a plurality of survey respondents report that their 5G transport network upgrades are already taking place, with an additional 18% reporting that upgrades will begin by the end of 2019. A full 77% of operators report that their 5G transport network upgrades will be underway by 2020. And just 20% expect to upgrade in 2021 or later **(Fig 22).**

We wanted to understand the existing physical media mix in mobile transport networks – fiber, wireless, or other – and how this physical media mix is expected to change as operators roll out 5G. On average, operators report 58% fiber access, 34% wireless access, and 8% other connectivity in their current mobile transport networks. "Other" transport would include primarily coax and satellite. Interestingly, the average physical media mix for planned 5G networks does not look dramatically different from the current picture. For planned networks, operators selected an average mix of 63% fiber (slightly higher than current allocation), 32% wireless (virtually unchanged), and 5% other (slightly lower).

Also interesting is the large role of wireless connectivity in both current and planned transport networks. Despite all the discussion about fiber connectivity in 5G transport – which clearly is important – operators also expect wireless connectivity to play a major role. This finding may surprise some fiber proponents. >

Fig 22 - When will your organization begin upgrading its transport network to support 5G?



- Already taking place **34.50%**
- 2019 ..... **17.90%**
- 2020 ..... **24.80%**
- 2021 ..... **11.70%**
- 2022 or later **7.60%**
- No plans to upgrade transport network for 5G **3.40%**

Fig 23 - Current and Planned Physical Media Mix in Mobile Transport Networks

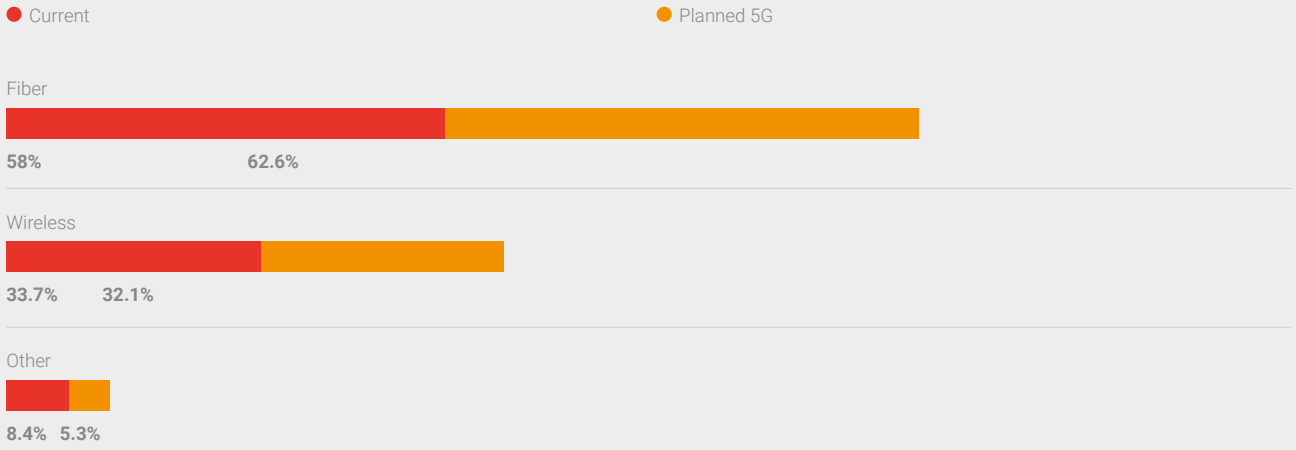
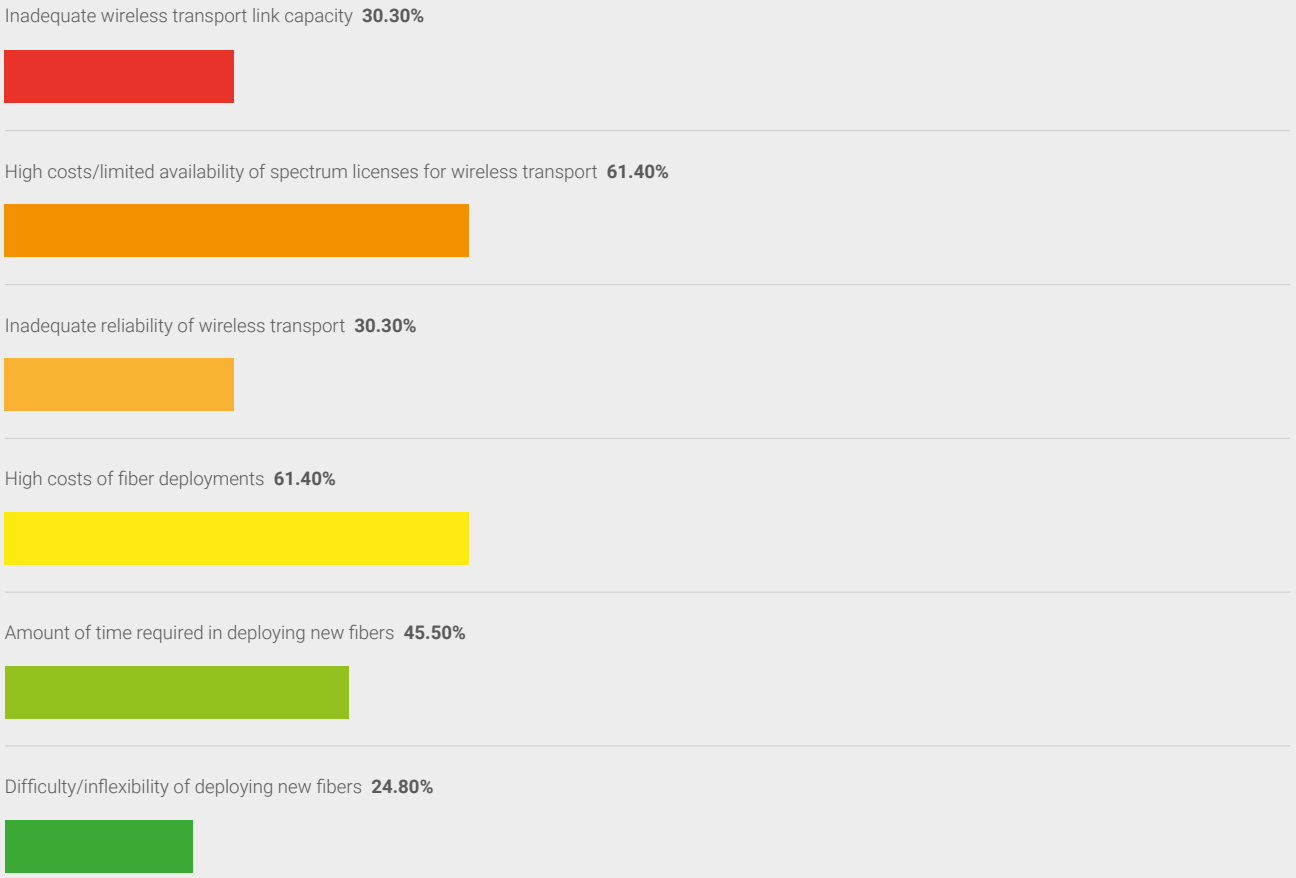


