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HEAVY READING
WHITE PAPER

Operator Strategies for 5G Transport:
2019 Heavy Reading Survey

A Heavy Reading white paper produced for Ericsson, Fujitsu, Juniper, and Viavi

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EXECUTIVE SUMMARY

Most 5G industry discussions focus on the radio network, but the transport network will also play a crucial role in 5G. The transport network will provide the backhaul and new fronthaul and midhaul connectivity that will enable the high bandwidth, ultra-reliable, and ultra-low latency applications for 5G end devices. In fact, the industry has recognized that this transport infrastructure must be put in place before 5G applications can be rolled out in volume. Due to the aggressive operator timelines for launching 5G, today is an urgent time for the transport network.

While 5G trials and limited commercial rollouts may not strain the transport network, significant architecture changes are required to roll out 5G services at scale. 5G promises a tenfold increase in capacity, in excess of 1 Gbit/s, to end devices. This capacity increase in the radio reverberates throughout the access network, and without upgrades, the network becomes the bottleneck.

Consider massive machine-type communications (mMTC), which describes Internet of Things (IoT) applications in which data rates to individual sensors can be very low (measured in kbit/s) but connected devices number in the billions. Transport networks must support these billions of IoT devices. In addition, ultra-reliable low latency communications (URLLC) describes mission-critical and extreme precision applications in which end-to-end latency may be 1 ms, jitter less than 1 µs, and reliability measured to six nines. Under the banner of "Xhaul," there are many technology options available. Combined with the functional split variations defined in 5G, the situation is complex.

Given the range of Xhaul transport options and the growing urgency to move forward with the right architecture, Heavy Reading conducted its most in-depth multi-sponsored global survey to date focused exclusively on 5G transport in April 2019. The survey received 104 qualified network operator responses from around the world (with 57% from North America). This Heavy Reading white paper, which is based on the survey results, provides the industry's most in-depth look at the current state and future trajectory of 5G transport (or Xhaul) based on operators' views and plans.

Additional details on the demographics of the survey group are included as an **Appendix** at the end of this paper. The following sections detail Heavy Reading's key findings from this study.

5G Service and Network Deployment Timelines

Mass-market 5G launches – not initial launches – are the critical timeframe for transport network planning. According to Heavy Reading's survey, the 2021-2023 timeframe will be the mass-market peak, in which 53% of the group said they plan a mass-market launch. Transport network capacity and performance must be in place for mass-market services to succeed.

A surprisingly high number of respondents said they have already started their upgrades – about 50% of the group. Heavy Reading does not believe this percentage equates to requests for proposals (RFPs) for network equipment, as anecdotal data from operators does not support the statistic. But fiber plant extension is well underway, and operators are at various stages of evaluating transport technology options.

Operators will think of their fronthaul networks and their midhaul/backhaul networks together in terms of upgrade timelines. In other words, operators do not intend to build their fronthaul networks first and then upgrade midhaul/backhaul networks later or vice versa.

Transport Network Migration Priorities

Enhanced Common Public Radio Interface (eCPRI) and Optical Transport Network (OTN) topped the list of most important 5G transport technologies. eCPRI was developed specifically to meet the bandwidth and performance requirements for 5G fronthaul, so it is difficult to imagine 5G fronthaul without eCPRI. OTN ranked high across all geographies. Heavy Reading believes OTN was largely a proxy for wavelength-division multiplexing (WDM) wavelengths (which use OTN framing) in our survey. For telecom, 5G will be the main driver for the expansion of WDM into access networks, and the survey results reflect this trend.

Network timing and synchronization also rated near the top of the list of most important 5G transport technologies (rated "high importance" by 45% of the group). A key industry topic at the advent of 4G Ethernet backhaul, 5G timing and synchronization have been curiously absent in 5G discussions until very recently. Heavy Reading believes that operators are realizing that migration from 4G to 5G necessitates big changes in timing and synchronization. Results show that suppliers must get out in front of their customers quickly.

Radio and IP network incumbency does not carry as much weight in 5G transport decisions as initially believed. Some operators will choose transport suppliers that also supply their radio networks or their IP networks – but only if their costs are also the lowest and their technology is also best in class. The survey results show that, in 5G, the transport network will not be an afterthought or an ancillary purchase. Rather, it will be its own distinct segment that will require its own set of RFPs.

With 5G, Heavy Reading sees a clear interest in moving toward open interoperability. In our survey, 77% of respondents reported that radio access network (RAN) interoperability between radio unit (RU) and baseband unit (BBU) equipment was at least "very important" to them, with 22% of respondents reporting that RAN interoperability was a "critical" requirement that must be supported by all vendors. These are significant findings that underscore the growing importance of industry initiatives such as the O-RAN Alliance.

Fronthaul Plans

It is early days still, but survey results indicate interest in RAN centralization is growing globally. Nearly two-thirds of operators (64%) expect that at least 20% of their 5G networks will be centralized RANs (C-RANs). And for 19% of operators, 40% of their 5G networks will be C-RAN. Just 6% of those surveyed said they have no plans for C-RAN at 5G. Although initial interest was strongest in North America, Heavy Reading's results show that interest is now strong across geographies.

While interest in C-RAN is common across geographies, preferred connectivity methods for fronthaul vary greatly by region. For North American operators, dark fiber fronthaul is the clear preference, selected by 31% of the survey group and followed by

passive WDM pluggables at 22%. But for respondents outside North America (Rest of World [ROW] in our survey), packet-based fronthaul using time-sensitive networking (TSN – IEEE 802.1CM) was the top choice – selected by 27% of the survey group. North American operators placed IEEE TSN near the bottom.

IP/Packet Layer Plans

The need for greater capacity is the chief reason leading operators to upgrade their midhaul and backhaul networks for 5G. In Heavy Reading's survey, 69% of respondents selected capacity as the primary reason – far ahead of the second option, latency (selected by 40% of the group). 5G New Radio (NR) ultimately promises a 10x increase in a capacity, and these requirements reverberate throughout the Xhaul network. While 5G may not fill a 10 Gbit/s midhaul/backhaul link on Day 1, it will require greater rates than the 1 Gbit/s backhaul port rates that are standard today. Similarly, higher speed ports and high speed port densities topped operator requirements for edge/core routers and cell site gateways (CSGs) in our survey.

