Report

Open RAN: ready for prime time? The operators' perspective

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1. Executive summary

The interest in the emerging concept of Open RAN is growing as operators start to evaluate cloud-based RAN infrastructure and to explore more deployment options for 5G. Various industry groups, consisting of established and new vendors and operators, are working on specifications to support a new RAN architecture and management platform that takes a more disaggregated approach than the classical 3GPP view of RAN.

There are many different ways to implement a virtualised RAN (vRAN), and there are multiple different open interfaces that may or may not be supported. This paper will specifically examine Open RAN architecture for vRAN in which the base station functions are split into three units (central unit, distributed unit and radio unit). We take into consideration the proposed O-RAN alliance specification of an open fronthaul connection to allow for the potential deployment of radio units (RUs) and distributed units (DUs) from different vendors. Open RAN also introduces a new element, the RAN Intelligent Controller (RIC) (see the appendix for the full Analysys Mason definitions).

The main benefits of Open RAN, according to Analysys Mason's survey of over 100 operators in 3Q 2020 are improvements to the total cost of ownership (TCO), supplier diversity and time to market for new services, and a broadening of the innovation base. However, the same survey also highlighted the risks that will inevitably apply to a new architecture. These are led by concerns about the increased cost and complexity of integrating and running a network based on elements from many different suppliers.

In this paper, we will explore the key drivers behind Open RAN and will provide a checklist of issues to address before deploying a commercial network, based on the concerns that operators stated in our survey. Some of the risks are inherent in a new and untried platform, such as those related to immature or incomplete standards. Others, such as the potential performance trade-offs in a disaggregated RAN, are more foundational and are the subject of intensive efforts by industry working groups and in tests and trials.

Much of the future impact of Open RAN will depend on the time taken to address these risks and whether this aligns with operators' timeframes to migrate to vRAN.

So far, Open RAN has been deployed in just one large-scale commercial network by Rakuten Mobile, although it is the focus of Dish Network's planned 5G roll-out. It is also being put through its paces in a range of trials, mainly focused on rural and enterprise markets. These markets are commonly being addressed with greenfield build-outs and have relatively low data loads and geographic coverage areas. As such, they are likely to feel the impact of Open RAN before other markets.

Commercial build-out in greenfield, rural and enterprise markets is likely in the near term (1–3 years), but there are bigger challenges when it comes to deploying in a 5G macro network that is capable of supporting very high traffic loads and ultra-low latency in a wide range of spectrum bands, including millimetre wave. Non-greenfield deployments of macro Open RAN will therefore be rare before 2023, and operators will need to feel confident that any losses are fully outweighed by gains.

The perception of these gains is likely to change as operators evaluate the new platforms in detail. The claimed objectives of reduced cost and supplier diversity look achievable in local or rural networks. However, 70% of operators expect operating costs in their main 5G networks to be the same or higher in the first 3 years of Open RAN. This is because of the greater complexity of deploying and running elements from many vendors, which may increase the reliance on internal or external systems integration (SI) efforts, and risks creating a new kind of lock-in at SI level. Operators will therefore be targeting other benefits, namely agility and scalability.

There are many options open to operators. If their timescales for virtualising the RAN are not urgent, they can trial Open RAN in enterprise or rural networks while maintaining traditional architecture in their primary RAN. Alternatively, they can migrate to 3GPP vRAN architecture and work with their established supply chains for the first phase, and then use this as a stepping stone to Open RAN later. Much of the outcome for Open RAN depends on whether operators' concerns can be addressed before their deadlines to migrate to vRAN.

In these very early days, operators are excited about the potential of Open RAN architecture, as our survey shows, but need to see their concerns addressed before they feel able to use the new architecture at scale in a business-critical macro network.

2. Context: several trends are driving open RAN

2.1 RAN disaggregation has highlighted the potential for open platforms

The current excitement surrounding Open RAN platforms may suggest that this is a new phenomenon. In fact, the whole history of cellular networks is bound up with the quest for an open set of network standards that would support solutions from multiple vendors and service providers and produce significant economies of scale. The 3GPP standards have been foundational to this since the definition of GSM, and now incorporate hundreds of specifications and interfaces developed by over 700 members worldwide.