Fig 24 - What are the main challenges inhibiting the build-out of a 5G transport network, for your organization?



Cost considerations will lead operators to use existing infrastructure whenever possible. Upgrading microwave links to 10 Gbit/s will prove less costly for many operators, particularly in less developed regions. Additionally, integrated access and backhaul (IAB) – known as self-backhaul – is a cost-saving option of interest, even in developed countries such as the U.S., where dense small cell deployments are needed **(Fig 23).**

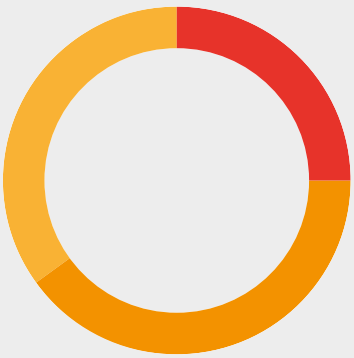
Dual challenges rise to the top in inhibiting operators from building out their 5G transport networks. The high costs of fiber deployments and the high costs/ limited availability of spectrum licenses for wireless transport were each selected as a top inhibitor by 61% of the survey group.

Additionally, time is critical in 5G transport, as 46% of respondents say that the amount of time required in deploying new fiber is a major challenge. This result should not be surprising as operators race to be first in 5G and secure their customer and territorial beachheads.

It is also worth noting that two common critiques of wireless transport – lack of reliability and capacity – ranked low among the inhibitors cited by respondents. While operators are worried about wireless transport license costs and availability for 5G, they are not particularly concerned about the medium's capacity or reliability in providing services **(Fig 24).**

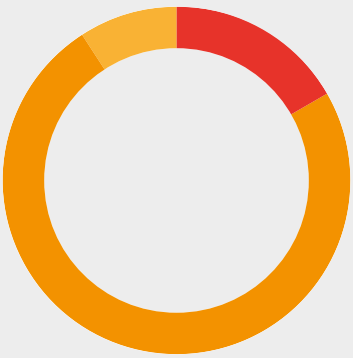
Looking at their high capacity 5G wireless transport networks specifically, Heavy Reading asked operators to segment their networks by distance, according to short (<2 km), medium (2-5 km), and long (5-10 km) distances. On average, these wireless transports are mostly evenly mixed, though sub-2 km links are expected to be most common, according to the survey. The average mix, based on all survey respondents, is 40% short, 35% medium, and 25% long distances **(Fig 25).** >

Fig 25 - Mix of Average Distances for 5G Wireless Transport Links



- Short links (<2km) **39.6%**
- Medium links (2-5km)..... **35.1%**
- Long links (5-10km)..... **25.3%**

Fig 26 - What is your organization's preferred vendor strategy for 5G transport networks?



- Single vendor deployments only (end-to-end)..... **16.70%**
- Multi-vendor/best-of-breed for each element **74.30%**
- White box hardware with open source software **9.00%**

collinear

Historically, operators have favored multivendor transport networks for several reasons. Having multiple suppliers avoids vendor lock-in, enables operators to pick the best technology for each function, and gives operators some pricing leverage in supplier negotiations. While there is some industry discussion that things will be different with 5G transport, Heavy Reading's survey research suggests that operator vendor strategies will remain largely the same.

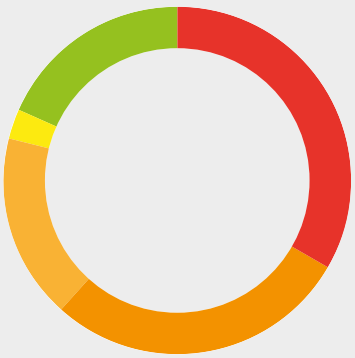
In our survey, an overwhelming 74% of respondents say that they will seek multiple transport vendors and seek best-of-breed functionality for each element. Just 17% of operators surveyed expect to deploy a single vendor end-to-end in their networks.

Survey findings on white box/open source are interesting. The white box topic is also hot at industry forums and in the media, but according to Heavy Reading's survey, few operators prefer open source for 5G transport. Just 9% of operators selected white box hardware/open source software **(Fig 26).**

Heavy Reading also asked operators how they plan to manage their 5G transport infrastructure under software-defined networking (SDN) control. 50% of respondents plan to rely on their transport vendors for SDN control while 42% intend to use SDN controllers supplied by third-party providers (i.e., separate software vendors). Operators were able to select multiple options in this question, and the results indicate that operators will have multiple approaches within their networks. Although homegrown SDN controllers were common in the earliest SDN deployments, interest in this option has clearly waned as SDN has matured. Homegrown controllers are preferred by just 26% of operators – the lowest response of all the survey options.

Still, many operators have yet to decide on the best approach for SDN control for 5G transport. For 27% of respondents, it is still too early to say how they will control their networks. This finding is not particularly surprising, as other Heavy Reading research has shown that many operators are prioritizing the basic buildout of their physical 5G networks first and are planning to tackle issues of SDN and virtualization later **(Fig 27)** ■

Fig 27 - How will your organization manage 5G transport infrastructure integration with SDN control?



