HEAVY READING
WHITE PAPER

Independent market research and competitive analysis of next-generation business and technology solutions for service providers and vendors

5G Transport
A 2023 Heavy Reading Survey

A Heavy Reading white paper produced for Ericsson, Fujitsu, and Nokia

AUTHOR: STERLING PERRIN, SENIOR PRINCIPAL ANALYST, HEAVY READING

EXECUTIVE SUMMARY

The mobile industry has made unprecedented progress since the first commercial 5G service rollouts in 2019. Omdia counted more than 1 billion global 5G subscriptions as of year-end 2022—the fastest rollout in history. But there is still much work ahead. New midband spectrum, migration from non-standalone (NSA) to standalone (SA) 5G cores, virtualization of the radio access network (RAN), and edge cloud deployments for low latency applications are among the many factors that will drive massive rollouts of 5G services, resulting in significant change for both the radio network and transport.

Some transport trends and technologies that Heavy Reading has been tracking for years have come to fruition. Massive fiber rollouts have taken place globally; line and system capacities have multiplied, often by tenfold. Some newer technologies and architectures are beginning to be adopted, including white box cell site routers (in other words, disaggregated cell site gateways), packet fronthaul gateways, and virtualized centralized units (CUs) and distributed units (DUs). At the same time, even more advanced functionality remains on the horizon—notably end-to-end network slicing across the RAN, core, and transport domains.

As operators move from NSA to SA cores and prepare for Release 18 from the 3rd Generation Partnership Project (3GPP), leading-edge service providers are investigating the kinds of transport technologies and architectures that will support the advanced 5G networks to come. Transport network upgrades must stay ahead of the radio network.

Now in its fourth year, Heavy Reading's ***Operator Strategies for 5G Transport Survey*** focuses on 5G transport timelines and requirements as operators prepare for 5G-Advanced. Project partners **Ericsson**, **Fujitsu**, and **Nokia** aided Heavy Reading in survey development.

Key findings

The following are the key findings from this study.

Priority initiatives

Cloud RAN (or virtualized RAN, vRAN) tops the list of priority initiatives that network operators expect to implement over the next three years. 59% of operators surveyed expect to implement RAN virtualization by 2025. Additionally, 5G microwave transport (selected by 51%), centralized RAN (C-RAN) (selected by 51%), and network slicing (selected by 49%) are all high on the priority list through 2025.

Capacities

5G will mark a big step up to 10Gbps capacity per cell site for backhaul, but the overall impact of this increase on backhaul, aggregation, and edge access networks will be much greater. Just over two-thirds of operators expect that at least 100Gbps of capacity will be required in backhaul (67%) and aggregation (68%), and nearly as many (59%) expect greater than 100Gbps will be needed for edge access. Although 10Gbps to an individual cell site will be sufficient for backhaul, operators expect to carry traffic from multiple cell sites in xHaul, such as with ring topologies. These survey results provide strong support that 100Gbps and even 400Gbps will play major roles in edge, aggregation, and backhaul networks over the medium term.

Centralized and cloud RAN

Following years of planning, C-RAN implementation is now well underway globally. For those planning C-RANs, just over three-quarters (77%) expect that more than 20% of RAN sites will implement centralization by year-end 2023, and nearly half (45%) expect more than 40% of RAN sites will be centralized. Expectations increase for 2025, but the increases are not dramatic. By year-end 2025, 84% of operators surveyed expect more than 20% of RAN sites will have implemented centralization, and 57% expect C-RAN in more than 40% of sites.

Lack of space looms large as the primary challenge for C-RANs, with lack of hub space for consolidated equipment cited by 55% of the survey group. Secondary challenges that emerged in the survey are distances between remote and hub sites (41%) and issues with cooling/power/battery backup (39%). These challenges are a clear reminder that C-RAN is an architecture that depends on the physical infrastructure and that, in the vast majority of cases, physical infrastructure does not align with C-RAN locations. These issues may become even more pronounced because RAN virtualization places servers in locations that are not data centers.

Network operators expect vRAN functions to be housed in many locations. In 2023, local hub sites and cell sites are expected to be the primary locations for vRAN deployments, selected by 67% and 65% of respondents, respectively. Picked by 45% of the survey group, edge data centers lag behind these other locations. By 2025, however, operators expect a shift in virtualization location. Results indicate a predicted uptick in virtualized CUs (vCUs) and/or virtualized DUs (vDUs) at both cell sites and local hubs and a significant jump in deployments at edge data centers, which will rise by 18 percentage points to 63% of the survey group.

In vRAN, security looms large as a transport network challenge. Security was picked by 57% of respondents as the biggest transport challenge. Other challenges—including Common Packet Radio Interface (CPRI) conversion, multi-vendor support, precise synchronization design, and operations, administration, and maintenance (OAM)—are all secondary to security and relatively closely clustered in the 33–39% response range.

Timing & synchronization

Multiple factors are driving the need for network-based timing and synchronization technology for 5G. Topping the list are better visibility into sync/troubleshooting per hop and improved synch source availability, both of which were selected by 47% of the respondents. Other highly important factors were the need for an alternate synch source to satellite (picked by 45%), the ability to meet stringent application synch requirements (42%), and the need to reach sites where satellite is unavailable (39%).

Operator preferences for different timing profiles vary by xHaul segment, as fronthaul, midhaul, and backhaul have different timing accuracy requirements. Preferred by 61% of respondents, operators see the greatest need for full timing support in fronthaul, where a maximum two-way time error is measured in tens of nanoseconds. Backhaul provides more margin for timing errors. A plurality (42%) of operators surveyed prefer partial timing support for backhaul. Still, 39% expect full timing support.

Network slicing

For network operators with network slicing plans, deployments are beginning—though with some caution. 28% of operators with slicing plans report that initial network slicing deployments are underway. An additional 33% of those surveyed expect initial deployments to occur this year, and 28% expect initial deployments in 2024. Early transport slicing plans focus on wholesale and enterprise services, with advanced 5G use cases scoring lower.

White box transport & routing

Enthusiasm for white box transport varies by geographic region, with North American operators expecting greater white box deployments across all segments and particularly in cell sites and aggregation. 52% of North American operators expect white box transport at cell sites, and 48% expect white box transport in aggregation, versus 35% in each for their Rest of World (RoW) counterparts.

In the procurement model for white box routers, operators prefer outside systems integrators (SIs) to the do-it-yourself integration model, but not by a large margin. 45% of respondents selected outside SIs versus 40% for do-it-yourself integration.

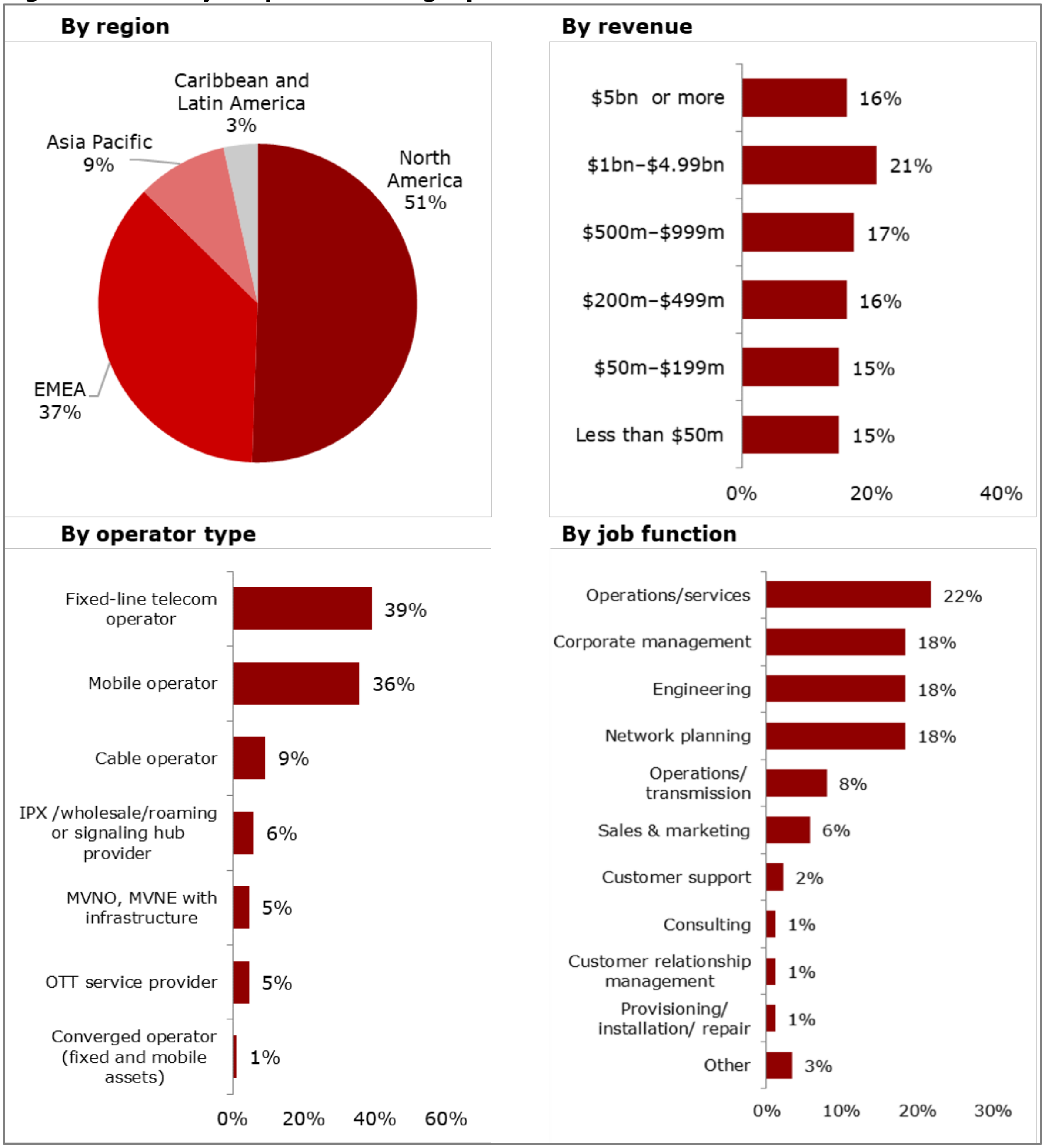
Microwave transport

Fiber is the first choice for 5G backhaul, but fiber's high cost and limited availability will continue to drive the microwave transport decision. According to the survey, the primary driver for deploying microwave transport for 5G is time to market/fiber availability, ranked first on the list by nearly half of operator respondents (45%). Ranking second on the list of deployment drivers was the high cost of leased fiber, a foremost problem for 28% of respondents.

Survey demographics

This Heavy Reading report is based on a web-based survey of network operators worldwide conducted in February 2023. After Heavy Reading reviewed responses, it deemed 87 participants to be qualified and tabulated their responses. To qualify, respondents had to work for a verifiable network operator and to be involved in network planning and/or network equipment purchasing. Additional screening was conducted to remove incomplete surveys and dubious respondents. The full survey demographics are detailed in **Figure 1**.

Figure 1: Survey response demographics



n=87

Source: Heavy Reading, 2023

PRIORITY INITIATIVES

Heavy Reading asked respondents to assess plans for various technologies and initiatives related to 5G, including cloud RAN/vRAN, C-RAN, microwave, and others. Specifically, the survey asked respondents to identify which of the technologies they intend to implement by 2025 by selecting all that apply (see **Figure 2**).