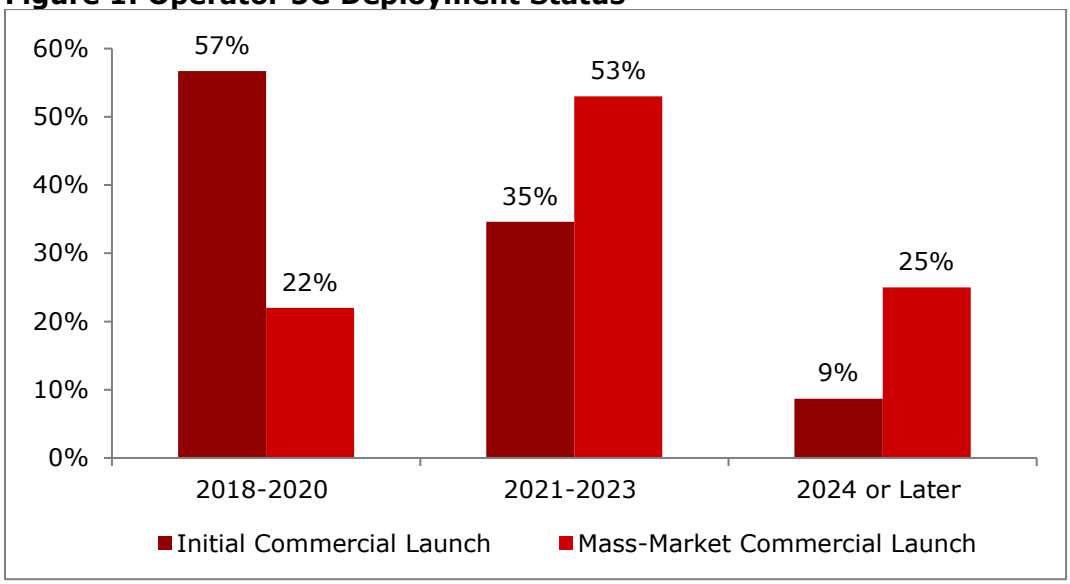
White box switches routers are important to many operators, but the degree of importance depends largely on the operator's geography. On a global level, nearly two-thirds (65%) of respondents reported that white box switches/routers are at least "very important," with 21% of the group reporting that 5G transport will not be deployed without white box. But North America is leading the white box charge. Twenty-eight percent of North American respondents stated that white box routers/switches are critical to 5G deployments while just 13% of respondents outside North America (ROW) believe white box routers are critical. Nearly half of these ROW respondents (49%) reported that white box switches/routers will be either just marginally important or will not be used at all in 5G. Either North America will largely move in its own white box direction in 5G or the rest of the world has yet to catch up on white box thinking. Right now, it is too early to know.

5G SERVICE AND NETWORK DEPLOYMENT TIMELINES

Any discussion around 5G transport migration must start with market timing: When do operators plan to launch commercial 5G services? In this study, Heavy Reading wanted to gain a more granular understanding of operators' 5G launch plans, including when they expect to make their initial 5G launches and then when they expect their mass-market launches to begin. Fairly consistent with previous Heavy Reading research as well as other industry research and announcements, initial launches are happening now. In our survey, 57% said they expect initial launches by 2020.

But mass-market commercial launches will come later. According to Heavy Reading's survey, the 2021-2023 timeframe will be the mass-market peak; 53% of the group said they plan a mass-market launch during that timeframe. From a transport network perspective, Heavy Reading believes that this mass-market timeframe is the critical one for planning – as transport network capacity and performance must be assured before mass-market services can succeed (see **Figure 1**).

Figure 1: Operator 5G Deployment Status

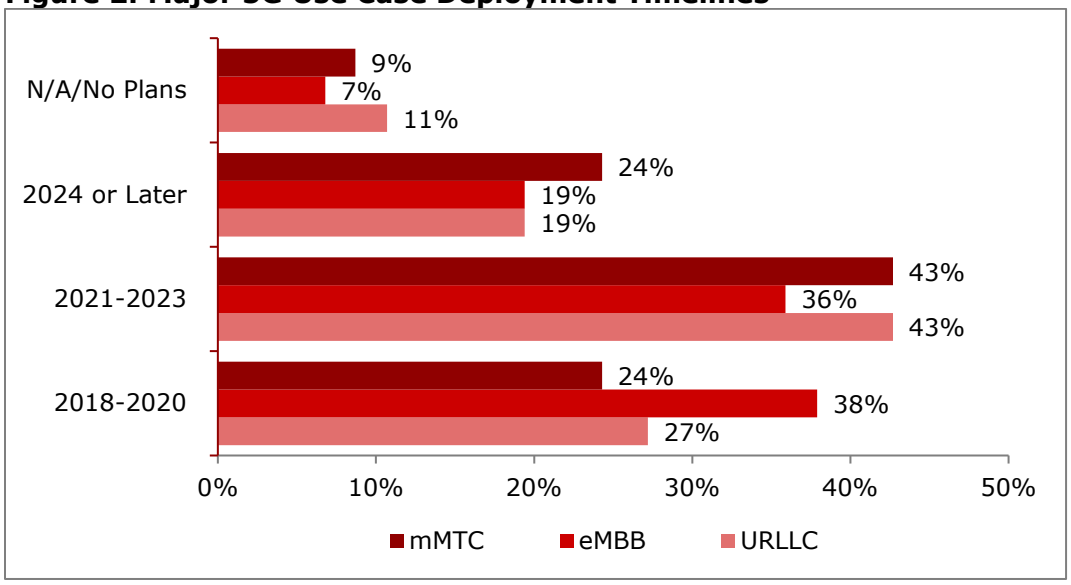


N=104
Source: Heavy Reading

Digging for more granular detail, Heavy Reading also wanted to understand operator deployment timelines across the major 5G use case types, specifically, Enhanced Mobile Broadband (eMBB), URLLC, and mMTC (see **Figure 2**). Results indicate that early launches – while largely being initial deployments – will also focus primarily on eMBB use cases, meaning faster speeds. In Heavy Reading's survey, 38% of respondents expect to launch eMBB services in the 2018-2020 timeframe. Advanced 5G applications in URLLC and mMTC are expected to pick up in the 2021-2023 timeframe. In fact, operators surveyed were in lock-step on these two use cases, with 43% of the group selecting 2021-2023 for each.

These expectations are consistent with the current planned timeline for full 5G NR standardization (3GPP Release 16), which is expected to be ratified in 1Q 2020. With full standardization, operators will launch the full set of use cases/applications.