- Vendor-supplied SDN controllers **50.30%**
- Third Party SDN controllers.....**42.20%**
- Home-grown SDN controllers.....**25.90%**
- Not planning SDN control for 5G transport network.....**4.10%**
- Undecided/too early to tell.....**27.20%**

"HISTORICALLY, OPERATORS HAVE FAVORED MULTIVENDOR TRANSPORT NETWORKS FOR SEVERAL REASONS. HAVING MULTIPLE SUPPLIERS AVOIDS VENDOR LOCK-IN, ENABLES OPERATORS TO PICK THE BEST TECHNOLOGY FOR EACH FUNCTION, AND GIVES OPERATORS SOME PRICING LEVERAGE IN SUPPLIER NEGOTIATIONS. WHILE **THERE IS SOME INDUSTRY DISCUSSION THAT THINGS WILL BE DIFFERENT WITH 5G TRANSPORT, HEAVY READING'S SURVEY RESEARCH SUGGESTS THAT OPERATOR VENDOR STRATEGIES WILL REMAIN LARGELY THE SAME."**

5G NETWORK SLICING

Author: Gabriel Brown, Principal Analyst - Mobile Networks & 5G, Heavy Reading

The ability to incorporate services into network slices where the configuration of a virtual network instance is optimized for a specific service type or user group is often considered one of the more compelling commercial benefits of 5G. The expectation is that multiple discrete slices operating across a common infrastructure platform will generate superior economics to dedicated networks. Moreover, by isolating users virtually, more demanding high value services can be supported.

Network slicing is, however, challenging in many aspects: common definitions are elusive, demand may be dynamic, multiple network domains must be coordinated, and service-level agreements (SLAs) must be met, and shown to be met, via reporting tools. In combination, this can generate great complexity.

THE KEY FINDINGS FOR THIS SECTION ARE AS FOLLOWS:

About a quarter of operator respondents say they are preparing for network slicing trials or are already running them. Given the status of 5G standards, this represents the vanguard of the industry. The majority **(56%)**, however, are in the "research, but no action" phase.

Business services are the lead use case for network slicing with **33%** of the vote, ahead of high throughput services in second with **28%** and low latency services in third with **23%.**

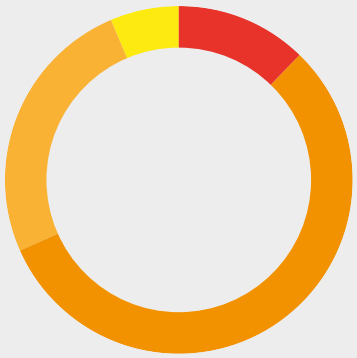
Just over half of respondents expect to launch 5G slicing before the end of 2021, but **60%** do not expect that to translate to mass-market offers until 2022. U.S. respondents are more bullish on this question than those in RoW.

About a quarter of operator respondents to the survey say they are now preparing for trials, or already running trials, of 5G network slicing. Given the status of 5G standards, this represents the vanguard of the industry.

It is hard to be much further ahead than this. The majority (56%) are very much in the "research, but no action" phase, and this (fairly accurately, in our view) represents the state of the industry as a whole. A good summary would be: in principle, slicing is interesting, but in practice, there is work to do before operators can implement it **(Fig 27).**

Asked about where they see value in network slicing, the largest response was for it to have a "positive impact on network costs" (49%). This is logical insofar as virtual slices would replace discrete physical networks (e.g., dedicated networks for utilities). However, the premise of network slicing is to increase revenue via differentiated services **(Fig 28).**

Fig 27 - Which best represents your company's current interest in network slicing?



- No interest yet **50.30%**
- Researching but no actions yet **42.20%**
- Moved from interest to action - preparing for, or running trials **25.90%**
- Have launched slicing services in 4G **4.10%**

Interestingly, when the 50 respondents working in technical roles at larger, mobile-only, and converged fixed/mobile operators are selected, the emphasis shifts to revenue. In this case, as shown below, 54% say it will have a positive impact on revenue via "chargeable slices" and 58% say it will benefit both the cost and revenue sides **(Fig 29).**

The attributes of a network slice – what it is supposed to do – are interesting. In this question, respondents could select the most valuable attribute from five different criteria. Business services, with specific security and subscriber treatment, have a narrow lead at 33%.

This is logical and understandable. Enterprises often have somewhat specific requirements and sometimes like to have control of their networking environment without having to operate the network themselves. They also need privacy and security, so a virtual network slice is well-matched to their requirement. High throughput services came second (28%), perhaps in part because many applications could be contained within this category – from video streaming and media delivery to standard internet access.

Low latency services came in third at 23%. This is consistent with a view that very demanding performance requires specific network configurations, siloed from other services that may compete for resources. Enthusiasm may be tempered by the need to deploy edge cloud to support low latency and by the lead time for the development of a premium low latency services market **(Fig 30).**

In the next two questions, Heavy Reading sought to understand when operators would introduce network slicing commercially and when it would scale to mass-market proposition. We asked about both 4G and 5G slicing because there is potential to offer pre-standards slices on 4G using techniques such as Dedicated Core Networks (DECOR) or, arguably, Access Point Names (APNs). As anticipated, the timeline for 4G was somewhat ahead of 5G.

In terms of 5G slices, there appears to be 1-2 years between the launch of commercial services and scaling to the mass market. Just over half of respondents expect to launch 5G slicing before end 2021, but 60% do not expect that to translate to mass-market offers until 2022.

Fig 28 - What value does your company see in network slicing?