Because there can be some confusion, respondents were provided with the following definitions for C-RAN and cloud RAN:

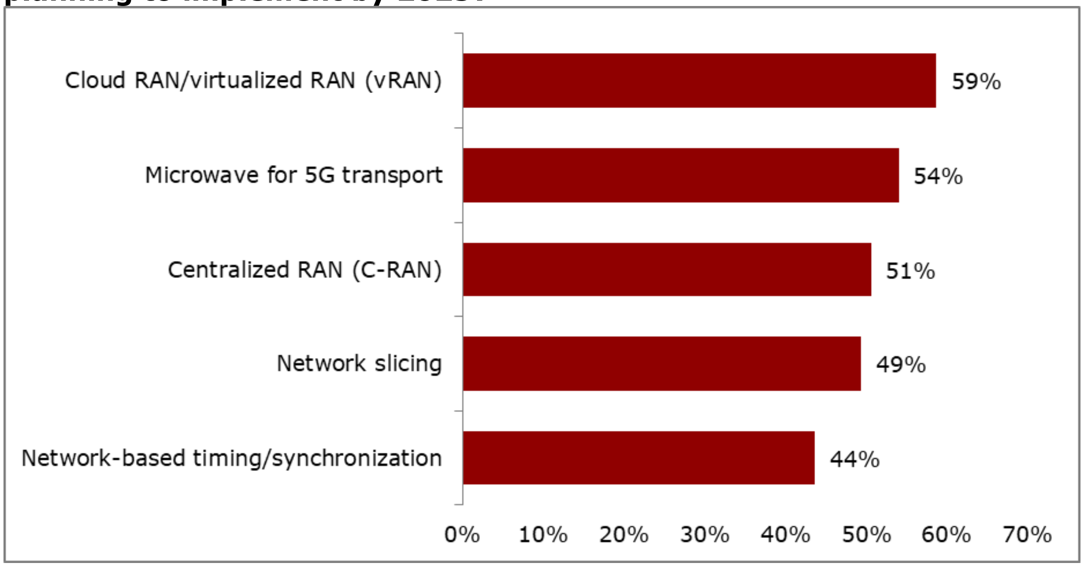
- **Centralized RAN (C-RAN):** A RAN in which radio units/remote radio heads are located at the cell site, and Layer 2 and higher baseband functionality are geographically separated at a centralized location for resource pooling. May be physical or virtual.
- **Cloud RAN:** A RAN that employs hardware and software disaggregation with RAN virtualization using commercial off-the-shelf (COTS) servers. Typically, it has a centralized architecture but can be a distributed RAN. Also called virtual RAN (vRAN).

Most popular is cloud RAN/vRAN, which was selected by 59% of respondents, followed by microwave for 5G (selected by 54%), RAN centralization (selected by 51%), and network slicing (selected by 49%). Last on the list for the full survey group is network-based synchronization, which was chosen by 44% of the survey group.

Heavy Reading asked a similar (though not identical) question in the 2022 project survey, which allows us to make some general comparisons in technology priorities from last year to this. The popularity of cloud RAN and C-RAN is largely in line from year to year, though the ascension of cloud/virtualization ahead of RAN centralization is a change. The results indicate that more operators are pursuing virtualization independent of their C-RAN strategies—meaning that these operators foresee benefits from virtualization in a distributed RAN.

Network slicing garnered an equal 49% share in both years, holding steady but also low relative to the other initiatives. As Heavy Reading has noted in other analyses, network slicing has slipped a bit down the priority list over the past two years as the complexities of end-to-end slicing across the RAN, core, and transport network have become apparent. Operators see the long-term value of network slicing, but their timelines are shifting as other initiatives take higher precedence.

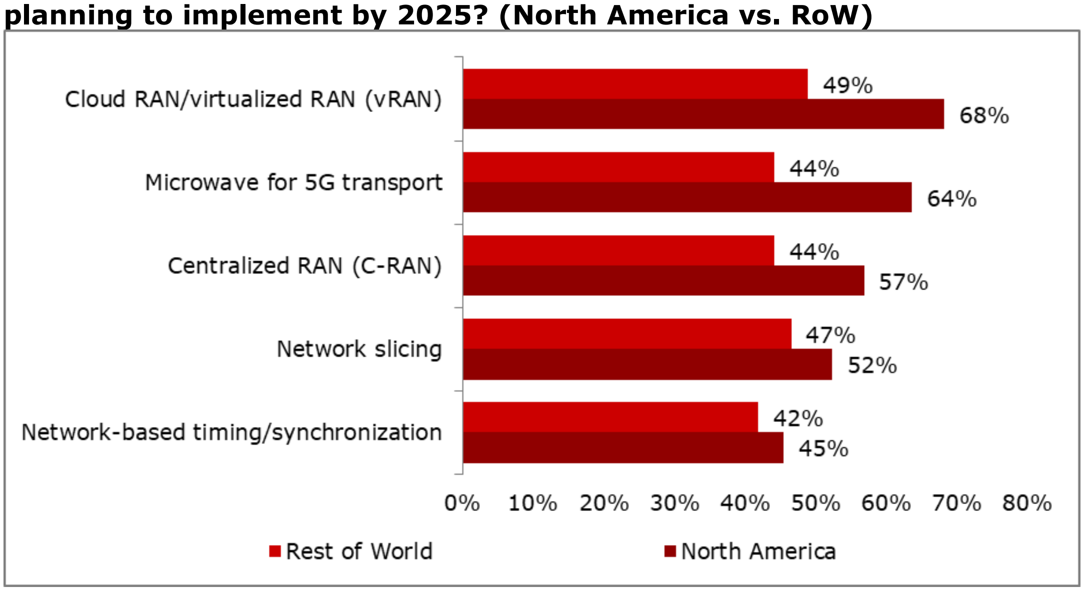
Figure 2: Which of the following is your organization currently implementing or planning to implement by 2025?



n=87
Source: Heavy Reading, 2023

There are differences by geographic region, as shown in **Figure 3**. North American operators surveyed have more aggressive timelines in general across technologies and initiatives, particularly in cloud RAN, 5G microwave, and C-RAN. For the past several years, North American operators have trended ahead of operators in most other regions in both C-RAN and cloud RAN expectations, so these regional results are completely in line with expectations. The relative strength of 5G microwave in North America, however, is a bit of a surprise.

Figure 3: Which of the following is your organization currently implementing or planning to implement by 2025? (North America vs. RoW)



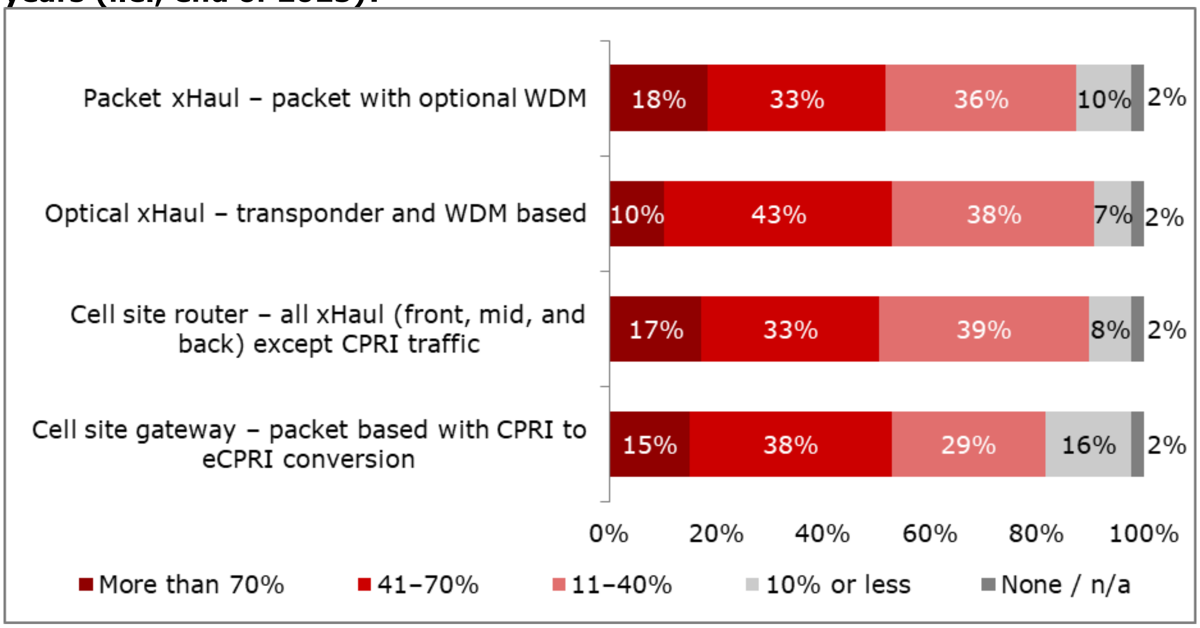
n=44 North America, 43 RoW
Source: Heavy Reading, 2023

XHAUL

XHaul is an industry term for the mobile transport network, encompassing the fronthaul, midhaul, and/or backhaul segments, each of which includes multiple technology options. Heavy Reading wanted to understand communications service providers' preferred technology mix for xHaul over the next three years (see **Figure 4**).

Results point to a mix of technology options across xHaul, with no clear winner. Packet xHaul, transponder-based xHaul, cell site routers (without CPRI), and cell site gateways (with CPRI-to-eCPRI conversion) will all be used extensively based on the survey results.

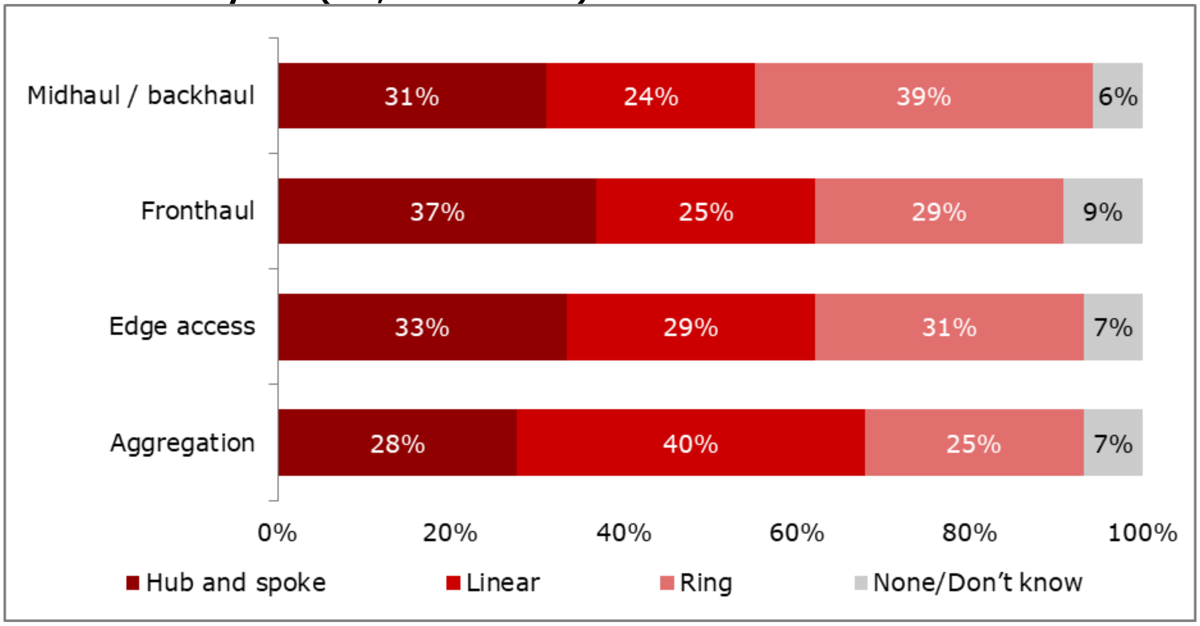
Figure 4: What is your preferred technology mix for xHaul over the next three years (i.e., end of 2025)?



n=87
Source: Heavy Reading, 2023

Similarly, operators expect a broad and even mix of xHaul topologies to be used across each of the network segments over the next three years, as shown in **Figure 5**. In backhaul, the largest share of operators (39%) expects ring topologies to dominate. In fronthaul, 37% of operators expect hub and spoke to dominate. In aggregation, 40% expect linear topologies. The survey points to edge access as having the most equitable distribution of topologies, with roughly one-third of respondents preferring each of the three major options (hub and spoke, linear, and ring).