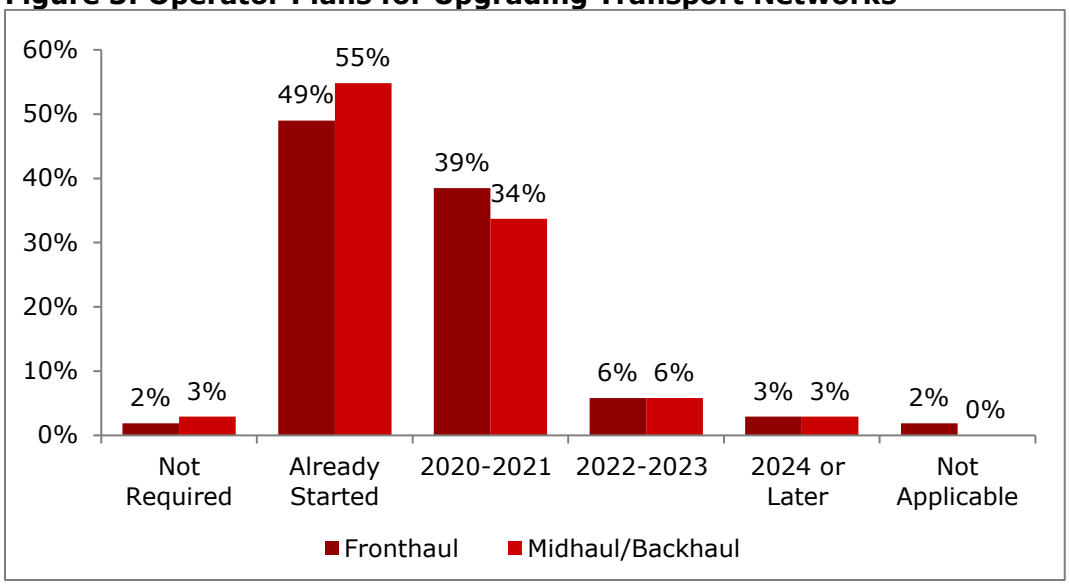
Figure 2: Major 5G Use Case Deployment Timelines



N=103
Source: Heavy Reading

The big question for the transport industry is: When will operators upgrade their transport networks to support 5G? Heavy Reading separated responses for fronthaul and for midhaul/backhaul to understand whether there were differences in planning (see **Figure 3**).

Figure 3: Operator Plans for Upgrading Transport Networks



N=104
Source: Heavy Reading

Results show that operators are thinking of their fronthaul networks and their midhaul/backhaul networks together, at least in terms of upgrade timelines. In other words, operators do not intend to build their fronthaul networks first and then upgrade midhaul/backhaul networks later or vice versa.

A surprisingly high number of respondents said they have already started their upgrades – about 50% of the group. Heavy Reading does not believe this percentage equates to RFPs for network equipment, as anecdotal data from operators does not support the statistic. In addition to RFP activity, we think initial upgrades also include fiber plant extensions, which are taking place across geographic regions (through builds and acquisitions).

Heavy Reading notes that while the transport buildouts may not coincide with initial 5G launch plans (**Figure 1**), the data does indicate that transport networks will largely be in place in advance of mass-market launches. Mass-market 5G launches are the true target for 5G transport network upgrades.

TRANSPORT NETWORK MIGRATION PRIORITIES

In this section, Heavy Reading delves deeper into operator views on transport architectures and specific technology options. To put transport in the greater context of the multiple network initiatives surrounding 5G (aside from radio), we asked respondents: **What areas of your current network will undergo the biggest changes with a migration to an infrastructure supporting 5G?** (See **Figure 4**.)

To be clear, we were not asking about what areas are most important for 5G, but which areas will have to change the most in order to support 5G. Interestingly – from the perspective of massive change – transport did not top the list; it ranked fourth. Consistent with all the industry hype, questions, and general anxiety we are witnessing, the network edge ranked No. 1 on the list. The "edge" is the topic du jour, and it showed in the survey results.

Figure 4: Areas to Undergo Biggest Change in Migration to 5G

Area	Overall Rank	Score
Edge/Core Transport (including Data Center Interconnect)	1	366
Virtualization (RAN, Backhaul, Edge, Core)	2	363
Distributing Data Center & Compute Capabilities to the Edge – Supporting Edge Compute	3	328
Xhaul Transport (including Fronthaul/Midhaul/Backhaul)	4	323
End-to-End Visibility & Operations (Telemetry, Automation, Orchestration, Analytics, Machine Learning)	5	281
Security	6	280

N=104
Source: Heavy Reading

Heavy Reading knows that operators are deeply concerned about how to address the stringent requirements of ultra-low latency applications. Up until a year ago, this latency burden was largely placed on the transport network: architecting a transport network to

have the lowest latency. However, operators quickly realized that to dramatically reduce latency, compute and storage need to be moved out of hub central offices and mega data centers and closer to the 5G users and devices. The location of compute and storage is, by far, the biggest factor in latency that will be achieved. We believe this realization has led to the focus on edge and core data centers.

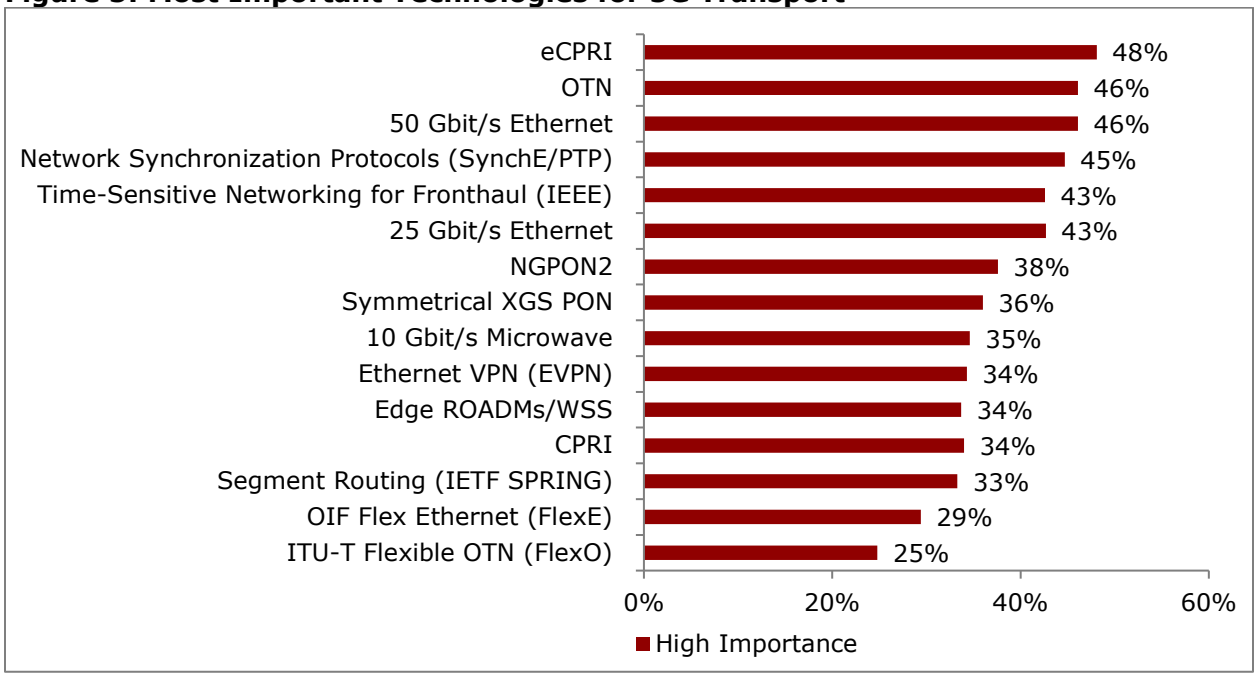
The transport plays a major role in the edge, but it is the placement of the edge that will define the transport architecture going forward. This is the reason that "where is the edge?" is such a critical question right now.