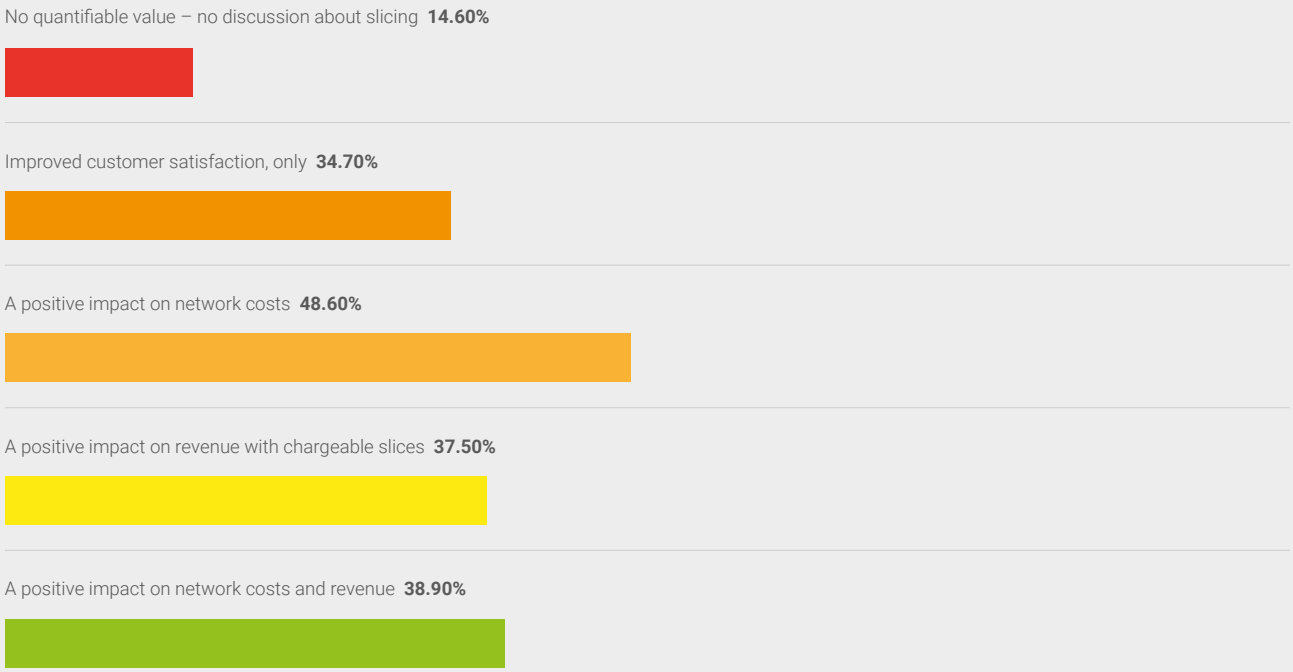
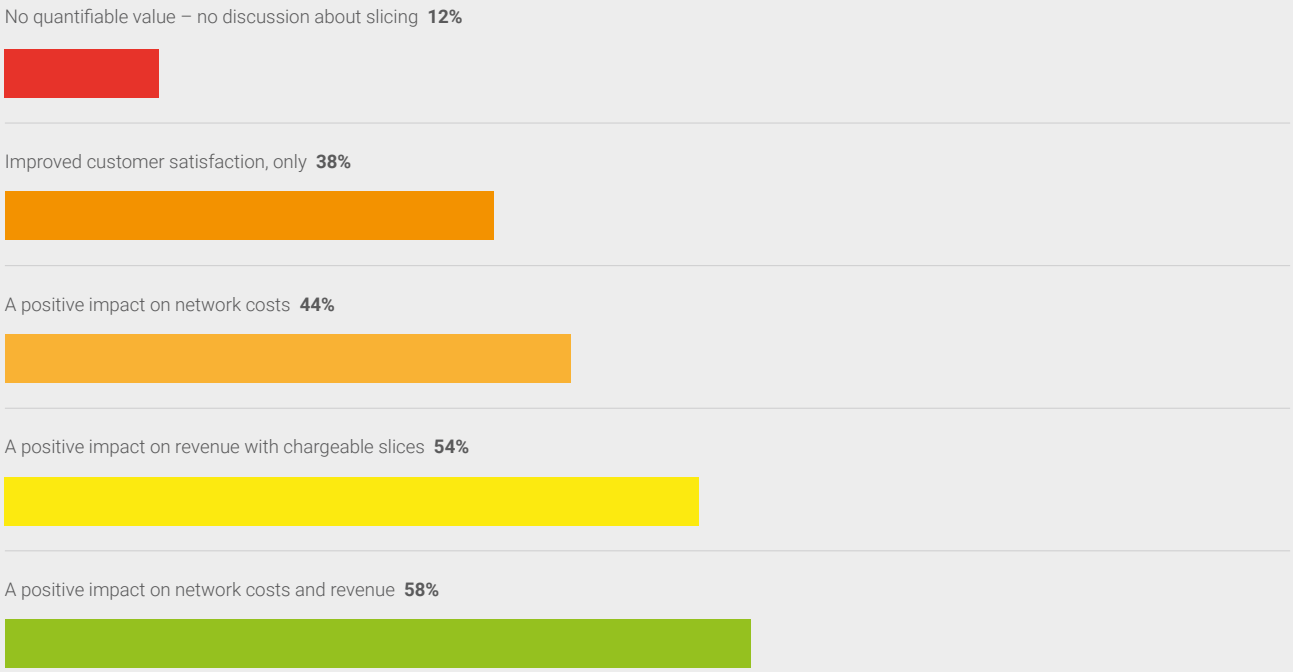


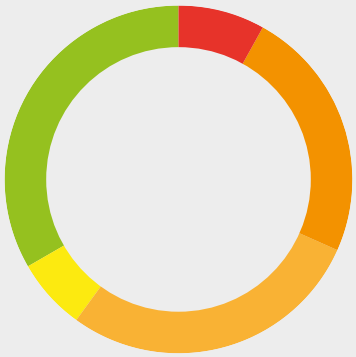
Fig 29 - What value does your company see in network slicing?



Note also that U.S. respondents are more bullish on this question than those in RoW **(Fig 31, 32).**

A major question about network slicing is how granular, and how service-specific, slices will be. Therefore, Heavy Reading sought to understand if operators would offer just a few types of network slice or many optimized slices. The 3-year time delimiter, following commercial launch of slicing, would mean most respondents were thinking about the 2021-2024 timeframe, based on the prior question. Most notable is that few respondents think more than 200 slices will be offered, and only 3% think more than 1,000 will be offered. Other than that, responses are distributed evenly – with a majority indicting anywhere between 5 and 60 slices types may be offered with 3 years. This seems reasonable, if a little cautious. Perhaps it also reflects the immaturity of slicing technology at the start of 2019 **(Fig 33).**

Fig 30 - Network slices based upon which of the following network attributes will provide the greatest opportunity?



- Ultra-reliability **8.30%**
- Low latency **23.40%**
- High throughput **28.30%**
- Low throughput - IoT **6.90%**
- Business services – security, specific subscriber treatment **33.10%**

"TO OFFER NETWORK SLICES COMMERCIALLY, THE OPERATOR SHOULD CUSTOMIZE THE SLICE TYPE ACCORDING TO THE TARGET INDUSTRY'S NEEDS, WHICH MEANS ENGAGING WITH VERTICALS TO UNDERSTAND THEIR REQUIREMENTS AND PREFERENCES. THIS TYPE OF CROSS-SECTOR ENGAGEMENT HAS LONG BEEN IDENTIFIED AS A CRITICAL ISSUE FOR 5G."