Figure 5: What is your preferred topology in each of the following segments over the next three years (i.e., end of 2025)?



n=87
Source: Heavy Reading, 2023

5G marks a big step up in capacity per cell site, with 10Gbps replacing 1Gbps as the standard for per cell site connectivity in 5G backhaul. This tenfold jump in capacity is needed to meet initial 5G cell site requirements, as well as to provide room to grow for future increases.

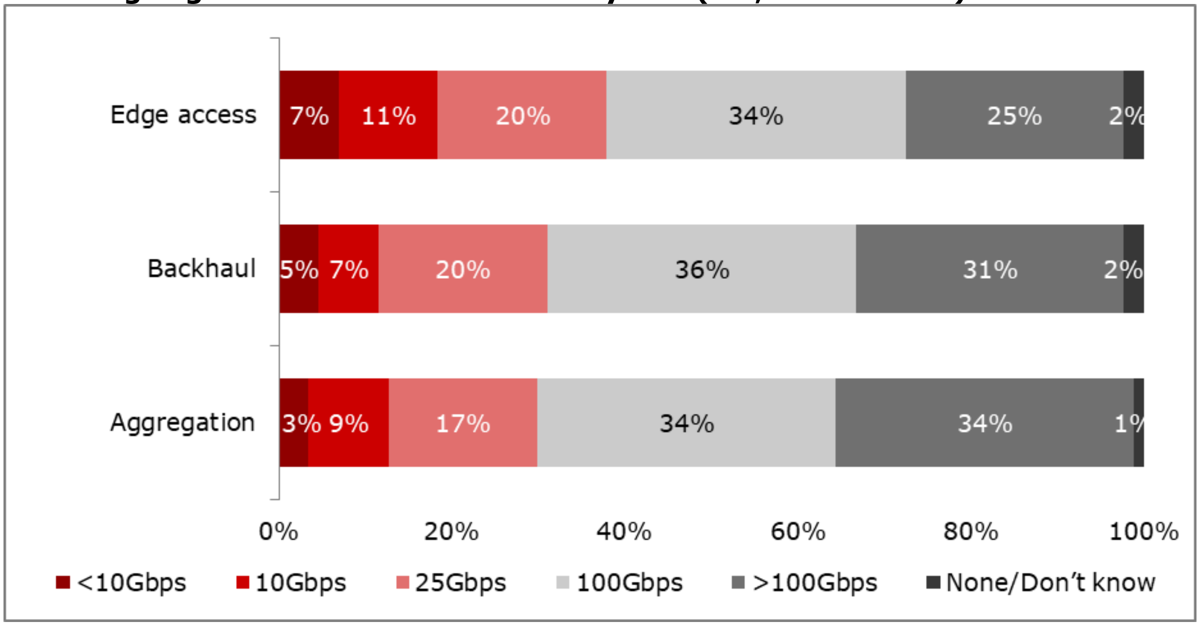
But how will 5G affect average capacity in various network segments? Based on survey results, operators expect massive capacity impacts across edge access, backhaul, and aggregation networks. Just over two-thirds of operators expect at least 100Gbps of capacity will be required in backhaul (67%) and aggregation (68%), while just under two-thirds of respondents (59%) expect that greater than 100Gbps will be needed in edge access (**Figure 6**).

Operators expect that particularly large capacity will be needed in aggregation. Just over one-third of operators surveyed (34% of the group) expect greater than 100Gbps connectivity will be required in aggregation over the next three years.

Heavy Reading notes that operators consistently report that 10Gbps to the individual cell site will be sufficient for several years, as it marks a 10x capacity increase compared with 4G backhaul. However, operators expect to carry traffic from multiple cell sites in xHaul, such as with ring topologies. These architectures will lead to requirements beyond 10G, as indicated in the survey results.

The survey results provide strong support for the conclusion that 100Gbps and even 400Gbps will play major roles in edge, aggregation, and backhaul networks over the medium term.

Figure 6: What is your average expected bandwidth capacity in each of the following segments over the next three years (i.e., end of 2025)?



n=87

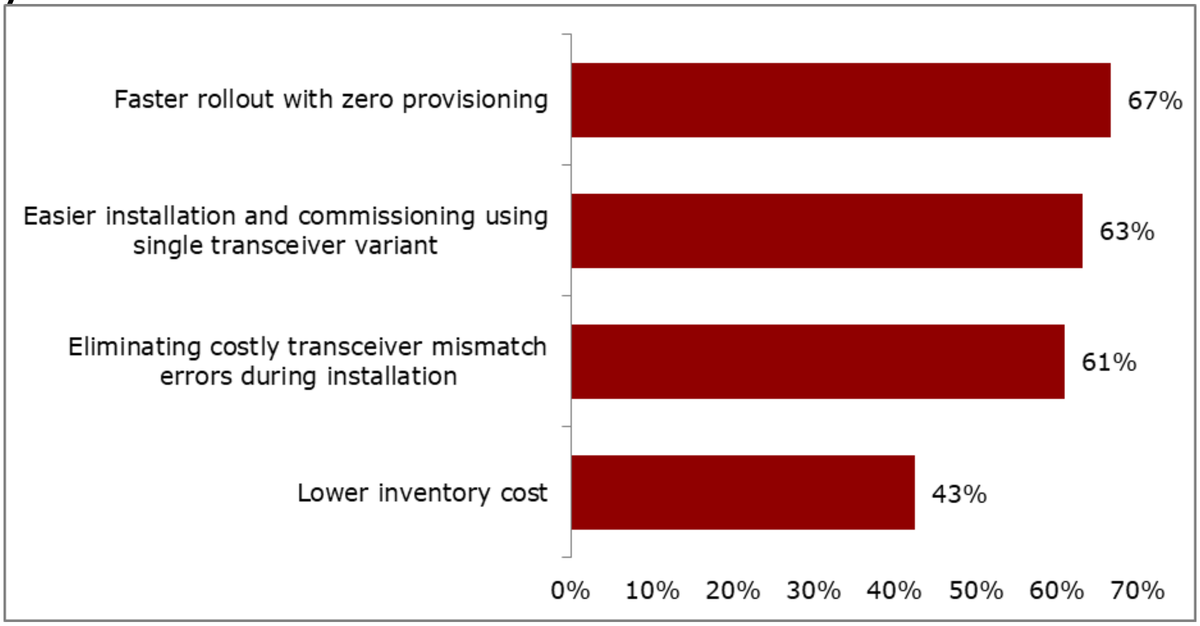
Source: Heavy Reading, 2023

Tunable DWDM transceivers replace the need for multiple fixed-wavelength spares because each transceiver can be tuned to any wavelength. Self-tuning adds additional functionality by enabling automatic wavelength turn-up once a transceiver is plugged in.

The top motivations for using self-tuning DWDM transceivers in 5G xHaul are faster rollout with zero-touch provisioning (selected by 67% of operators surveyed), easier installation and commissioning (selected by 63% of the survey group), and elimination of transceiver mismatch errors during installation (selected by 61%) (**Figure 7**).

All three motivations point to the need for maximum operational speed and efficiency during installation. This finding is consistent with the macro trend among network operators to lower their total operational costs over the next couple of years, with automation as a crucial means toward this end.

Figure 7: What are the top motivations for using self-tuning DWDM transceivers in your 5G xHaul network?



n=87

Source: Heavy Reading, 2023

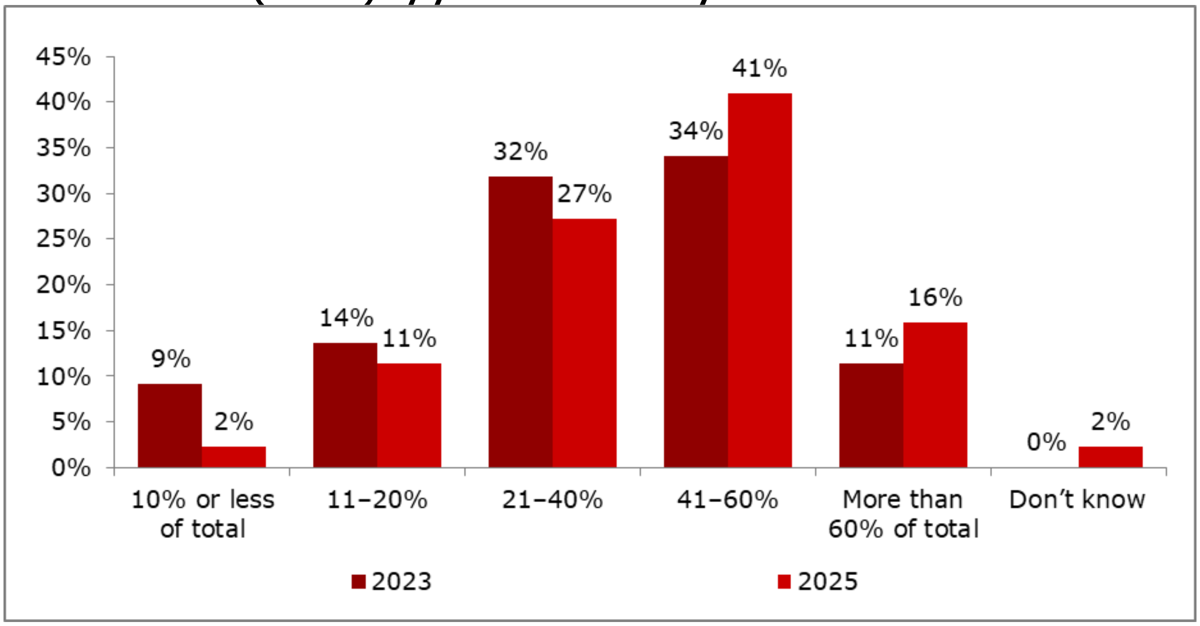
CENTRALIZED AND CLOUD RAN

This section addresses questions around C-RAN and cloud RAN. The respondents in this section are the subset of the full survey group that identified plans to implement centralized or cloud RAN by 2025 (from **Figure 2**). The C-RAN and cloud RAN data points represent the plans of 51% and 59% of the full survey group, respectively.