5G Transport Technologies

Next, Heavy Reading asked about the most important technologies for 5G transport. Results are shown in **Figure 5** in descending order according the percentage that selected "high importance" for each.

We are not surprised that eCPRI topped the list. The migration to C-RAN architectures creates a new network segment – the fronthaul segment – and the CPRI Consortium created eCPRI specifically to economically meet the higher bandwidth requirements of 5G fronthaul compared to 4G fronthaul. At this point, it is difficult to imagine 5G fronthaul without eCPRI.

Figure 5: Most Important Technologies for 5G Transport



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Source: Heavy Reading

Also scoring at the top of the technology list was OTN, and Heavy Reading notes that OTN's top ranking was not limited to a specific geographic region but spanned them all (including North America). In this respect, we believe OTN was largely a proxy for WDM wavelengths (which use OTN framing). For telecom, 5G will be the main driver for the expansion of WDM into access networks. What we do not know from this question is the extent to which

operators will want OTN switching in their access and aggregation networks. From one-on-one discussions with operators, we get mixed opinions; this a survey question that requires further study.

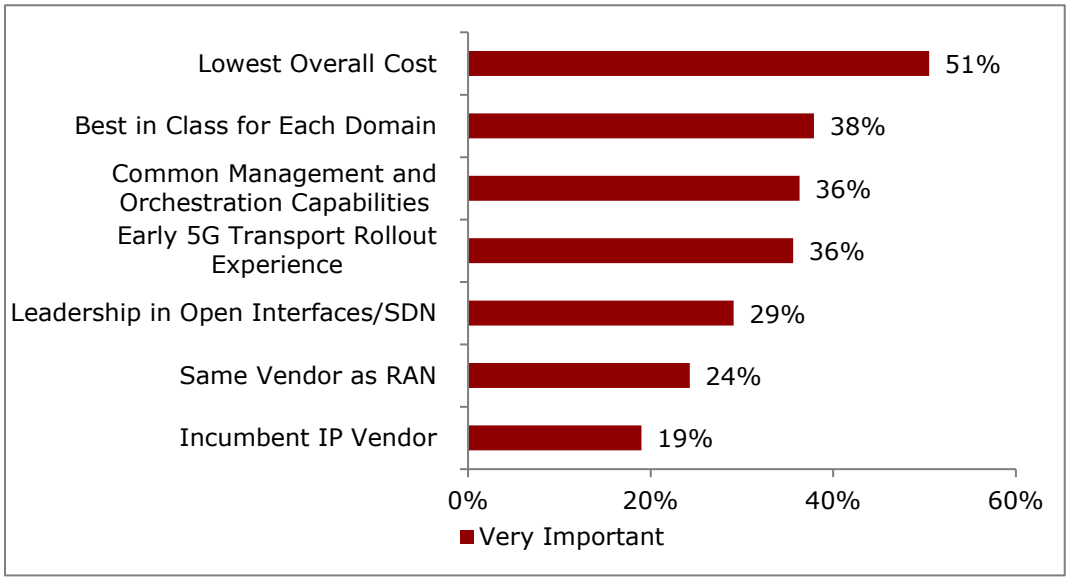
The high priority placed on network timing and synchronization (rated "high importance" by 45% of the group) was also an important finding from the survey. A key industry topic at the advent of 4G Ethernet backhaul, 5G timing and synchronization have been curiously absent in 5G discussions until very recently. Heavy Reading believes that operators are realizing that migration from 4G to 5G places some big changes in timing and synchronization and that suppliers must get out and front of their customers on this one quickly.

Finally, we note a reasonable showing from 10 Gbit/s microwave (selected as "high importance" by 35%). While fiber is the first choice for transport, it will not always be available or economical. Heavy Reading's market research continues to show that high data rate microwave will play a role in 5G transport.

5G Transport Vendor Selection

We asked operators about the most important transport vendor selection criteria for 5G. Unsurprisingly, lowest overall cost topped the list. From every transport network survey that we have conducted at Heavy Reading over many years, we know that lowest cost transport is always the top priority. 5G transport will be no exception to the transport rule (see **Figure 6**).

Figure 6: Most Important Selection Criteria When Deciding on 5G Transport Supplier



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Source: Heavy Reading

But a big question answered here is: What is the role of radio and/or IP incumbency in the 5G transport decision process? The answer is that incumbency will count for very little. Yes, some operators will choose transport suppliers that also supply their radio networks or their

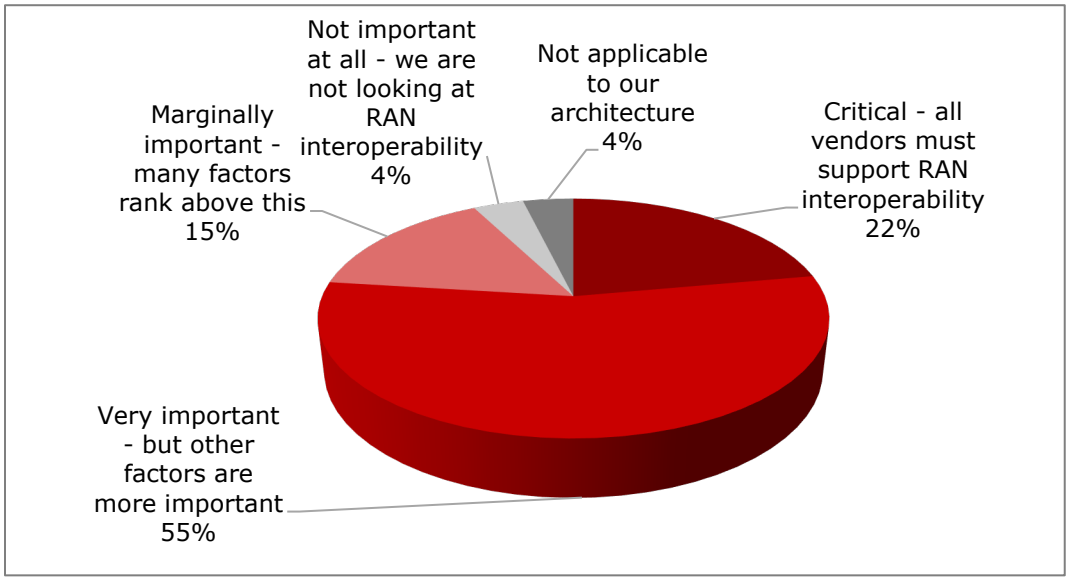
IP networks – but only if that vendor's costs are lowest and its technology is best in class. The survey results clearly state that the transport network will not be an afterthought or an ancillary purchase to the radio network in 5G. Rather, the transport network will be its own distinct segment that will require its own set of RFPs.