Fig 31 - When might your company launch Network Slicing as a commercial proposition?

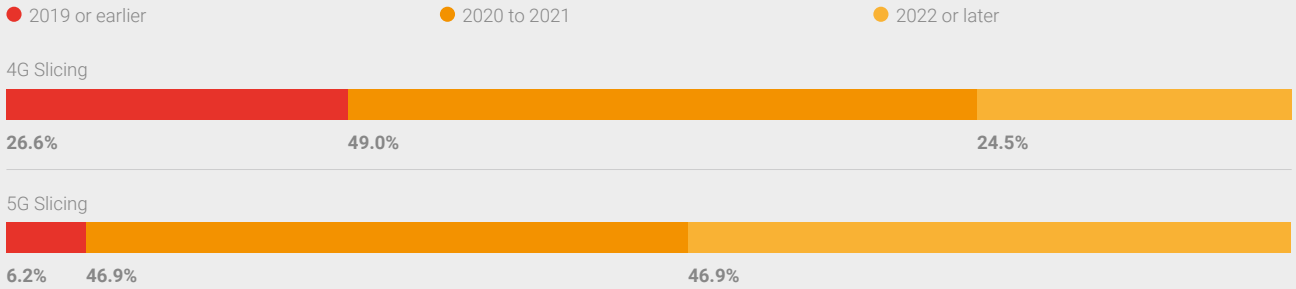
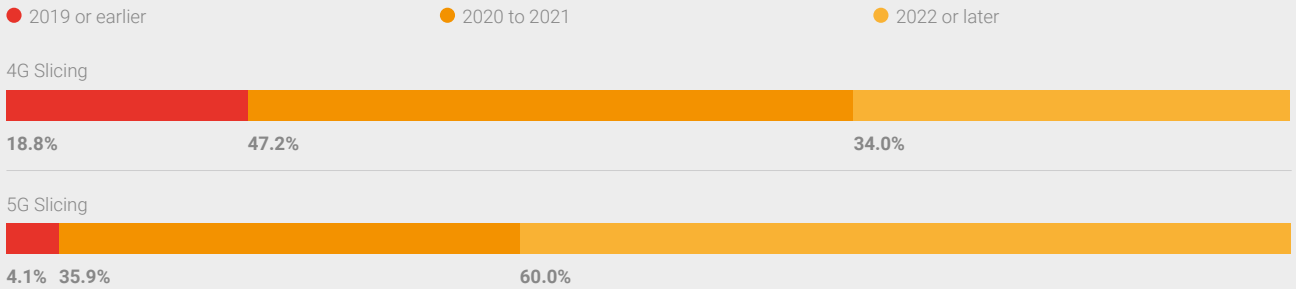


Fig 32 - When might your company offer Network Slicing as a mass market proposition?



To offer network slices commercially, the operator should customize the slice type according to the target industry's needs, which means engaging with verticals to understand their requirements and preferences.

This type of cross-sector engagement has long been identified as a critical issue for 5G.

Response to this question shows only 4% think progress has been "excellent" in this regard, versus 17% who have made no progress at all. The rest of the response is split evenly between "good progress" and "some high-level progress." The number reporting "good progress" is heartening, but the overall picture is a little concerning. To effectively sell network slicing, operators will need engagement with industry verticals to be "excellent." The implication is the mobile industry should redouble its efforts in this area; "good progress" is not enough **(Fig 34).**

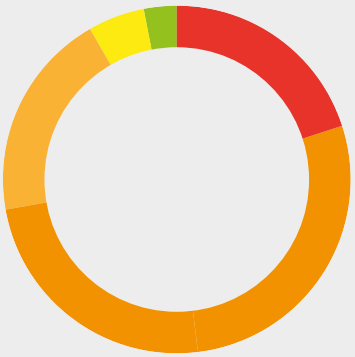
Network slicing is reasonably well understood as a concept but is not yet formally defined. The 3GPP is working on standards for slicing and therefore on a de facto reference definition; however, this work is ongoing and is not comprehensive. Within the 3GPP domain, an end-to-end slice can run from the user equipment (UE; e.g., handset) across the RAN and into the core network.

But 3GPP does not specify how the slice should be handled in the underlying transport network. This question asks about mapping the 3GPP slice to quality of service in the transport domain to create a vertically integrated slice.

As the figure shows, a majority (60%) of respondents think this integration will be addressed via the convergence of fixed and mobile networks, and this jumps to 74% when responses from larger operators in the survey are isolated. This result presumably reflects the fact that the respondent base primarily works for large converged operators. However, this in turn indicates that a large proportion of customers are now served by converged operators **(Fig 35).**

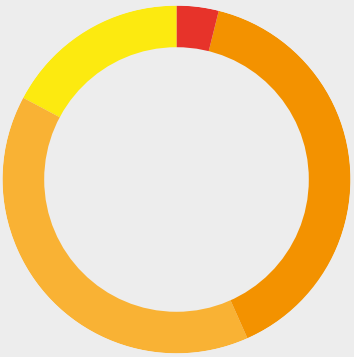
Almost one-third (29%) either do not think integration is needed (8%) or have not thought about it yet (21%). This might indicate that slicing is still in the very early days for some operators. ■

Fig 33 - Once your company launches network slicing, how many slices (e.g. automotive-low latency; automotive-high throughput; healthcare, etc.) do you think will be offered within 3 years?



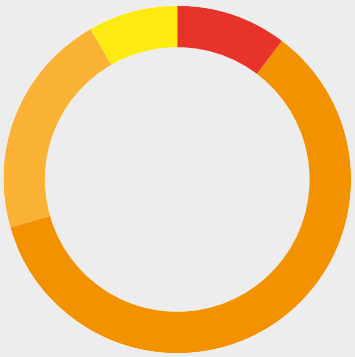
- Less than 5 ..... **20.00%**
- 5 - 30 ..... **28.30%**
- 30 - 60 ..... **24.10%**
- 60 - 200 ..... **19.30%**
- 200 - 1000 ..... **5.50%**
- More than 1000 ..... **2.80%**

Fig 34 - Characterize the progress your company has made towards defining specific network slices for targeted vertical industries?