For those planning C-RANs, just over three-quarters (77%) expect that more than 20% of RAN sites will implement centralization by year-end 2023, and nearly half (45%) expect that more than 40% of RAN sites will be centralized. These results confirm that following years of planning, C-RAN implementation is now well underway.

Naturally, expectations increase for 2025, but the predicted increases are not dramatic. By year-end 2025, 84% of operators surveyed expect more than 20% of RAN sites will have implemented centralization, and 57% expect C-RAN in more than 40% of sites.

Figure 8: What percentage of your organization's RAN sites will implement a centralized RAN (C-RAN) by year-end 2023? By 2025?



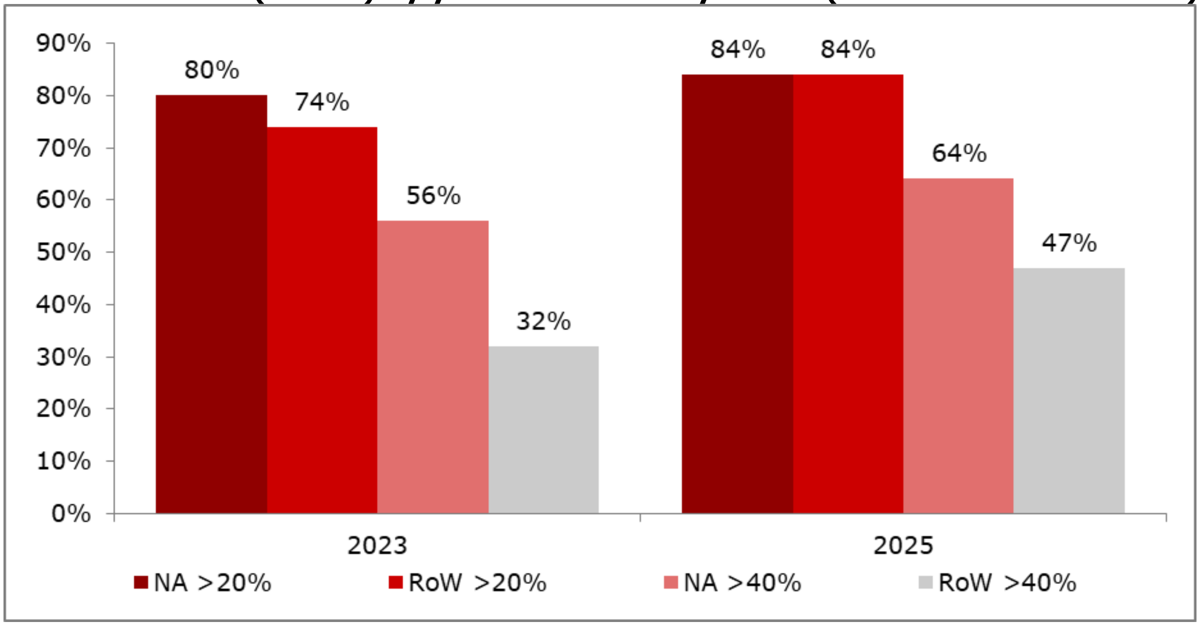
n=44

Source: Heavy Reading, 2023

Past surveys have indicated that North American operators' plans and timelines for C-RANs have been more ambitious relative to their RoW counterparts. This trend continues to hold true. In the 2023 survey, a greater percentage of North American operators report C-RAN plans compared to RoW operators, with 57% of North American respondents expecting C-RAN implementation by 2025 compared to 44% of RoW respondents (see **Figure 3**).

Additionally, among operators with C-RAN plans, North America is ahead of RoW in larger-scale deployments. For example, 56% of North American operators expect that more than 40% of RAN sites will be centralized in 2023, versus just 32% for RoW (see **Figure 9**). By 2025, nearly two-thirds of North American respondents (64%) expect more than 40% of RAN sites will be centralized, while nearly half of RoW operators (47%) expect the same. Despite North America's lead, the survey results do indicate that over the next few years, C-RAN architectures are expected to hold an increasing appeal for regions outside North America.

Figure 9: What percentage of your organization's RAN sites will implement a centralized RAN (C-RAN) by year-end 2023? By 2025? (North America vs. RoW)



n=25 North America (NA), 19 RoW
Source: Heavy Reading, 2023

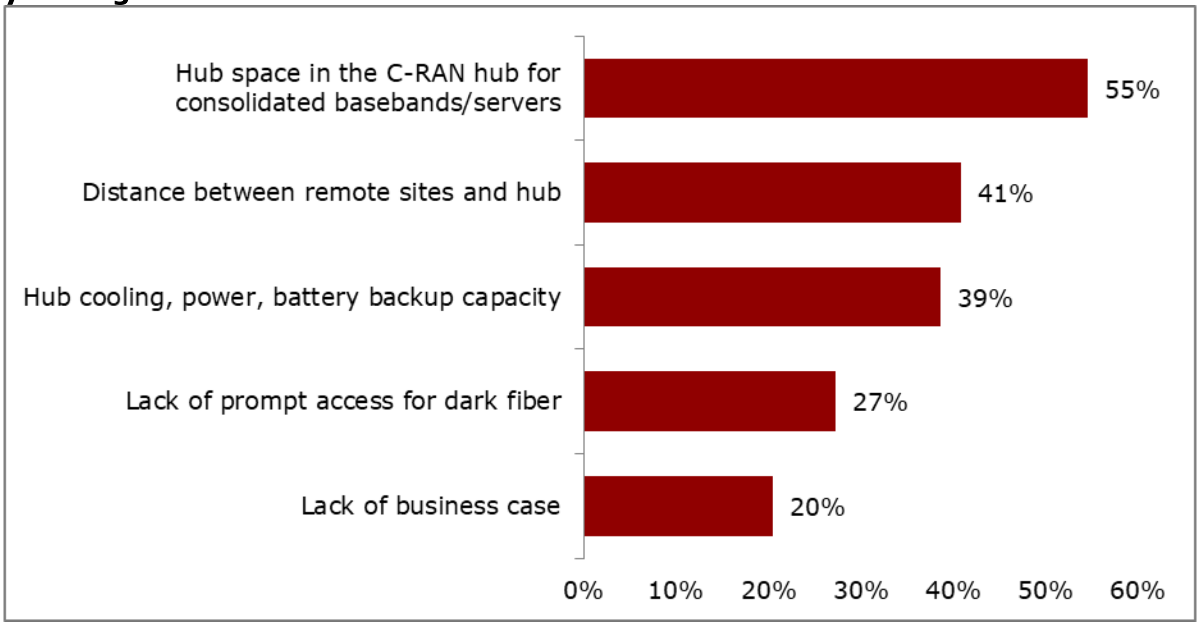
Lack of space looms large as the primary challenge for C-RANs, as 55% of the survey group cited a lack of hub space for consolidated equipment. Secondary challenges, based on the survey, are distances between remote and hub sites and cooling/power/battery backup issues, selected by 41% and 39% of respondents, respectively (see **Figure 10**).

These challenges are a clear reminder that C-RAN is an architecture that depends on the physical infrastructure and that, in the vast majority of cases, the physical infrastructure pre-dates, often by decades, C-RAN. Operators have abundant central office (CO) space and can free up space in those locations by moving to higher capacity equipment with smaller footprints (in essence, following Moore's Law). However, existing COs do not necessarily match up with ideal C-RAN hubs, which must be sited at central locations close to multiple cell towers. Distance restrictions (the second ranked challenge) are a major contributor, as radio unit (RU) to DU communication requirements limit hub sites to 10–15km maximum from RUs.

Many of these challenges may become even more pronounced as RAN virtualization places servers in locations that are not data centers. Space, power, and HVAC will all need to be reviewed for cloud RAN sites outside the data center.

Lastly, the lack of business case for C-RAN ranks at the bottom of the list, selected by just 20% of respondents. This is encouraging news for the architecture. However, the respondents are the subset of survey takers who already have plans to implement RAN centralization, so it is not surprising that the vast majority have already identified a business case to move forward.

Figure 10: What are the main challenges to deploying centralized RAN (C-RAN) for your organization?



n=44

Source: Heavy Reading, 2023

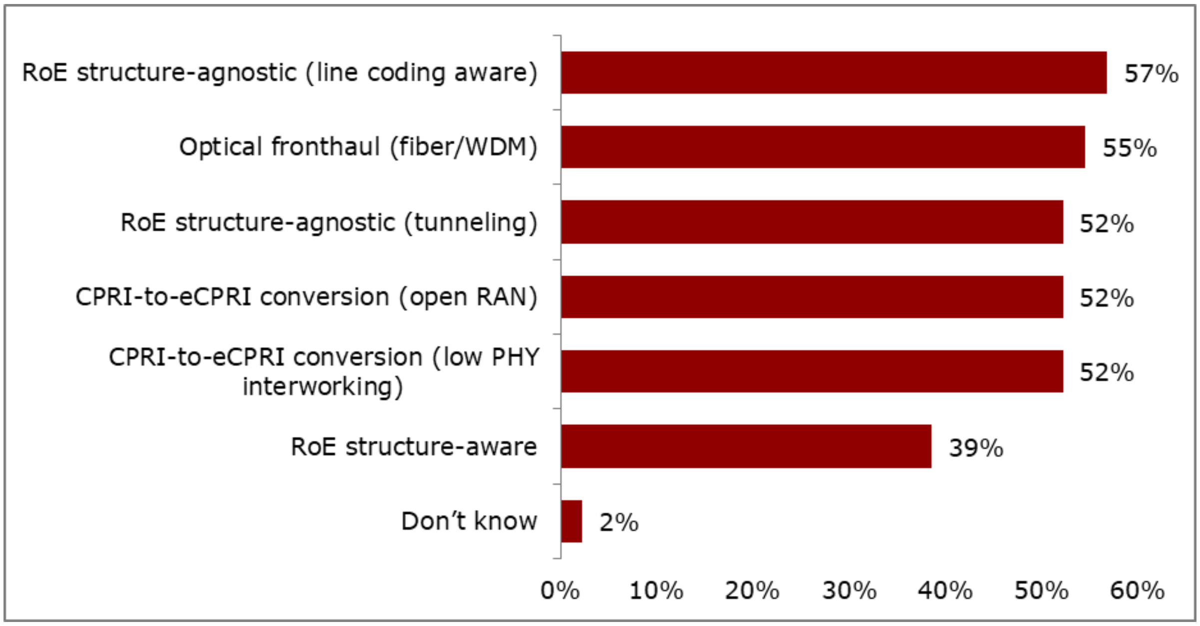
Because of the large installed base of LTE CPRI and even 5G CPRI traffic in the network, transporting CPRI traffic in the fronthaul network is crucial. Even as new installations move to eCPRI, these CPRI-based radios remain in place. CPRI over fiber or CPRI over WDM wavelengths make up the vast majority of CPRI transport in C-RAN to date. Technology-wise, that may be the easiest way to handle CPRI, but it is also highly inefficient for transport. There is no stat muxing, and CPRI runs completely independent of newer eCPRI.

Packetized transport of CPRI is the future mode of operations due to its benefits in scaling and network efficiency. It offers two general options: IEEE-standardized radio over Ethernet (RoE) and CPRI-to-eCPRI conversion. Each broad packetized approach also can be subdivided into variants.