As a final point, while not the top requirement, early experience in 5G transport rollouts is an important consideration for operators. Operators are looking for guidance, and they will turn to suppliers that have early-mover experience in 5G transport and that are able to guide them down the right path for their networks.

RAN Interoperability

Historically, the RAN was a closed network in which RUs and BBUs were supplied by the same vendor. With 5G, however, the RAN is distinctly moving toward open interoperability based on operator demand. In Heavy Reading's survey, 77% of respondents reported that RAN interoperability between RUs and BBU equipment was at least "very important" to them, with 22% of respondents reporting that RAN interoperability was a "critical" requirement that must be supported by all vendors. These are important findings that underscore the growing importance of industry initiatives such as the O-RAN Alliance. **Figure 7** shows the results.

Figure 7: Importance of RAN Interoperability in 5G



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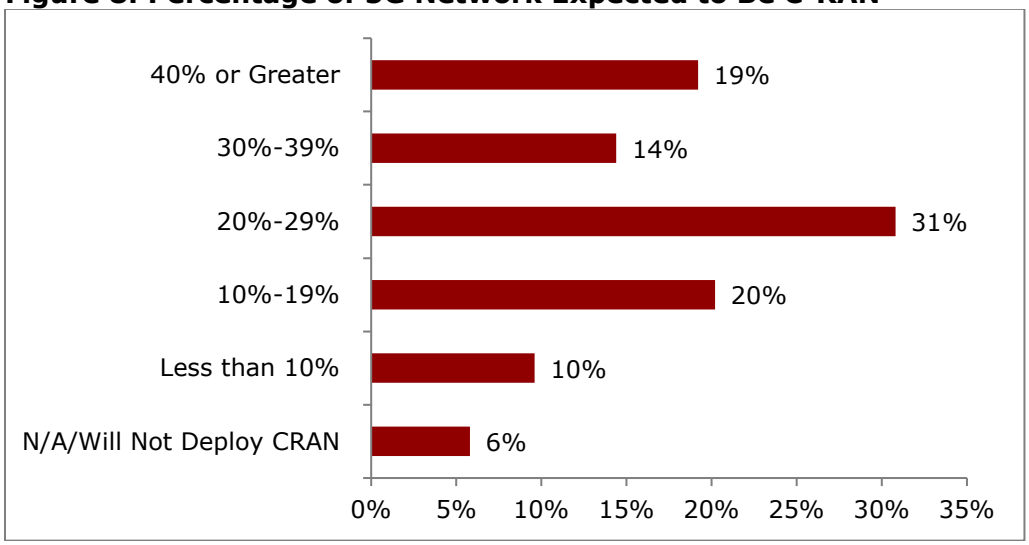
Source: Heavy Reading

FRONTHAUL PLANS

Architecturally, the biggest transport network change in moving from 4G to 5G is the centralization of the RAN functionality and the creation of the fronthaul segment between the RU and the physically separated BBU functions. Some operators moved to C-RANs with advanced 4G technologies, but for most operators around the world, 5G marks the beginning of the C-RAN migration.

In Heavy Reading's survey, we asked operators to estimate how much of their 5G networks they expect will be C-RAN. Results are shown in **Figure 8**. It is early days still, but results indicate interest in RAN centralization is growing globally. Nearly two-thirds of operators (64%) expect that at least 20% of their 5G networks will be C-RANs. And for 19% of operators, 40% of their 5G networks will be C-RAN. Just 6% of those surveyed said they have no plans for C-RAN at 5G.

Figure 8: Percentage of 5G Network Expected to Be C-RAN



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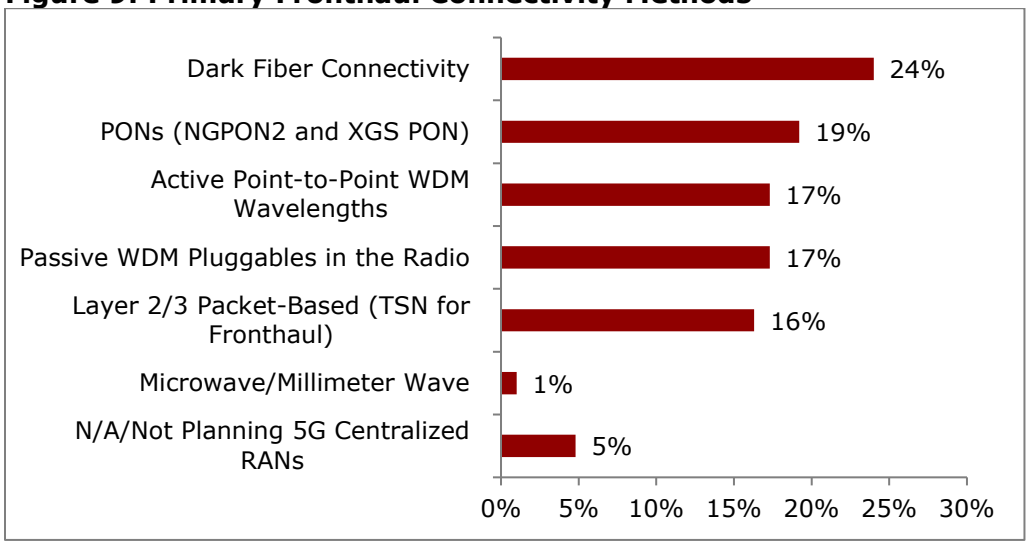
Source: Heavy Reading

Identifying the most efficient fronthaul connectivity method has been a hot topic of debate in C-RAN, in part because there are many options to choose from. On a global level, operators prefer dark fiber connectivity (selected by 24%), but passive optical networks (PONs), active WDM, passive WDM, and packet-based fronthaul are all in play at this time. While it is possible a single connectivity method will come to dominate in time, it is more likely that multiple options will remain in play, given the diverse requirements of different types of operators and different regions (see **Figure 9**).