- Excellent progress **4.10%**
- Good progress **39.30%**
- Some progress, but only high-level **39.30%**
- No progress at all **17.20%**

Fig 35 - How will you integrate mobile (3GPP) network slicing to the transport network quality-of-service to create a vertically integrated slice?



- Fixed network service providers we use will support internetworking slicing **4.10%**
- Convergence of fixed and mobile networks is needed **39.30%**
- We have not thought about it **39.30%**
- It is not needed **17.20%**

5G CORE NETWORK

Author: Gabriel Brown, Principal Analyst - Mobile Networks & 5G, Heavy Reading

The core network controls user sessions, manages mobility, authenticates users, meters usage, manages traffic, enforces policy, and more. It is a relatively small part of CAPEX investment (around 15% of the total), but vital to the functioning of the system and critical to monetization. 5G core strategies are, therefore, of great interest to how the wider 5G market develops.

THE KEY FINDINGS FOR THIS SECTION ARE AS FOLLOWS:

A large majority **(81%)** of respondents say they are likely to launch 5G in non-standalone (NSA) mode using an Evolved Packet Core (EPC), of which **38%** say "yes definitely" and **43%** say "yes, probably."

A combined **38%** have either already implemented control-user-plane separation (CUPS) in their EPC as preparation for 5G **(8%)** or will do so this year **(30%).**

Only **10%** of respondents say they expect their company to offer "many 5G-only services." The large majority **(90%)** expect their service portfolio to stay mostly the same in the 3 years after launch, with scope for "a few new services" **(43%).**

In terms of packet core, there are two ways to support 5G NR access: 1) using an EPC in what is known as NSA mode; and 2) using a new 5G core to operate in standalone (SA) mode. In NSA mode, the 5G RAN is deployed on a host LTE network, whereas in SA mode there are no dependencies on LTE. However, in later releases, evolved LTE may be supported by the 5G core.

NSA mode was developed, as part of 3GPP Release 15, to enable faster deployment of 5G NR. SA mode is also part of Release 15 but, for now, is 5G-only and does not support integration with LTE.

This question asks if operators will deploy in NSA mode, as might be expected from the acceleration of this work in standards. Because of the "within the next two years" time delimiter, Heavy Reading is showing only the 99 responses from those that say they would launch 5G as a commercial proposition in the 2018-2020 period. Using this view of the data, 38% say "yes, definitely" and 43% say "yes, probably" to give a total of 81% likely to launch 5G in NSA mode using an EPC.

We might have expected the "yes, definitely" to score more highly. The fact that it scored only 38% may indicate some operators do not have their final deployment plans in place and signed off yet. It may also reflect some lack of knowledge as to the specifics of the operator's core network strategy, and in this case "probably" is a safer answer than "definitely."

Conceivably, part of the "yes, probably" response could also be because some operators are considering launching 5G-only networks using SA mode – for example, for industrial IoT use cases such as factory automation. SA mode with a 5G core is supported in the first standards release. Although deployments are likely to be limited in number, this should not be discounted **(Fig 36).**

For this question on CUPS, Heavy Reading considers only the respondents with plans to deploy over the next 2 years and that will "probably" or "definitely" launch using an EPC. This gives a total of 79 responses. Of these, 8% say they have already implemented CUPS and are close to commercial readiness and 30% say they will be ready this year.

Fig 36 - Within the next two years, do you expect to deploy 5G New Radio (5G NR) in non-standalone mode using an Evolved Packet Core (EPC)?

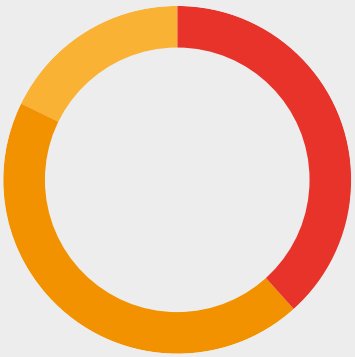


Fig 37 - How much progress have you made on the upgrade to "CUPS" (control- user-plane separation) to support 5G NR in your existing EPC?