The 2023 survey shows that although WDM/fiber is still a strong CPRI transport preference, packetized options are rising sharply in rank. Five options top the list of CPRI transport preferences; indeed, they are virtually tied statistically, with just 5 percentage points between the top and bottom preference. Those options are structure-agnostic RoE with line coding awareness (selected by 57% of respondents), fiber/WDM fronthaul (selected by 55%), and structure-agnostic RoE with tunneling, open RAN CPRI-to-eCPRI conversion, and low PHY CPRI-to-eCPRI conversion (each selected by 52% of the group). Structure-aware RoE ranks last among the options, chosen by 39% (see **Figure 11**).

It is worth noting that the 2022 survey, in which a similar question was asked, yielded a different result. In 2022, WDM/fiber fronthaul topped the preferences and was selected by nearly two-thirds of respondents, followed by CPRI-to-eCPRI conversion and then by RoE options. Heavy Reading believes the natural progression for most operators is to start simplest with separate CPRI and eCPRI transport and then take the next step to packetization—whether by RoE or eCPRI conversion. The results indicate that early adopters are increasingly planning for their packetized future and are now weighing the pros and cons of the multiple packet transport options available.

Figure 11: Which technologies will your organization use to transport legacy CPRI radio traffic?



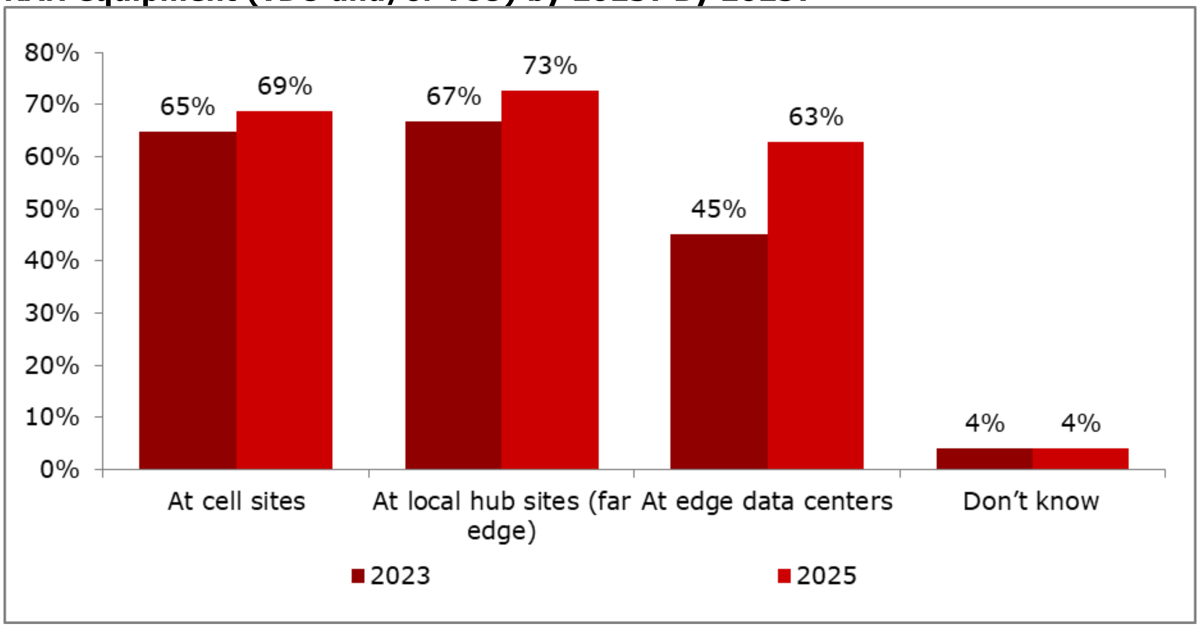
n=44
Source: Heavy Reading, 2023

Virtualization of the RAN (or cloud RAN) is often coupled with C-RAN, but RAN centralization is not itself a firm requirement for virtualization. Virtualization may exist in both C-RAN and distributed RAN architectures. In the 2023 survey, 59% of operators identified plans to introduce virtualization by 2025 (a higher percentage than the 51% planning C-RAN). In the 2022 survey, 57% of respondents identified plans for vRAN, so the trend is holding steady.

Virtualized CU and DU functions can be deployed in different parts of the network, including cell sites, local hub sites, and edge data centers. In 2023, local hub sites and cell sites are expected to be the primary locations for vRAN deployments, selected by 67% and 65% of respondents, respectively. Picked by 45% of the survey group, edge data centers trail behind these other locations (see **Figure 12**).

By 2025, however, operators expect a shift in virtualization location. Results indicate that they foresee an uptick in vCUs and/or vDUs at both cell sites and local hubs, as well as a significant jump in deployments at edge data centers, up by 18 percentage points to 63% of the survey group by 2025. The edge as a concept has been discussed for several years, but the reality is that operators are still defining their edge strategies. Based on the survey results, a majority of operators expect to define their edge strategies by 2025 and see these locations as suitable for hosting vRAN functions.

Figure 12: In which part of the network will your organization deploy virtualized RAN equipment (vDU and/or vCU) by 2023? By 2025?

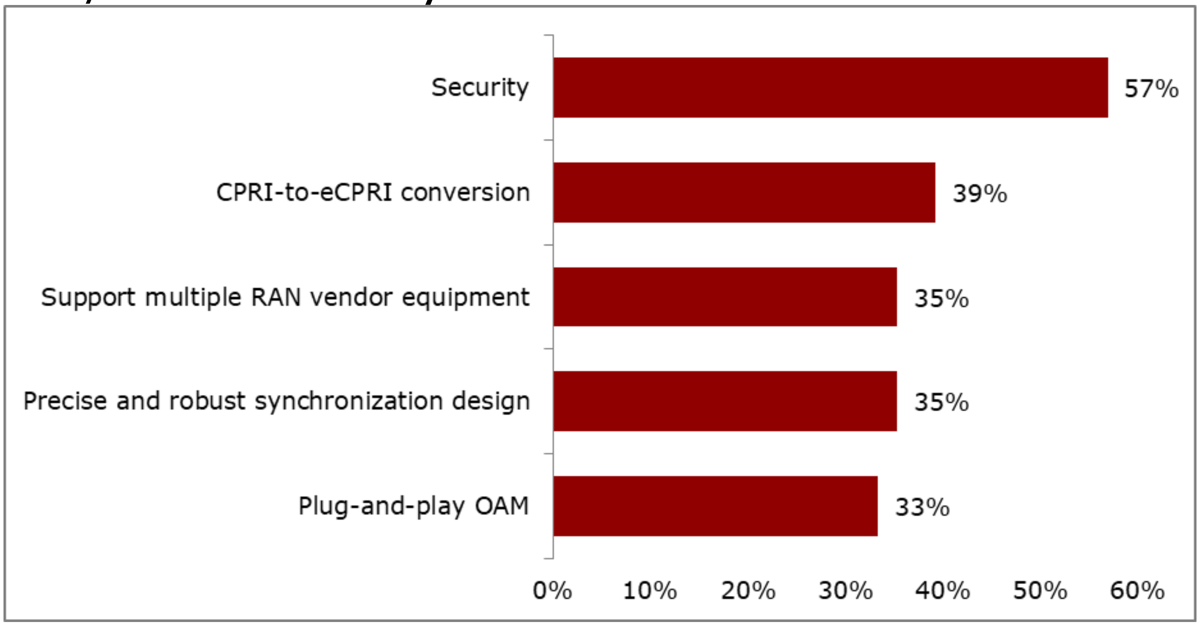


n=51
Source: Heavy Reading, 2023

Cloud RAN adoption introduces several challenges for operators, but nothing is more top of mind than security, which was picked as the biggest transport challenge by 57% of respondents. Other challenges—including CPRI conversion, multi-vendor support, precise synchronization design, and OAM—are all secondary to security and closely clustered in the 33–39% response range (see **Figure 13**).

Heavy Reading did not ask about this explicitly, but virtualization with multi-vendor open RAN likely contributed to the security concerns expressed in the survey. Open RAN security is a major topic within operators, standards bodies, and governments globally. Still, operators can virtualize functions independently of open RAN, and the earliest deployments do so.

Figure 13: What are the biggest transport challenges you foresee in supporting cloud/vRAN architecture in your network?



n=51

Source: Heavy Reading, 2023

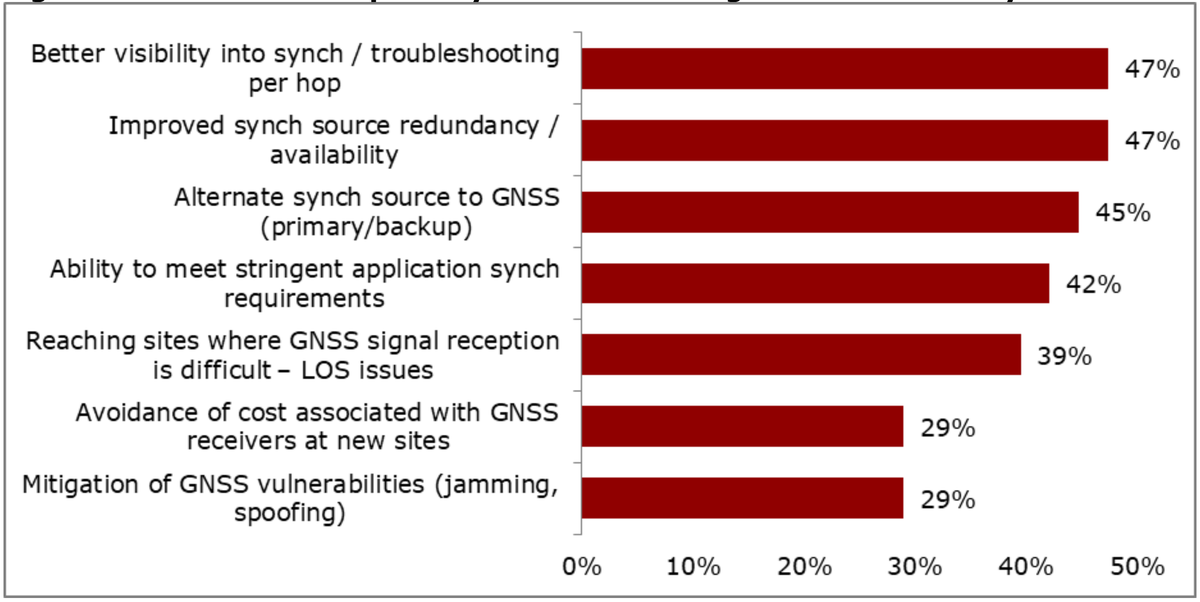
NETWORKING TIMING & SYNCHRONIZATION

The move from 4G to 5G radio technologies introduces new challenges and requirements in delivering timing and synchronization. These challenges include the migration from frequency division duplex (FDD) spectrum to time division duplex (TDD) spectrum, cell site densification (particularly at street level), and fronthaul connectivity requirements, among others. Heavy Reading has been covering 5G timing and synchronization since the advent of 5G (including in these annual surveys), but the topic appears to have taken on more urgency over the past 12 months.