Various factors are driving the interest in extending common platforms to network elements that go beyond the 3GPP specifications. One is the relentless pressure on operators to reduce the total cost of ownership (TCO) of their networks as mobile data usage outstrips the rise in average revenue per user in most markets. Some argue that this can be achieved, at least partly, by expanding the supplier ecosystem to increase competition, and that this will be enabled by supporting the nascent trend to disaggregate and virtualise the RAN. Vendors do not have to provide every element in a disaggregated architecture, so the supply chain can be extended to include more specialist providers alongside the end-to-end network vendors. Of course, this multi-vendor approach is only practicable if there are common interfaces between the elements. Open RAN initiatives such as the O-RAN Alliance are seeking to define these additional interfaces as well as the broader virtualised, disaggregated architecture.

There are other motivations to migrate to a vRAN; scalability and resource flexibility were cited as leading drivers in a recent Analysys Mason survey of 78 operators. However, it is important to distinguish between vRAN and Open RAN. Virtualisation is a journey that the telecoms industry has been on for several years to transform network functions into virtual network functions (VNFs). The VNF software is then decoupled from the purpose-built hardware and run on standardised, common off-the-shelf (COTS) hardware. The interfaces between each component in such a set-up may still be closed or proprietary.

Open RAN, on the other hand, refers to the standards used to create more open internal interfaces and define a particular architecture for disaggregation, virtualisation and automation, with the aim of introducing new capabilities and helping to integrate new vendors into the supply chain.[1] This is particularly relevant for the

[1] See the appendix for additional detail on the migration from an integrated RAN to a disaggregated and open RAN.

RAN given that its disaggregation into separate hardware and software has proven to be far more challenging than that for other network domain elements, such as the packet core.

The RAN has stringent requirements for latency and interworking between the functions at various layers. Some functions are virtualised in the cloud (the central unit or CU), but many RAN functions take place in a distributed unit closer to the cell site, which is split into a baseband unit (BBU) and a radio unit (RU). Deployment and use case considerations drive how CU and DU functions are distributed between network locations. It is important to note that the 3GPP has specified that the DU must contain both the RU and part of the BBU as one integrated logical unit. This is because separating the DU into two logical entities introduces additional latency and jitter. In the Open RAN proposition, the DU and RU can be separate units, both physically and logically, and are connected by an open fronthaul interface such as that specified by the O-RAN Alliance. This enables the DU and RU to be sourced from different vendors. It is a more challenging architecture to deploy, but does not have any performance or latency trade-offs. This balance of risks and rewards is central to the assessment in this paper.

The large network equipment providers (NEPs) have developed their own vRAN solutions in which different combinations of CUs, DUs and RUs can be placed at different locations. One option is to place both the CU and DU together at the same location and the RU at the physical cell site. Another option is to place the CU at a data centre (DC) and the DU and RU at the site. A third alternative is to place the CU at a DC, the DU at a far-edge site and the RU at the cell site. The decisions on how to split these components are based on the use case requirements, the architecture that best meets these requirements and the fronthaul bandwidth available.

However, the end-to-end stack remains proprietary in NEPs' set-ups, given that the vendors use their own software algorithms in the CUs and DUs and that some interfaces are either proprietary or semi-proprietary (such as CPRI[2]). All of the key interfaces between the disaggregated base station elements are fully open and standardised in an open RAN, which means that multi-vendor networks are feasible.

2.2 Industry groups are starting to work on open specifications

The development of a multi-vendor RAN ecosystem is one goal of the O-RAN Alliance and other vendor and operator groups. There are other important objectives, such as an expanded and open service management and orchestration framework designed for vRAN.

The O-RAN Alliance (referred to as O-RAN from here onwards) was formed to develop specifications, reference architecture and open interfaces between RAN components. One of O-RAN's work groups is focused on creating an open, interoperable fronthaul interface, which will enable the integration of DUs and RUs from different vendors and is essential to enable a multi-vendor ecosystem. Another is developing the RAN Intelligent Controller (RIC). This comes in two variants: the non-real time RIC provides an open platform for intent-driven, policy-based RAN control with rApps, while the near-real-time RIC aims to abstract control processes that are usually embedded in base stations and run them as xApps on cloud infrastructure.