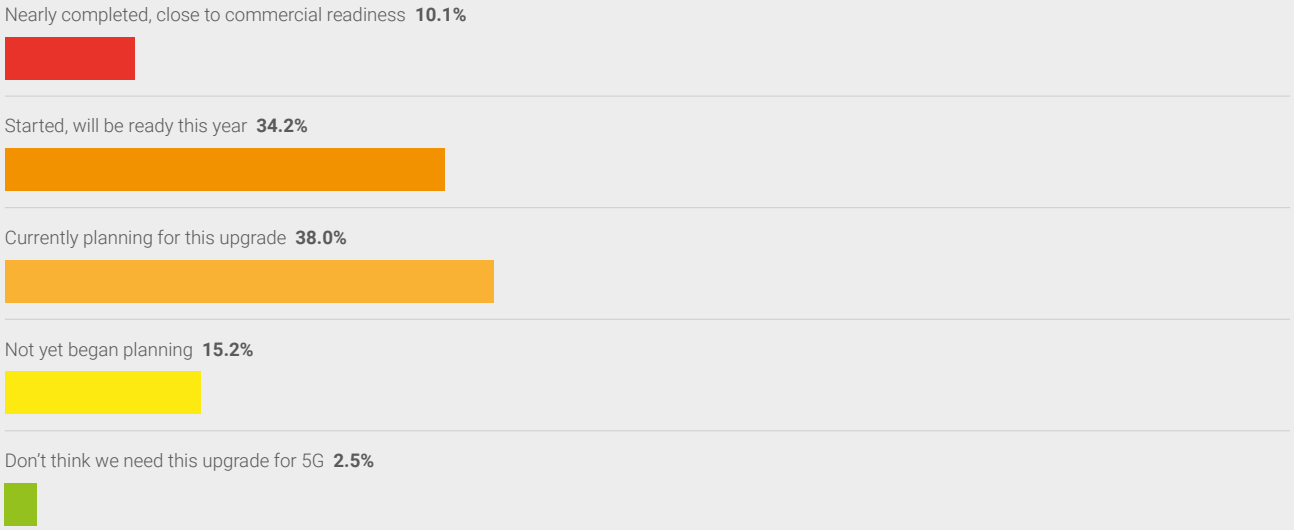


Fig 38 - How do you expect CUPS will be implemented

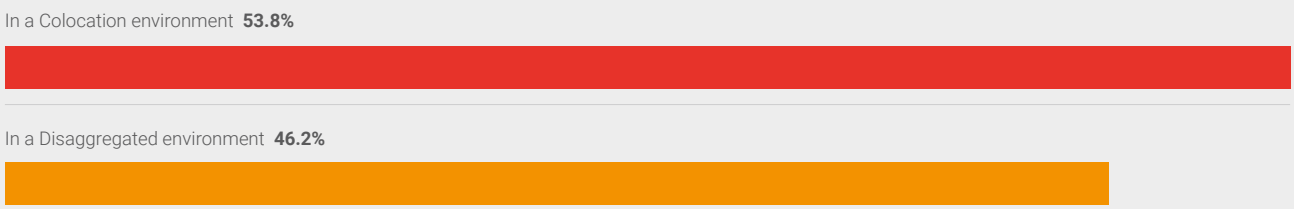
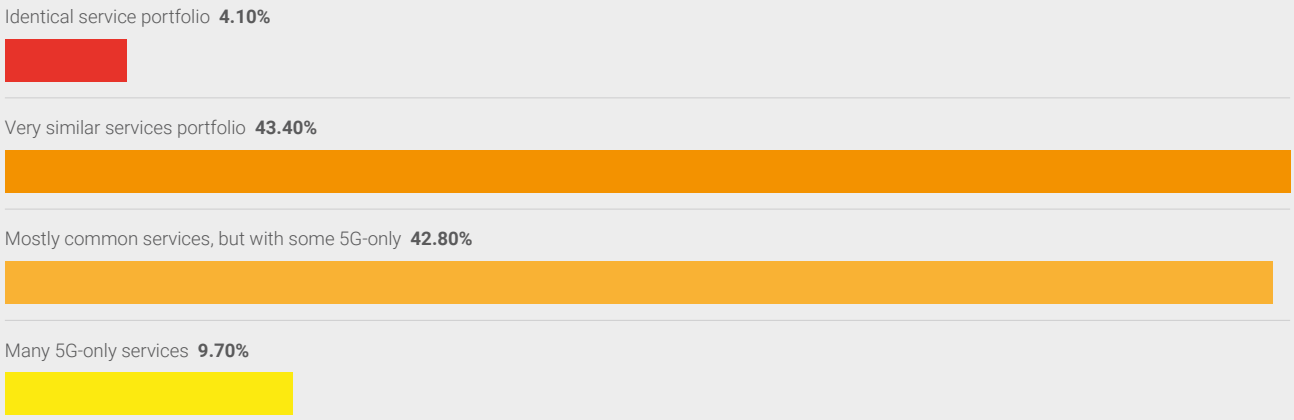


Fig 39 - How much commonality do you expect between your 4G and 5G service portfolio three years after your 5G launch?



This shows a high degree of readiness to deploy 5G in NSA mode. The 37% in the planning stages for a CUPS upgrade further strengthens the view that preparations for 5G are ongoing at pace **(Fig 37).**

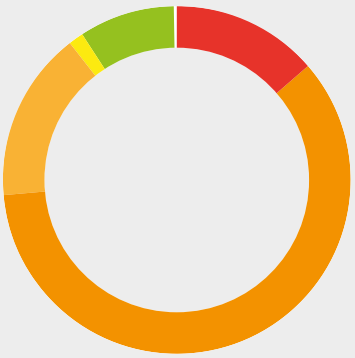
CUPS can be deployed with user plane gateway colocated at the same facility as the control plane or with the user plane distributed to an edge node – this is sometimes called a disaggregated deployment. Isolating only the 65 respondents that have deployed CUPS or are in the planning process is logical for this question. The results show a fairly even split; colocation is just ahead of disaggregated, with scores of 54% and 46%, respectively **(Fig 38).**

Services are obviously what will make 5G successful – or not. Operator expectations for variations between their 4G and 5G service portfolios may, therefore, be revealing about the wider 5G market opportunity. And because of the role the core plays in services, this question is also revealing about the need for operators to migrate quickly from EPC to a full 5G core. Note the 3-year time delimiter in the question. The response here is interesting in that only 10% say they expect their company to offer "many 5G-only services." The large majority (90%) expect their service portfolio to stay mostly the same in the first 3 years after launch **(Fig 39).**

The next question asks respondents if they agree that a new 5G core will be needed to realize the full benefits of 5G. The response, largely, is yes, with 14% indicating "strongly agree" and a dominant 60% saying "agree." Given that respondents think their service portfolio is likely to be similar for 3 years, this may indicate that the full 5G core will not be deployed at scale for mass-market services in the near term. This also fits with the 3GPP standards development timeline for 5G core. Even when Release 16 is completed at the end of 2019, 2 or more years will be needed to develop, implement, and deploy 5G core technical solutions in a robust way. However, this does not mean 5G core is unimportant today because a transition of this magnitude to a new system architecture, should – and will – take time **(Fig 40).**

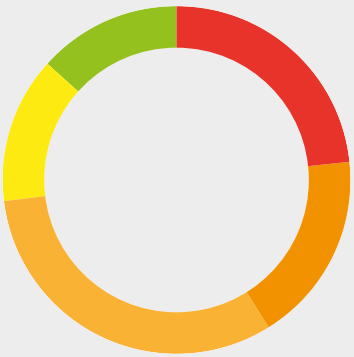
The next two questions on when operators expect to deploy virtualized and cloud-native packet core can be addressed together. Generally speaking, virtualization precedes cloud native,

Fig 40 - To what extent do you agree or disagree with following statement: It will be difficult to offer the full range of 5G services in NSA mode using a 4G core; we will need a 5G core to capture the full benefits of 5G.



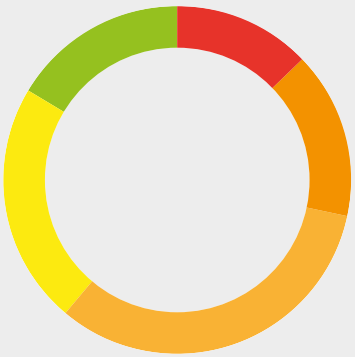
- Strongly Agree 13.80%
- Agree 60.00%
- Disagree 15.90%
- Strongly disagree 1.40%
- Not sure 9.00%

Fig 41 - When do you intend to deploy virtualized packet core?