This section investigates timing and synchronization issues for the 44% of the survey group that plans to implement network-based synchronization by 2025. Multiple factors drive this group's need for network-based technology, most especially better visibility into sync/troubleshooting per hop and improved synch source availability, with both factors selected by 47% of the respondents. The need for an alternate synch source to satellite (picked by 45%), the ability to meet stringent application synch requirements (42%), and the need to reach sites where satellite is unavailable (39%) are all also highly important factors (see **Figure 14**).

Although satellite vulnerabilities such as intentional jamming are often cited as a crucial concern at industry conferences and in the trade press, it is the least cited driver for network-based synch in the survey, tied at the bottom with receiver costs.

Figure 14: What are the primary drivers for using network-based synchronization?



n=38

Source: Heavy Reading, 2023

Timing profiles are a hot topic in 2023, as many operators are concerned that partial timing support—in which only some nodes have network-based timing—may be insufficient for 5G moving forward. The issue is that partial timing cannot support the tens-of-nanoseconds timing accuracy that may be needed. Full timing support is ideal, but it may require costly upgrades of nodes throughout the entire network. Assisted partial timing support is a hybrid approach that uses satellite to fill the gaps when network timing is not available.

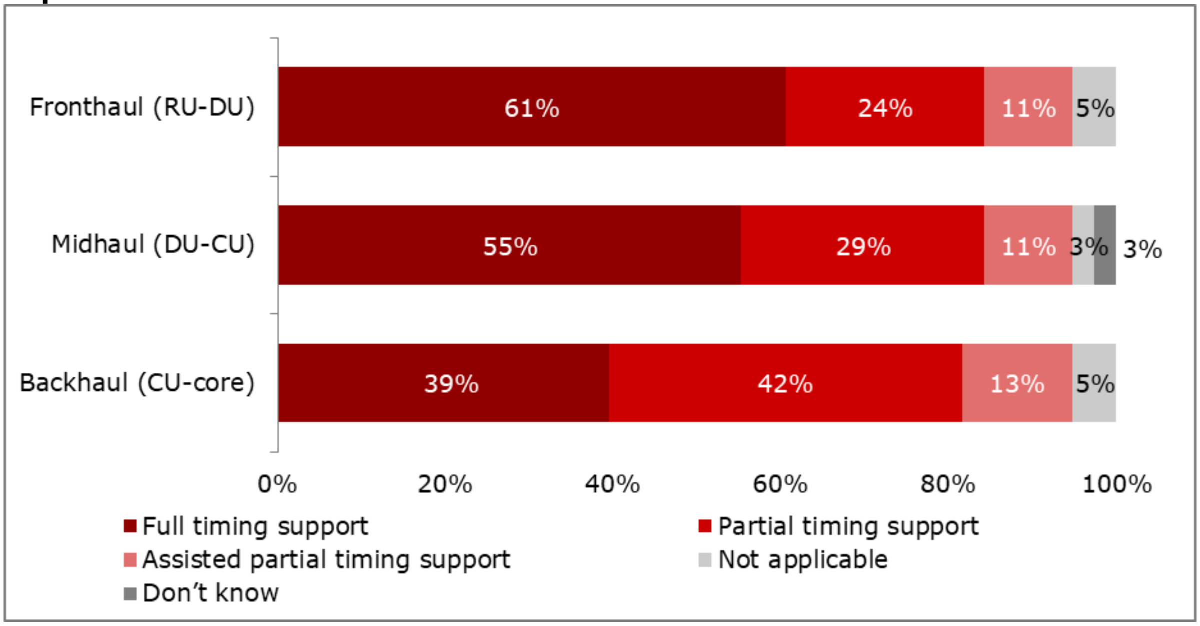
Operator preferences for different timing profiles vary by xHaul segment, according to the survey. Among operators, 61% of respondents see the greatest need for full timing support in fronthaul. Given that in fronthaul, the ITU recommends Class C boundary clocks with a maximum two-way time error of 30ns, full timing support may be the only option (see **Figure 15**).

Midhaul, too, has stringent time accuracy specifications in 5G. Reflecting these needs, 55% of operators surveyed expect full timing support in midhaul (only 6 percentage points fewer than for fronthaul).

For backhaul, the ITU recommends Class A or B accuracy, which provides more margin for timing error. Some 42%, a plurality of operators surveyed, prefer partial timing support for backhaul, with an additional 13% expecting assisted partial timing. Still, 39% expect full timing support.

Lastly, across the three xHaul segments, operators expressed preferences for either full or partial timing support but showed relatively little enthusiasm for the hybrid option of assisted partial timing support (a tepid 11–13% response). The reason is unclear. It may be that operators want to move away from satellite, or it may be that operators are not familiar with the benefits of the hybrid approach.

Figure 15: Which of the following timing profiles will your organization implement?



n=38

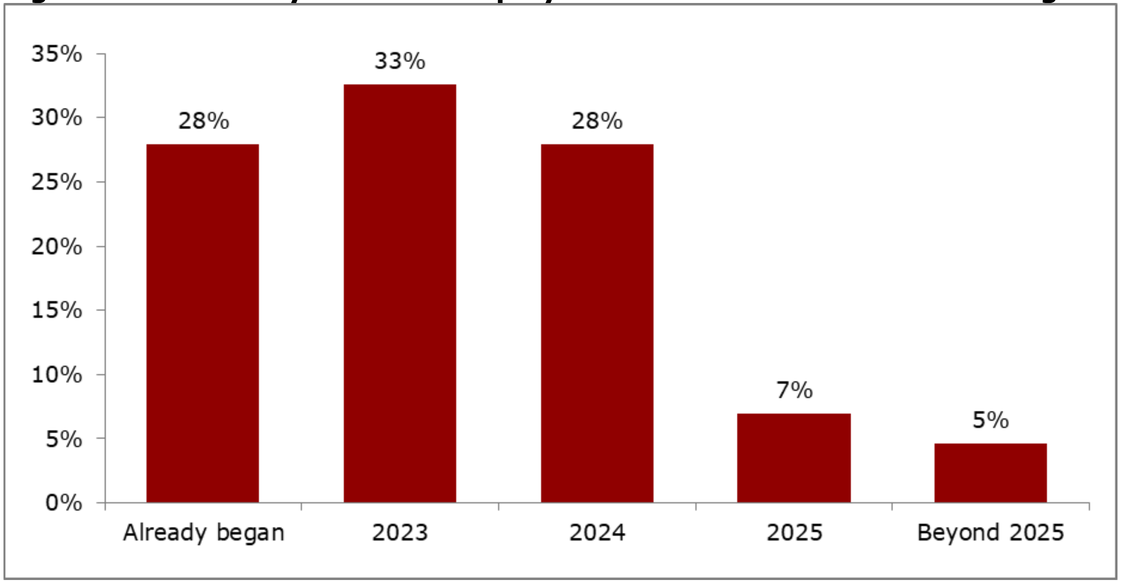
Source: Heavy Reading, 2023

NETWORK SLICING

One of the biggest differentiators in 5G compared to previous mobile generations is the ability to use network slicing to offer different types of services to multiple customers, all sharing the same operator infrastructure. Slicing involves both the RAN and the transport network and requires coordination of requirements and delivery across the two domains.

This section addresses network slicing in the transport domain, with results based on the 49% of the survey group that has plans for network slicing. Among those with network slicing plans, 28% report that initial network slicing deployments have already begun (**Figure 16**). An additional 33% of those surveyed expect initial deployments to occur this year, and 28% expect initial deployments in 2024. Operators with network slicing plans in place are clearly moving forward with deployments.

Figure 16: What is your initial deployment timeline for network slicing?

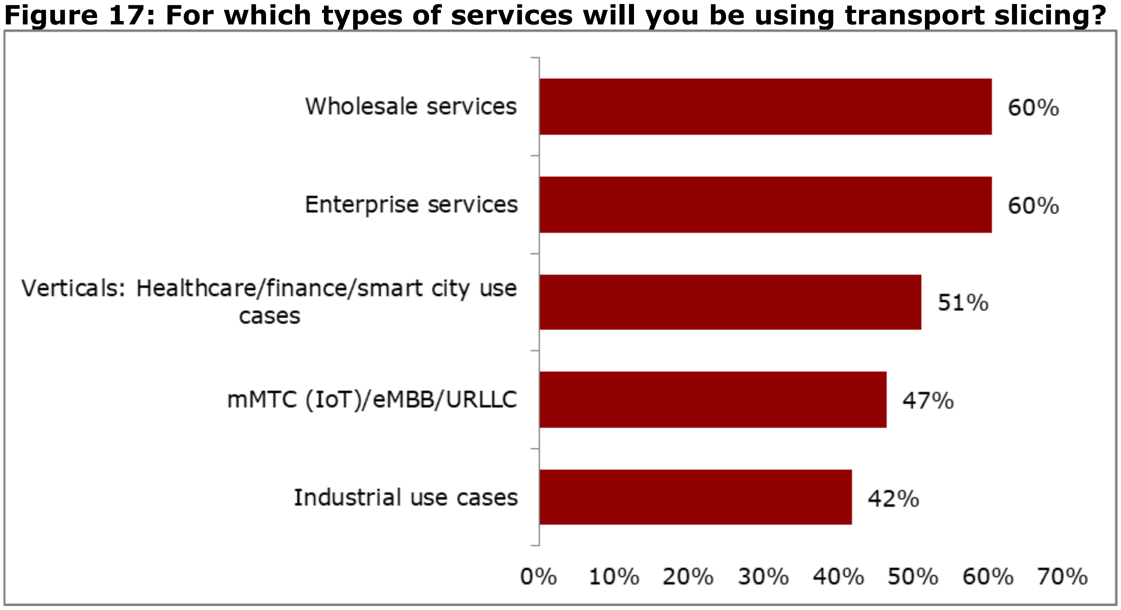


n=43

Source: Heavy Reading, 2023

For transport slicing specifically, network operators see the most promise in delivering wholesale services and general enterprise services, both of which were selected by 60% of respondents (**Figure 17**). But, at this early stage, all types of services are applicable for transport slicing, based on the survey results. Industrial use cases received the fewest number of responses, but this option was still selected by 42% of respondents. Industrial use cases are an early target for enterprise 5G, but a preference for private networks might be making the shared model of slicing less applicable for those use cases.

Figure 17: For which types of services will you be using transport slicing?