There is certainly momentum to realise Open RAN, as highlighted by the formation of the O-RAN Alliance in early 2018. The Telecom Infra Project (TIP), which was set up by Facebook in 2016 as a way to drive cloud economics into telecoms networks, established an Open RAN working group in 2019. Other groups also have multi-vendor vRAN projects, including Small Cell Forum's 5G nFAPI interface and Open Networking Foundation's new SD-RAN working group, which is focusing on another implementation of the RIC.

2 See the appendix for more architecture details.

3. Most early Open RAN deployments will be outside the macro RAN

The emergence of disaggregated vRAN technology is driving interest in Open RAN, but both are in their infancy in terms of commercial deployments. The vRAN represents a significant disruption to operators' architecture, skill sets and processes, and most non-greenfield operators will proceed cautiously with their virtualisation journeys. In particular, they need to be confident that a vRAN platform (whether Open RAN or not) is as mature and reliable as a traditional one, even with the very demanding requirements of 5G use cases, and that they understand the performance trade-offs. When multi-vendor open networks are added to the migration roadmap, the challenges become even more difficult to overcome, as we describe in Section 5.

For this reason, we expect that Open RAN macro networks will be adopted only slowly until the end of 2023 as operators wait for platforms to mature. This is especially true in the complex macro deployments that take place in higher-frequency spectrum bands, such as the 3.5GHz or millimetre wave bands, where high orders of MIMO antennas and carrier aggregation will be combined with time division duplexing (TDD), thereby creating a highly challenging scenario. To exploit the full potential of 5G, operators need to support combinations of standalone, non-standalone and dynamic spectrum-sharing (DSS) cells, as well as carrier aggregation between TDD, frequency division duplexing (FDD), sub-6GHz and millimetre wave spectrum. The first moves in macro networks are therefore likely to be seen in lower frequency bands with FDD, as Telecom Infra Project has described.[3]

A small group of greenfield macro 5G deployers (including Rakuten Mobile and Dish) will move straight to open networks in their main macro RANs, but there will be more activity in new deployments such as enterprise or private 5G RANs, where operators do not have to integrate legacy equipment (see Section 6). We refer to these deployments as secondary networks, and they will increasingly be deployed by a greater diversity of service providers than nationwide macro networks. Alternative deployers will include mobile network operators (MNOs), private network operators, neutral hosts, cable operators, cloud providers and enterprises. Some will take advantage of new spectrum sources, such as shared bands, while others will partner with MNOs. They will particularly target enterprise use cases, typically those with localised footprints and specialised connectivity requirements, and so will tend to be focused on small cells and edge computing platforms.

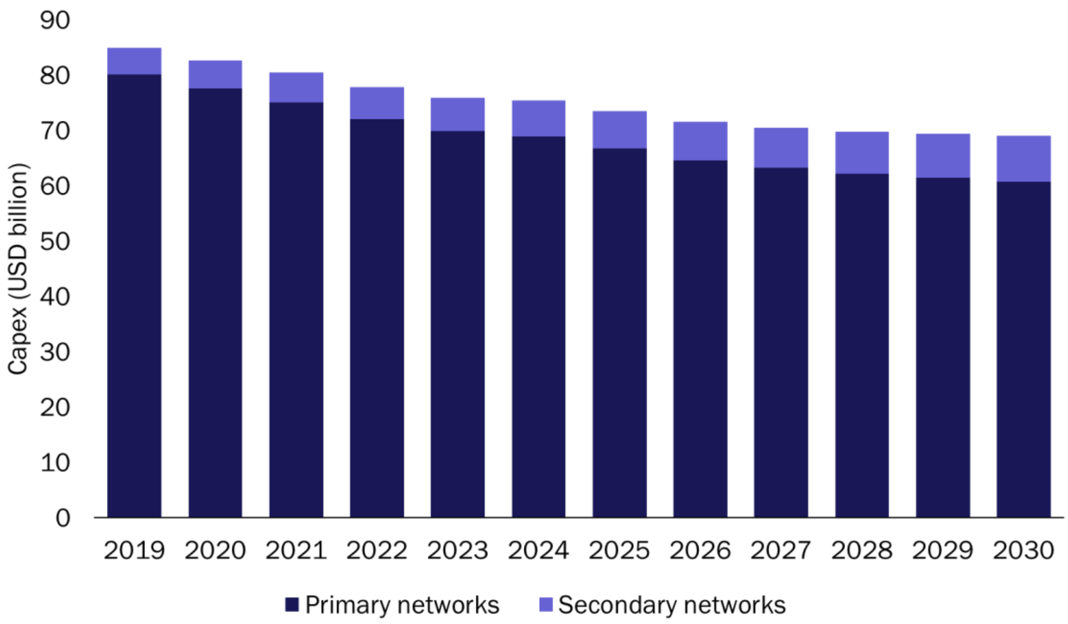
These networks are more suited to trials of new architecture than primary macro networks thanks to their relatively low coverage and traffic demands, greenfield status and reduced criticality to the core business. Open RAN will make more rapid progress in such scenarios. The same will be true in rural expansion scenarios, which is where many early O-RAN triallists are testing multi-vendor networks (for instance, Vodafone is trialling networks in diverse rural settings from Ireland to the Democratic Republic of Congo).