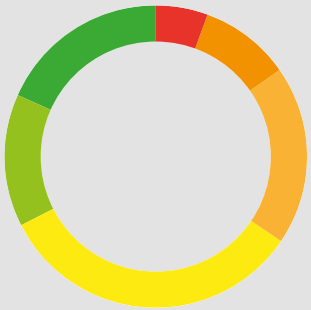
- Already implemented and running 23.40%
- 6 - 12 months 17.90%
- 13 - 24 months 31.70%
- 25 – 36 months 13.80%
- No plans currently 13.10%

Fig 42 - When do you intend to deploy cloud native packet core?



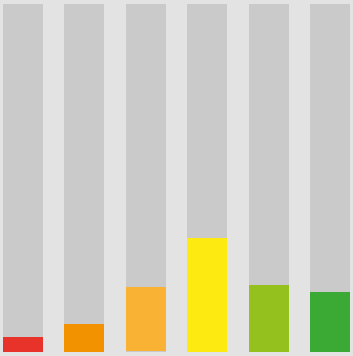
- Already implemented and running 12.90%
- 6 - 12 months 15.60%
- 13 - 24 months 32.70%
- 25 – 36 months 22.40%
- No plans currently 16.30%

Fig 43 - If CI/CD is part of your plans, when will your primary Mobile Core Network Vendor will be ready to introduce?



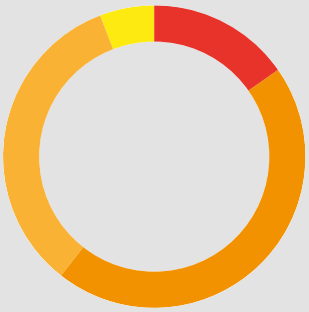
- Now 5.60%
- Within 6 months 9.90%
- 6 - 12 months 19.00%
- 13 - 24 months 33.10%
- 25 – 36 months 14.10%
- Beyond 36 months 18.30%

Fig 44 - If CI/CD is part of your plans, when will your own department responsible for mobile core network services be ready to introduce?



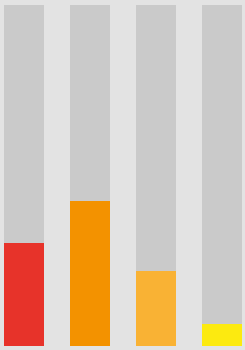
- Now 4.30%
- Within 6 months 7.80%
- 6 - 12 months 18.40%
- 13 - 24 months 32.60%
- 25 – 36 months 19.10%
- Beyond 36 months 17.70%

Fig 45 - How important is it for your virtual or cloud native packet core to support a (CI/CD) model?



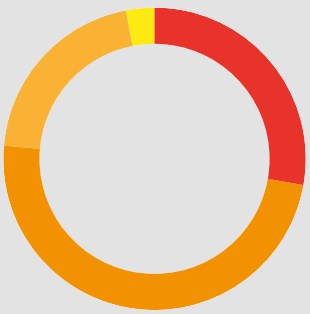
- Very important 15.50%
- Important 45.10%
- Somewhat important 33.80%
- Not at all important 5.60%

Fig 46 - How important is a 4G/5G converged packet core to your operational plans?



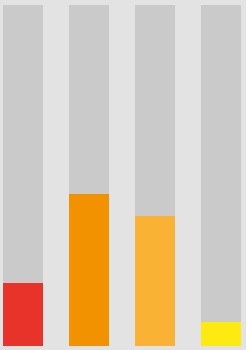
- Very important 29.50%
- Important 42.50%
- Somewhat important 21.90%
- Not at all important 6.20%

Fig 47 - How important is a converged core supporting all wireless access (4G, 5G, IoT, WiFi) to your operational plans?



- Very important 27.80%
- Important 48.60%
- Somewhat important 20.80%
- Not at all important 2.80%

Fig 48- How important is a converged core supporting all wireless methods plus Fixed Wireline (xDSL/Ethernet) and Cable (DOCSIS) to your operational plans?



- Very important 18.50%
- Important 44.50%
- Somewhat important 30.10%
- Not at all important 6.80%

and this appears to be borne out by the response (although there is a route from physical to cloud-native designs). Interestingly, however, the differences in the answers to these two questions is not all that large. This perhaps suggests the respondent base is not entirely clear on the difference or that the two models somehow merge in the transition from a virtual to cloud-native state **(Fig 41).**

Cloud native is associated with the continuous integration/ continuous delivery (CI/CD) operating model. One objective of this is to shorten the time required to release new services to customers and to make changes to the network. This generally also means making more smaller changes and fewer large systemic changes. In previous Heavy Reading surveys, we found strong support for the idea of CI/CD, but relatively limited use of the model in practice.

This same finding is also seen in the response to the following two questions on vendor readiness and internal readiness for CI/CD, with only around 5% claiming to be active already. The majority do not expect either their vendors, or themselves, to be ready for at least a year.

This relative lack of uptake might in part be because these questions ask specifically about CI/CD in the mobile core, which is the most critical part of the network and therefore an area where operators are very risk-averse. That there is little difference between vendor readiness and internal readiness for CI/CD might also suggest that operators and vendors must work in lock-step to make such a fundamental change in the mobile core operating model **(Fig 42, 43).**The next question appears to confirm that CI/CD for mobile core is desirable but not essential, with only 15% saying it "very important" versus 45% for "important." The explanation for this is probably as above: risk aversion. Note, however, that the "very important" score climbs to 25% for U.S. respondents versus just 7% for RoW **(Fig 44).**

The next three questions are related to common, multi-access 5G core networks. In the first instance, Heavy Reading asks about converged 4G/5G packet core, with 30% saying this is "very important" to their operational plans (this number jumps to 38% for technical roles in big operators). Clearly, this is an important issue – and more so than CI/CD. However, the 43% "important" score indicates the respondent base as a whole is a little ambivalent – it suggests that operators think they would like a common core, but it is not a hard requirement **(Fig 45).**

The same kind of pattern is repeated for this next question which extends the idea of a common 4G/5G core to all wireless access, including Wi-Fi **(Fig 46).** Extending this further still and asking about a converged core for mobile and fixed access networks causes the number saying this is "very important" to drop to 18%. At this level, the respondent base is probably signalling that a common fixed/mobile core is an aspiration rather than something a significant number of operators really need, or expect to get, in the near term **(Fig 48)** ■

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