Figure 9: Primary Fronthaul Connectivity Methods



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Source: Heavy Reading

In fact, preferred fronthaul connectivity methods varied significantly by geographic region in Heavy Reading's survey. For North American operators, dark fiber fronthaul is the clear preference, selected by 31% of the survey group and followed by passive WDM pluggables at 22%. At just 9%, North American operators expressed little interest in packet-based fronthaul using IEEE TSN technology.

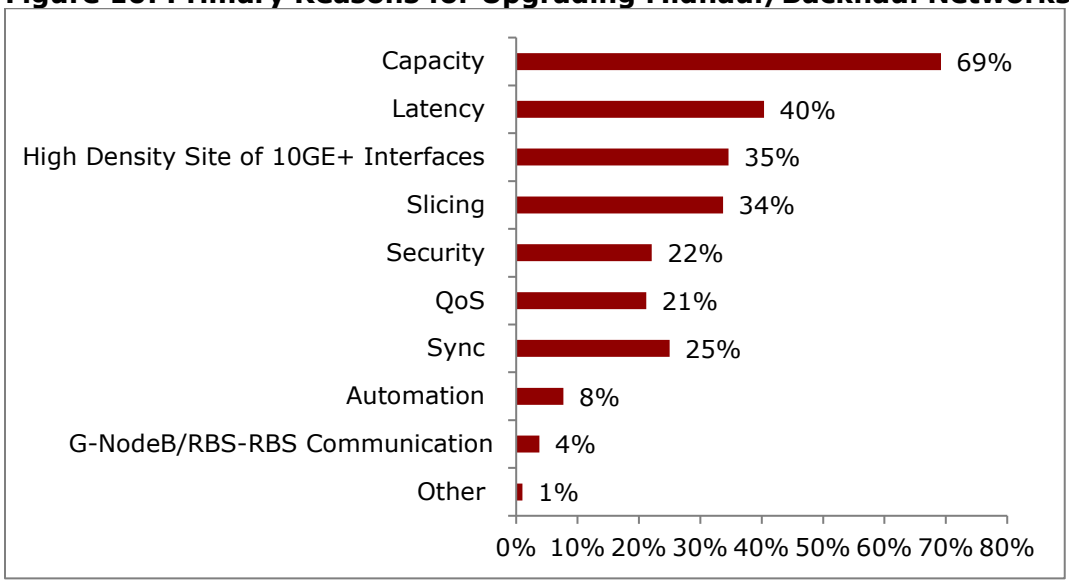
Outside of North America, however, the connectivity story is different. For ROW respondents (all respondents outside North America), packet-based fronthaul using TSN was the top choice – selected by 27% of the survey group. These ROW respondents expressed far less interest in dark fiber (selected by 16%) or in passive WDM pluggables (selected by just 11%) compared to North America. Preferences for PON technologies and active WDM were reasonably aligned across regions and consistent with the global data in **Figure 9**.

IP/PACKET LAYER PLANS

Like the optical layers below, packet switching/routing must also change as operators move from 4G backhaul to 5G Xhaul architectures. This final section focuses specially on the 5G IP layer.

Several factors will lead operators to upgrade their midhaul/backhaul networks, but the need for greater capacity is the chief reason. In Heavy Reading's survey, 69% of respondents selected capacity as the primary reason – far ahead of the second option, latency (selected by 40% of the group – see **Figure 10**).

Figure 10: Primary Reasons for Upgrading Midhaul/Backhaul Networks for 5G



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Source: Heavy Reading

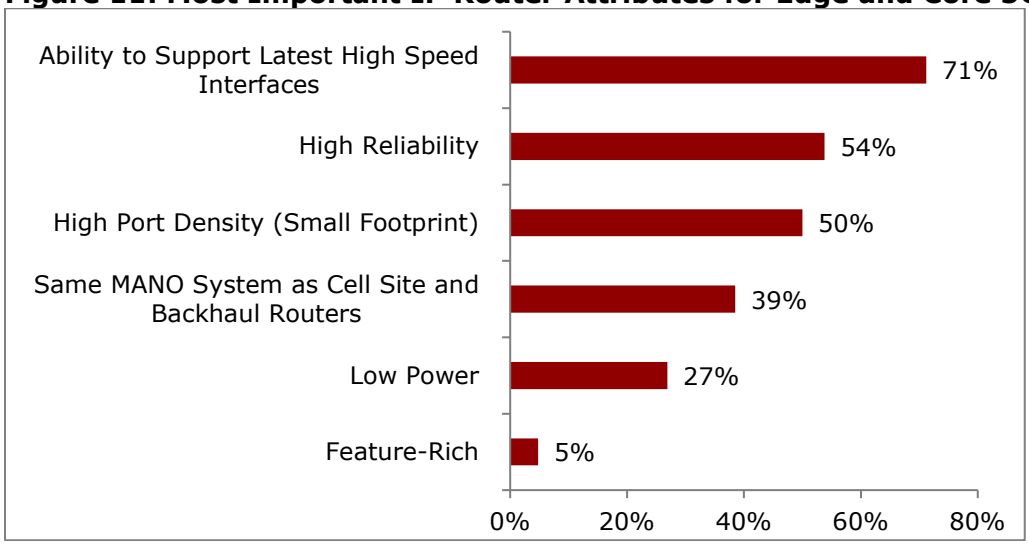
5G NR ultimately promises a 10x increase in capacity, and these requirements reverberate throughout the Xhaul network. Current 4G backhaul networks are based on 1 Gbit/s Ethernet connectivity. While 5G may not fill a 10 Gbit/s midhaul/backhaul link on Day 1, it will require greater than 1 Gbit/s per port. Related, and also of high importance in the survey, is the need for greater switch density at 10 Gbit/s since multiple 10 Gbit/s ports will be required at cell sites in many cases.

Second only to greater capacity, low latency was a primary reason for midhaul/backhaul network upgrades (selected by 40% of respondents). Fiber connectivity, short links, and edge compute are not effective if packets get delayed in processing or in buffers. Therefore, the packet layer must also be upgraded for the most efficient processing.

Heavy Reading delved deeper into the IP layer by asking about the most important IP router features and breaking them out by edge and core transport and cell site routers. **Figure 11** shows the most important IP router attributes for edge and core. Respondents were able to select up to three attributes.