Figure 3.1 shows that the capex for secondary networks is growing much more rapidly than that for macro networks, but that it accounts for a much smaller percentage of the total. Indeed, secondary networks will account for about 10% of network capex in 2030, and alternative providers will be responsible for about 35% of this (Figure 3.2). RAN capex accounts for almost 35% of a mobile operator's total network capex during a time of intensive build-out, typically in the first stages of a new technology generation (though for context, this typically represents less than 5% of revenue, and a major RAN upgrade is designed to deliver increased revenue

3 Telecom Infra Project. Available at: https://telecominfraproject.com/openran/.

streams).[4] As such, the overall spending in 2019 was much greater (by about 20%) than that in 2017 and 2018 thanks to major 5G roll-outs, but will fall gradually to 2017 levels by 2026 as 5G deployments reach completion in many areas.

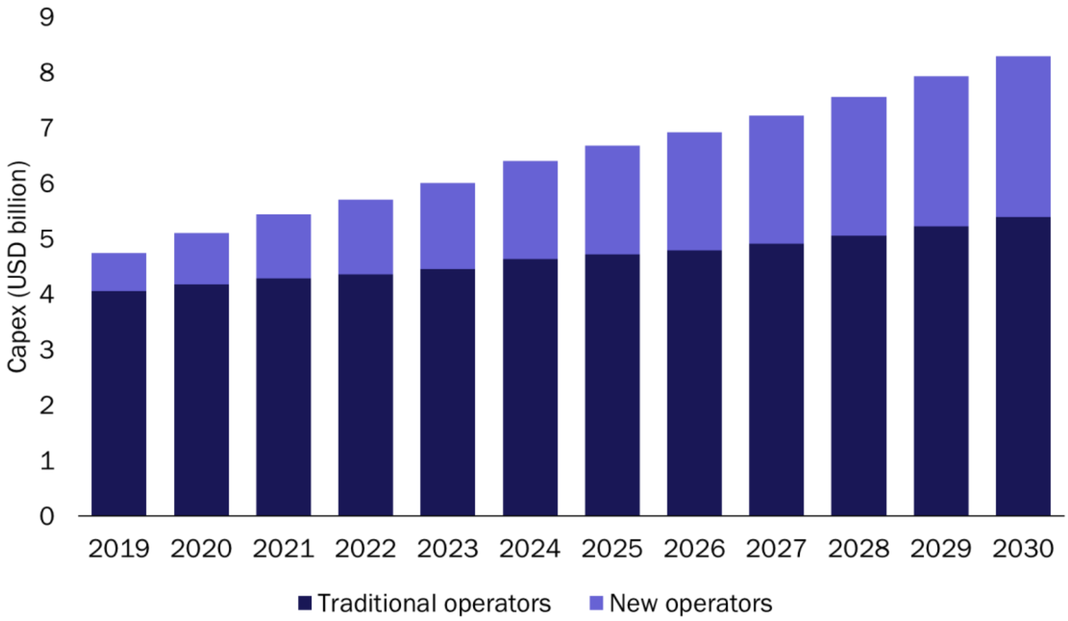
Figure 3.1: RAN capex by network type, worldwide, 2019–2030



Source: Analysys Mason, 2021

[4] For more information, see Analysys Mason's Telecoms capex: worldwide trends and forecast 2017–2026. Note that RAN capex includes capex from equipment, capitalised labour and services, plus some from spectrum.