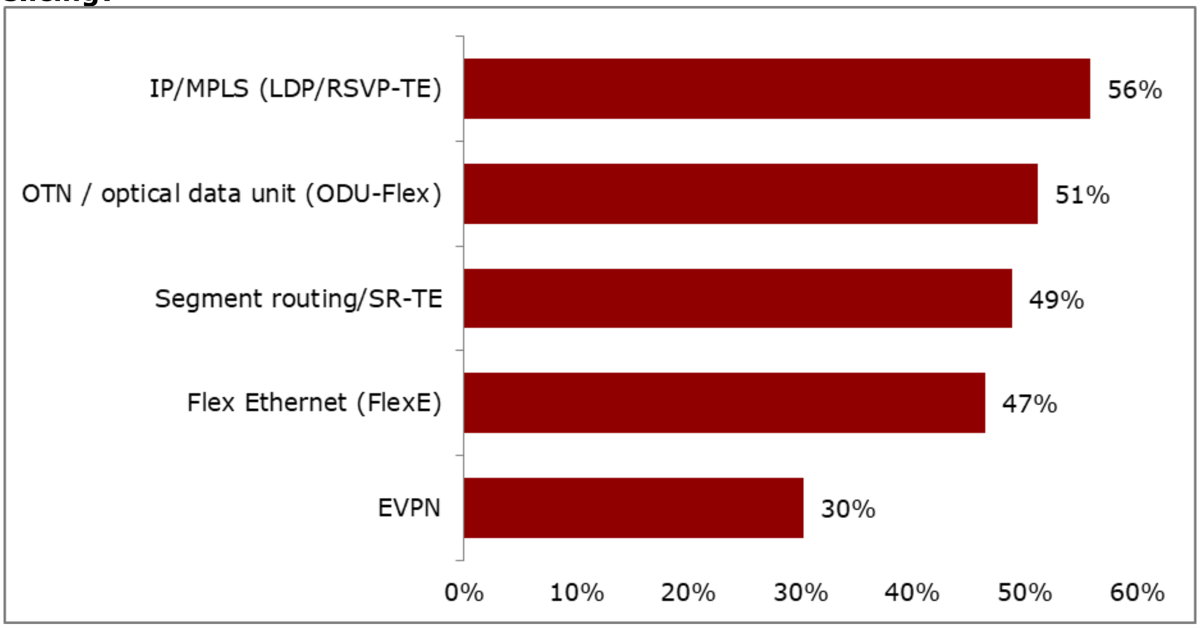


n=43

Source: Heavy Reading, 2023

Multiple technologies exist for slicing, including hard slicing options, such as ODU-Flex (short for flexible optical data unit), and soft slicing options, such as IP/MPLS and segment routing. Operators surveyed expect a mix of transport slicing, led by soft slicing using IP/MPLS (selected by 56% of the group) and hard slicing using ODU-Flex (picked by 51%). Segment routing (49%) and FlexE (47%) also scored highly among the options (see **Figure 18**).

Figure 18: Which technologies will your organization use for transport network slicing?



n=43

Source: Heavy Reading, 2023

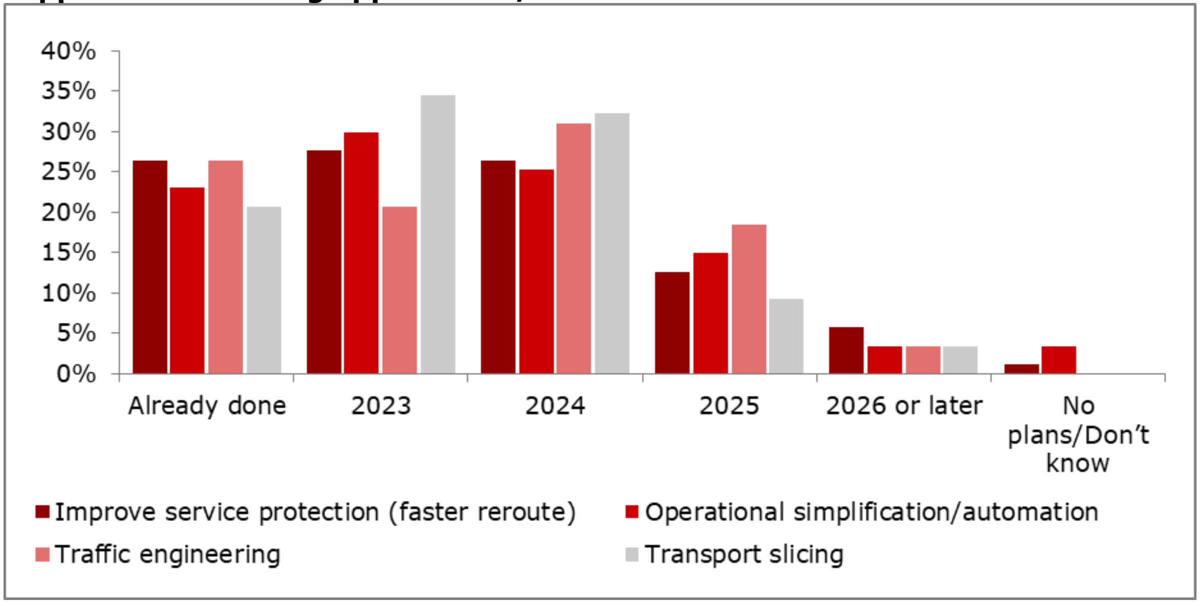
As shown above, segment routing has emerged as an important tool for network slicing in the transport network, in particular for soft slicing, which relies on virtual pre-negotiated paths. However, segment routing has a much broader appeal than network slicing alone. **Figure 19** shows operator timelines for segment routing across multiple use cases/applications, including slicing.

The data shows that currently, faster rerouting, operational automation, and traffic engineering use cases are all further along than transport slicing. This is not surprising because all three segment routing use cases are more mature than slicing. Expectations for segment routing for slicing, however, jump over the next two years, with 34% of respondents expecting introduction in 2023 and an additional 32% anticipating 2024.

End-to-end network orchestration and assurance will be critical for network slice performance; transport slicing will not succeed in isolation. Given the nascent state of slicing and the complexity of end-to-end implementation, the timelines appear ambitious. Still, the question asks only about the introduction of the technology. It is likely that wide-scale deployments will follow these introductions by a year or more.

As a final note, the results are consistent with those from a similar question asked in Heavy Reading's 2021 5G transport survey. Operators have ambitious plans for segment routing in transport slicing over the medium term, but use of the technology is not quite here yet.

Figure 19: When does your organization plan to introduce segment routing to support the following applications/use cases?



n=87

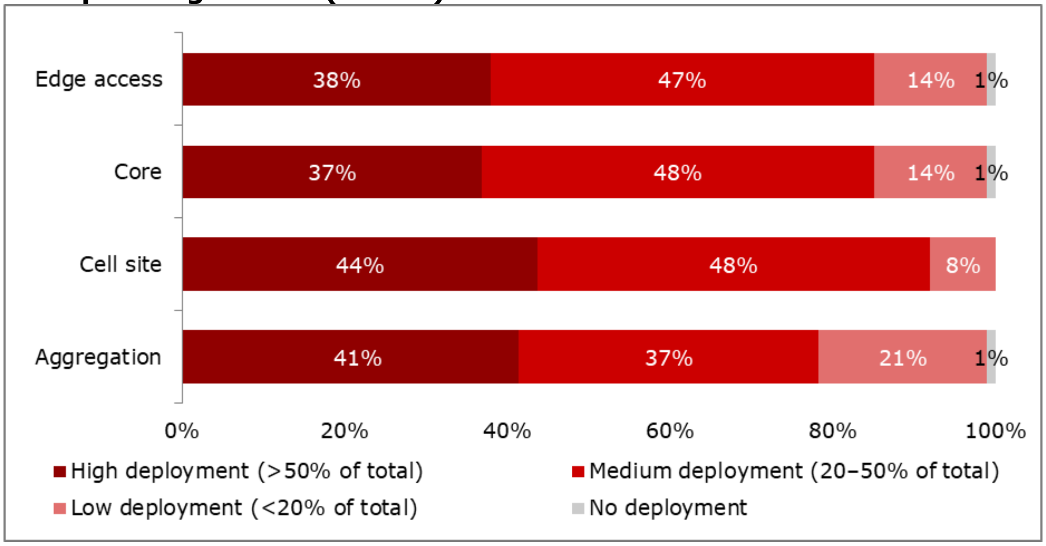
Source: Heavy Reading, 2023

WHITE BOX TRANSPORT & ROUTING

In the white box business model, the network operating system is separate from the underlying hardware, with each supplied by different vendors. In transport networks, these white box elements can be routers, packet-optical equipment, or DWDM transponders. Heavy Reading asked network operators to identify how extensively they plan to adopt white box transport elements across various network segments (see **Figure 20**).

Operators surveyed expect white box elements to have their highest deployments in cell sites and aggregation nodes. 44% of operators expect high deployments in cell sites (defined as greater than 50% of total elements), followed closely by aggregation, with 41% expecting high deployments.

Figure 20: How extensively does your organization expect to deploy white box optical transport platforms over the next three years for the following 5G transport segments? (Global)

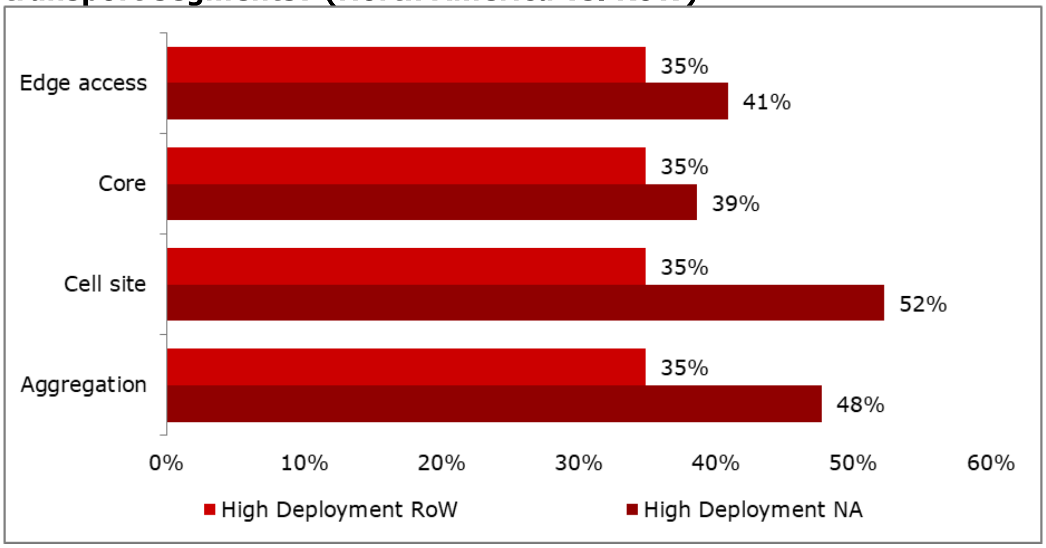


n=87

Source: Heavy Reading, 2023

Enthusiasm for white box transport varies by geographic region, with North American operators expecting greater white box deployments across all segments and particularly in cell sites and aggregation. 52% of North American operators expect white box transport at cell sites, and 48% expect white box in aggregation, versus 35% in each region for the RoW counterparts (see **Figure 21**).