Consistent with their reasons to upgrade midhaul/backhaul networks, respondents overwhelmingly selected support for the latest high speed interfaces as the top attribute (selected by 71% of respondents). High reliability and high port density are also important for the 5G IP edge and core.

Figure 11: Most Important IP Router Attributes for Edge and Core 5G Transport



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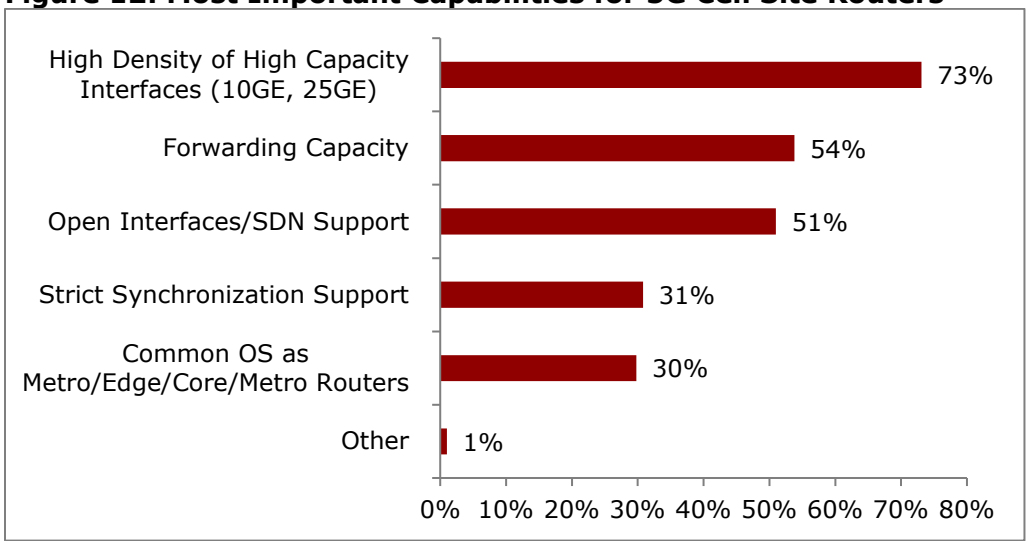
Source: Heavy Reading

For cell site routers, high speed port density tops the list of most important capabilities (selected by 73% of respondents), followed by forwarding capacity (54%) and open interfaces (51%). Again, the trend is consistent with the overall need to boost Xhaul capacity to accommodate the roughly 10x increase in data rates from 5G NR. **Figure 12** shows the results.

Figure 12: Most Important Capabilities for 5G Cell Site Routers



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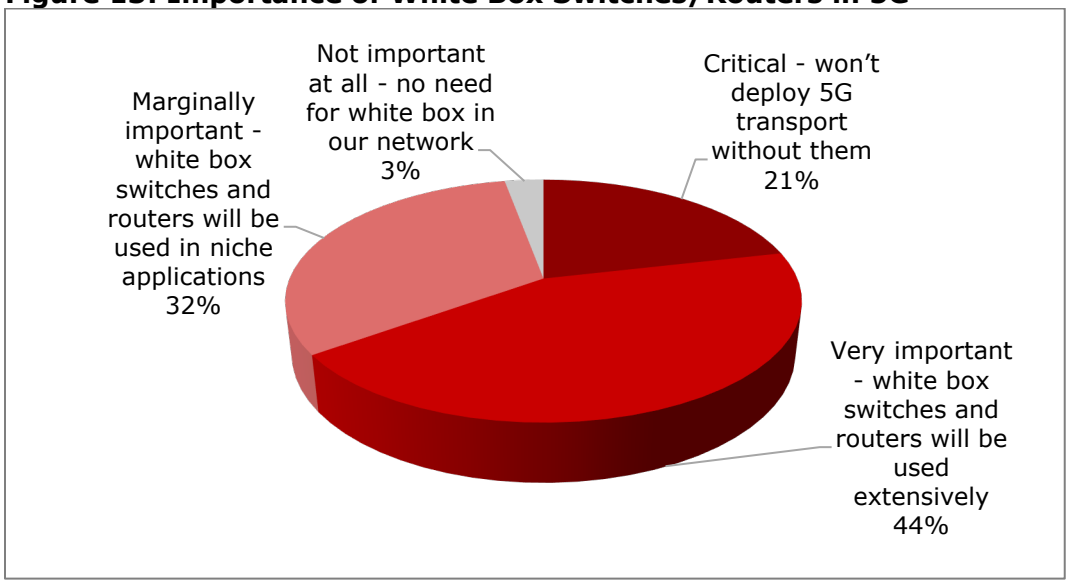
Source: Heavy Reading

From past Heavy Reading surveys, we know that operators are interested in applying disaggregation and "white box" models at Layer 3 – and particularly in edge routing. In this survey, we asked operators about the importance of white box switches and routers in their 5G networks (see **Figure 13**). On a global level, white box interest is high. Nearly two-thirds (65%) of respondents reported that white box switches/routers are at least "very important," with 21% of the group reporting that 5G transport will not be deployed without white box.

Figure 13: Importance of White Box Switches/Routers in 5G



N=103
Source: Heavy Reading

Yet, operators view white box differently depending on their geographic region, the survey found. Driven by AT&T's aggressive and highly publicized white box router plans, interest is highest in North America. Twenty-eight percent of North American respondents stated that white box routers/switches are critical to 5G deployments, while in ROW (all respondents outside North America), just 13% stated that white box is critical.

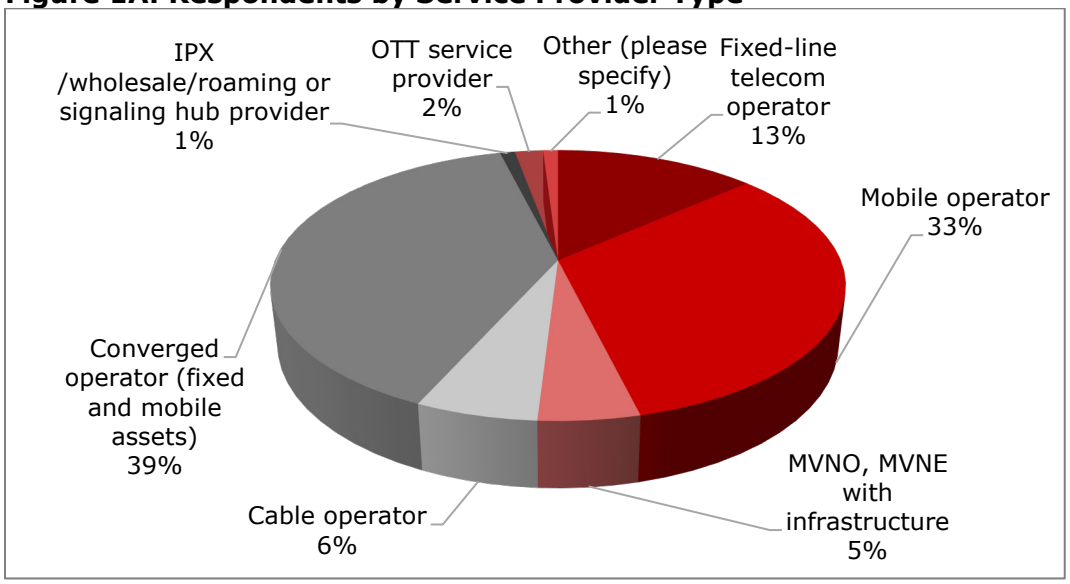
On the other end of the spectrum, 49% of ROW respondents reported that white box switches/routers will be either just marginally important or will not be used at all in 5G. By contrast, just 24% of North American respondents stated that white box will be marginally important, with 0% believing that white box will not be deployed.