Figure 3.2: Secondary RAN capex by operator type, worldwide, 2019–2030



Source: Analysys Mason, 2021

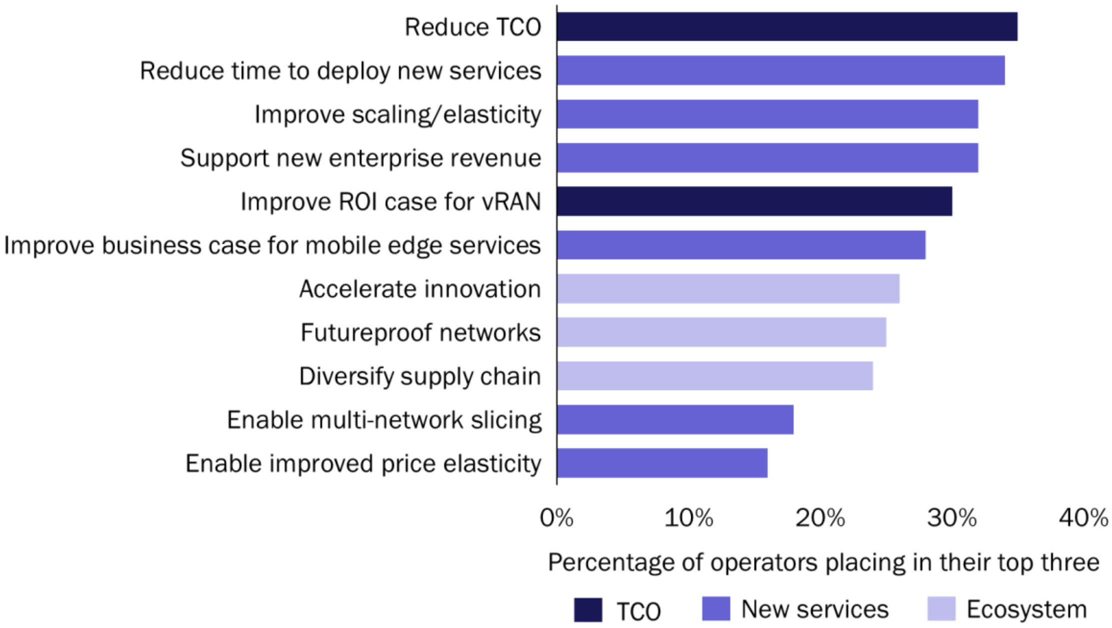
The importance of primary networks to overall RAN investment shows that, while these greenfield and secondary build-outs are very important for providing a relatively low-risk way to trial and deploy new architecture, it will be essential for the Open RAN ecosystem to be used in primary networks too in order to achieve economies of scale and thereby attract innovation and investment. However, when assessing the early stages of Open RAN, it is important to consider different deployment scenarios, each of which will have a different balance of drivers and risks.

4. There are complex drivers for the adoption of Open RAN

Many early discussions of the benefits of an open disaggregated RAN platform centred on two main factors: lower total cost of ownership (TCO) and the end of supplier lock-ins. However, a more complex picture of the drivers for Open RAN emerges when detailed research is carried out with different types of operators.

Figure 4.1 shows that there are a wide range of drivers for operators to adopt Open RAN architecture over the coming years. Some of these may apply more generally to all vRAN architecture, but the survey focused specifically on advantages that operators perceived to be unique to Open RAN, as we define it, or where Open RAN enhances a benefit already delivered by other vRANs. The results are drawn from a survey of 107 operators (78 Tier-1 and 2 MNOs and 29 greenfield or alternative deployers, with 13% from North America, 41% from Europe, 36% from Asia–Pacific and 10% from the rest of the world). They were first asked to list all the ways in which they believed Open RAN could enhance their business model. A list of the 11 factors cited by at least 15% of respondents was compiled and the respondents selected the 3 that were the most important to their business.