Figure 21: How extensively does your organization expect to deploy white box optical transport platforms over the next three years for the following 5G transport segments? (North America vs. RoW)



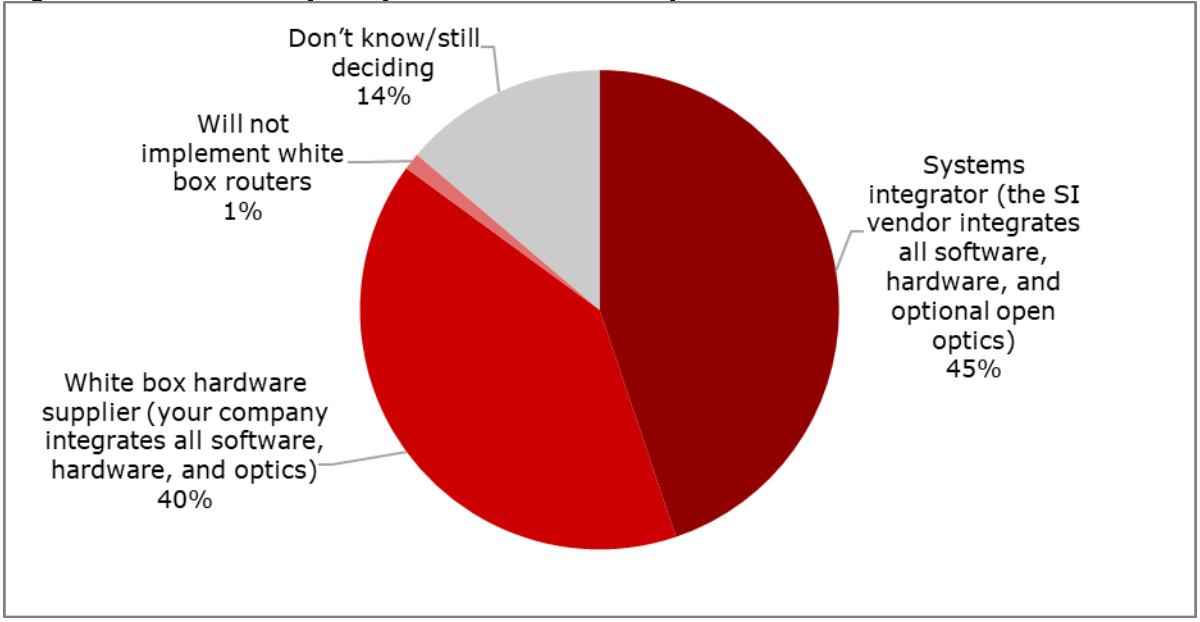
n=44 North America (NA), n=43 RoW

Source: Heavy Reading, 2023

Procurement is a major part of the white box business model. There are two major options. Operators can act as their own SIs and do all the work themselves, or they can use outside suppliers to handle systems integration. An outside SI can be one of the operator's white box vendors, or it can be a third-party company that works directly with hardware and software suppliers.

Results show that operators prefer outside SIs to the do-it-yourself model for white box routers, but not by a large margin. 45% selected outside SIs versus 40% for do-it-yourself integration. 14% of the survey group is still deciding (**Figure 22**).

Figure 22: Who will your procurement team purchase a white box router from?



n=87

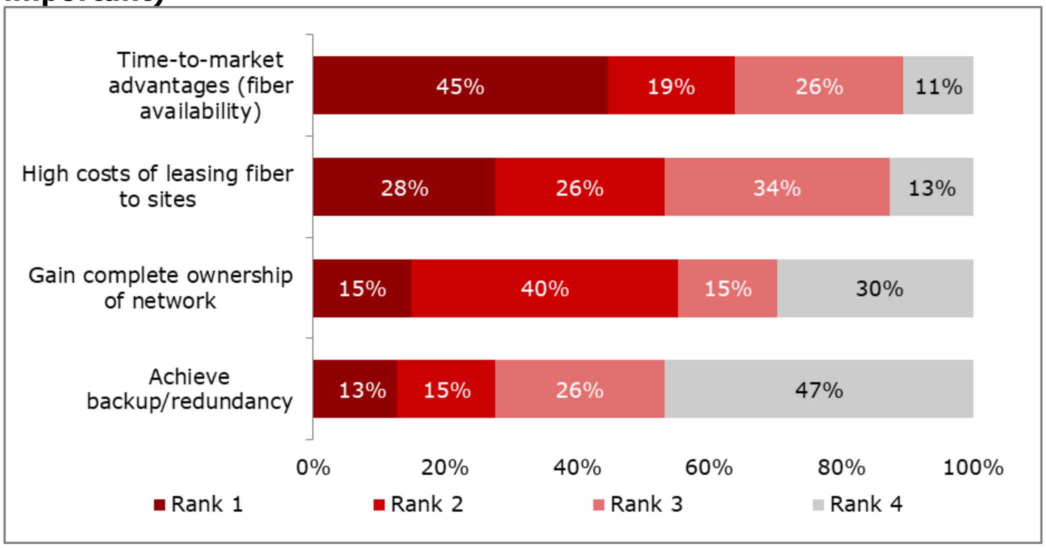
Source: Heavy Reading, 2023

MICROWAVE TRANSPORT

Fiber is the first choice for 5G xHaul, but fiber is not always physically available or financially feasible. In these cases, microwave transport is an option. More than half of operators surveyed (54%) have deployed or plan to deploy microwave transport for 5G, and Heavy Reading research consistently shows that microwave transport has an important role to play in 5G xHaul, across all geographies.

According to the 2023 survey, the primary driver for deploying microwave transport for 5G is time to market/fiber availability, which was ranked first on the list by nearly half (45%) of operator respondents. Second on the list was high cost of leased fiber, the first choice of 28% of respondents. In other words, a lack of fiber availability and/or the high cost of obtaining fiber will continue to drive the microwave transport decision (see **Figure 23**).

Figure 23: How important are the following motivations for deploying microwave transport in your 5G transport network? (Rank in order, where 1 = most important)

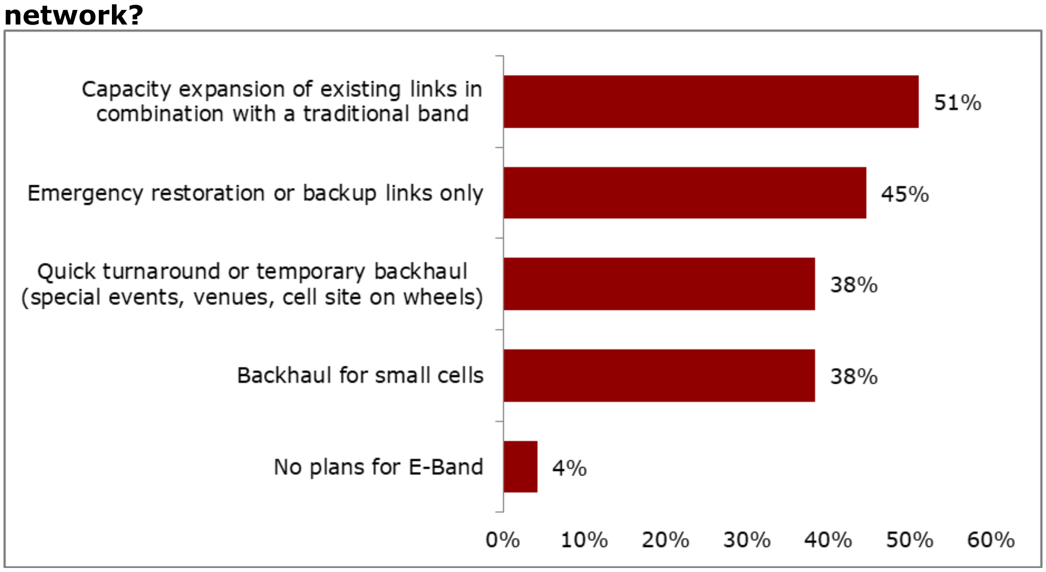


n=47

Source: Heavy Reading, 2023

E-Band microwave radio operates in the 70–80 GHz spectrum band and provides some advantages compared with other microwave bands. Two primary applications for E-Band radio rise to the top in the survey. Capacity expansion of existing links along with traditional microwave is the top application (selected by 51% of operators), followed by emergency restoration or backup links only (selected by 45%). Temporary backhaul and small cell backhaul are important secondary drivers for E-Band deployments, with each picked by 38% of the survey group (see **Figure 24**).

Figure 24: What are the primary applications for E-Band (70/80 GHz) radio in your network?



n=47

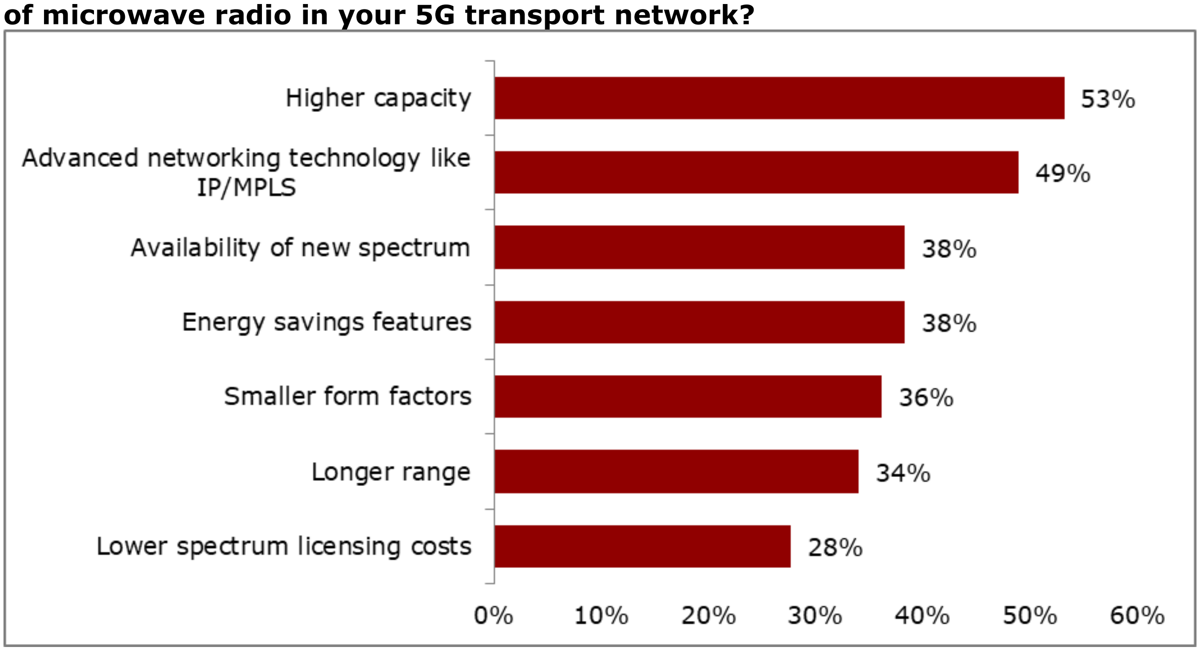
Source: Heavy Reading, 2023

Lastly, higher capacities and advanced network features top the list of features that operators would like to see in microwave transport equipment, selected by 53% and 49% of operators, respectively. Meeting 5G backhaul capacity needs is absolutely required, and 10Gbps to the cell site is table stakes, or the minimum entry requirement, for any 5G deployments today. Among the technologies that can increase microwave capacity are higher order modulation, adaptive modulation, dual-band antennas, dual polarization and cross-polarization interference canceling (XPIC), higher order MIMO (multiple-input, multiple-output), and carrier aggregation.

The desire for advanced technologies shows that operators are eyeing the advanced use cases promised by 5G beyond enhanced mobile broadband (eMBB). Network slicing, for example, will make use of Ethernet VPNs (EVPNs) and segment routing, so microwave sites cannot be excluded from these types of functions (see **Figure 25**).

Beyond capacity and features, other capabilities are important but take a secondary role, including new spectrum, energy consumption, and small form factors. There is a great deal of justifiable industry discussion about power reduction and sustainability this year, but it is the RAN—not the transport network—that drives most of the energy consumption. The survey results indicate that operators will take energy-saving features when available, but only after addressing the main functionalities.

Figure 25: What features/developments would you like to see to increase your use of microwave radio in your 5G transport network?



n=47

Source: Heavy Reading, 2023