APPENDIX: SURVEY DEMOGRAPHICS

This Heavy Reading report is based on a web-based survey of network operators worldwide conducted in April 2019. Respondents were drawn from the network operator list of the Light Reading readership database. After reviewing responses, 104 were deemed qualified participants and were counted in the results. To qualify, respondents had to work for a verifiable network operator that generated at least $50 million in annual revenue and be involved in network planning and/or purchasing of network equipment. The full survey demographics are detailed below.

Figure 1A shows the type of service providers respondents work for. Respondents that said they do not work for a service provider were rejected and could not complete the survey.

Figure 1A: Respondents by Service Provider Type



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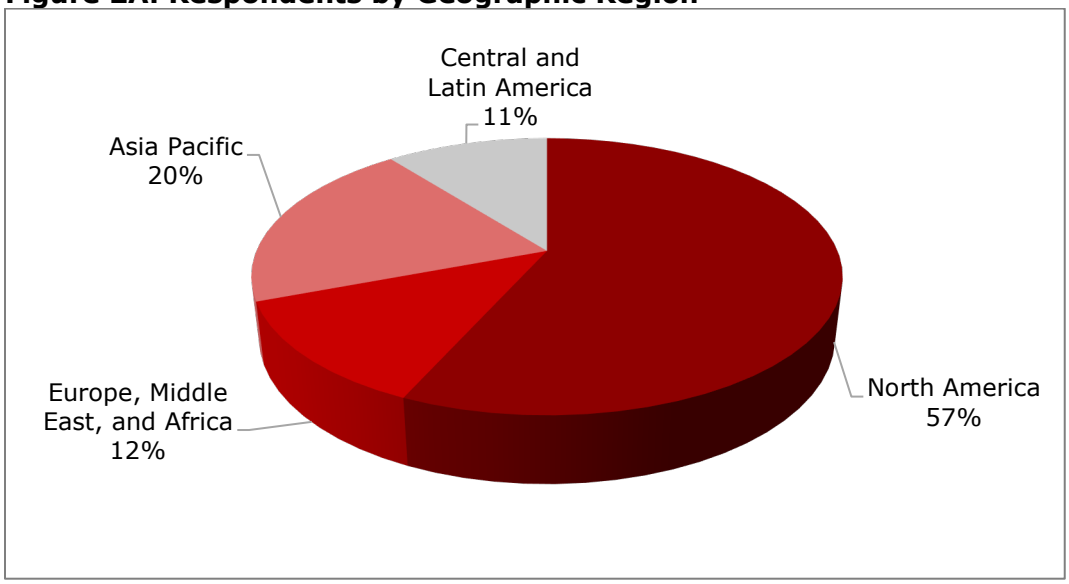
Source: Heavy Reading

Figure 2A shows survey respondents broken down by geographic region.

Figure 2A: Respondents by Geographic Region



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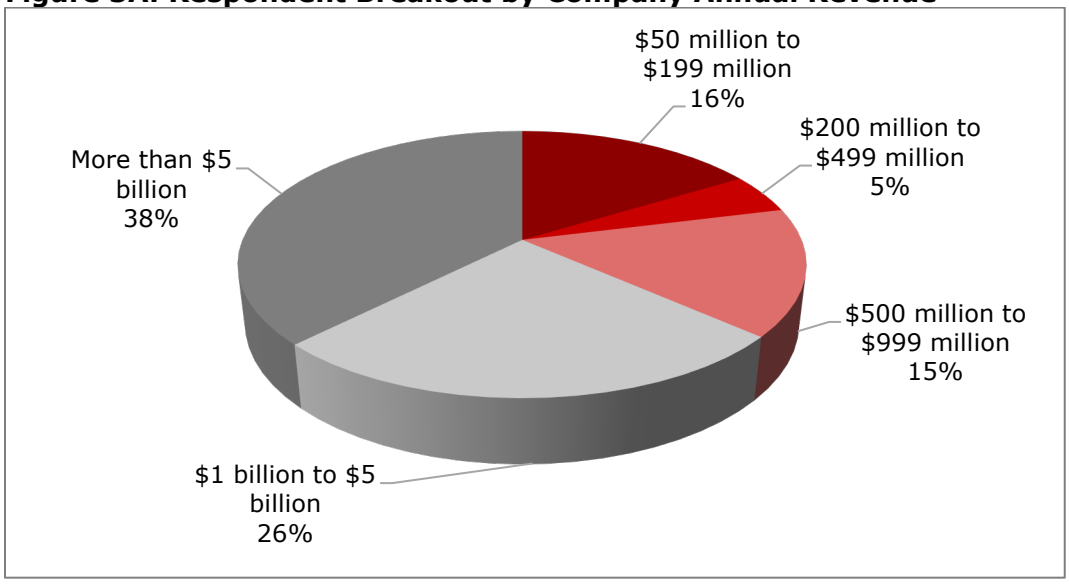
Source: Heavy Reading

Figure 3A shows survey respondents broken out by company annual revenue.

Figure 3A: Respondent Breakout by Company Annual Revenue



N=104
Source: Heavy Reading

Figure 4A shows survey respondents broken out by job function.

Figure 4A: Respondents by Job Function

Job Function	Percent
Engineering	30.8%
Network Planning	22.1%
Operations/Transmission	10.6%
Operations/Services	10.6%
Corporate Management	10.6%
Sales & Marketing	3.8%
Consulting	3.8%
Customer Support	1.0%
Sourcing/Procurement	1.0%
Customer Relationship Management	1.0%
Other (Please Specify)	4.8%

N=104
Source: Heavy Reading