Figure 4.1: Top 11 drivers for adopting Open RAN, 3Q 2020



Source: Analysys Mason, 2021

In total, only 2 of the drivers that emerged in the top 11 were directly related to cost, and 3 related to a more open supplier ecosystem. More than half of the drivers were focused on a more flexible RAN that could facilitate the deployment of new service platforms and revenue streams. It should be noted that two out of the five top-five drivers are related to operational ease. In other words, operators identify other potential benefits that relate to their revenue growth strategies and service platforms once they start to consider real-world deployment plans in detail, even though cost and supply chain issues are often the headline drivers for Open RAN.

Five drivers were placed in the top three by 30% or more of the respondents, but no single factor was selected by more than 35%. This indicates the diverse range of ways in which operators believe that Open RAN would enhance their businesses. The emphasis is heavily influenced by region. The political and industry impetus for a broader supplier ecosystem has been the strongest in North America, and diversifying the supplier chain emerged as a much more dominant driver in this region than elsewhere.

Globally the drivers can be divided into three main categories relating to key operator goals for the 5G era: cost, supply chain and support for new service models. These are covered in more detail in the next three sections.

4.1 Improving TCO and ROI for new networks is the most-cited driver

Two of the top drivers that emerged in our survey relate to cost. Overall, 35% of respondents believe that TCO reduction is an important reason to adopt Open RAN platforms. 30% believe that open interfaces will be necessary to achieve an acceptable return on investment (ROI) on vRAN migration, though the reality will vary widely depending on disaggregation architecture, spectrum, capabilities required by key use cases and other factors.

The belief that open platforms will greatly reduce the total cost of ownership of a RAN rests on two main premises, according to our operator survey.

- Operators believe that there will be greater price competition because an open platform lowers the barriers for new vendors to enter the market and enables operators to deploy network elements from a range of suppliers. The carrier and enterprise Wi-Fi markets are cited as sectors where an open platform has facilitated a broad ecosystem, and there is high interest in the potential to achieve a similar change in the cellular market, by using common reference platforms to drive down the cost of developing complex elements such as radios, as has been seen in some Wi-Fi segments. Of course, the complexity and level of criticality of most Wi-Fi platforms is very different from that of macro cellular networks, so these lessons may be most commonly applied to simpler small cell architecture.

- Operators also believe that a software-based network, in which some network functions are run on general-purpose cloud infrastructure, will be cheaper to deploy and run than an integrated platform. Many of these savings apply to all vRANs, since even a single-vendor vRAN will be built on open cloud platforms. Some operators say that expanding the number of suppliers engaged in developing RAN software will result in a broader skills base and lower-cost access to developer and lifecycle expertise.

4.2 Operators want to shake up the supply chain and innovation base

There are three main ways in which operators believe Open RAN would affect their traditional supply chains and ecosystems. Each of them was cited as a top-three driver for Open RAN by about a quarter of respondents. The main arguments are as follows.

- The supply chain is more easily diversified if vendors can specialise in just one element. Very few companies have the capability to develop a macro network radio, for instance, but may be in position to innovate in RAN software, small cells or management capabilities.

- Open interfaces mean that it is easier to swap one vendor's hardware or software for that of another. This lowers the risk, especially if an operator wants to work with a new or small supplier, and so makes it more viable to diversify the supply chain, even for critical elements such as RAN VNFs or radios. It also futureproofs the network.

- Open platforms provide access to a broader base of innovation than traditional platforms and so accelerate progress, as demonstrated in enterprise open-source communities. Smaller operators, in particular, may enhance their ability to influence requirements and specifications through open alliances.

The consolidation of many RAN vendors in the past decade has increased operators' urgency to broaden the supply chain. Recent restrictions placed on some suppliers regarding 5G build-outs in the USA and other countries have also played a role. Many operators are now looking for ways to introduce new players into their ecosystems, especially in countries where restrictions apply.

4.3 The most important drivers are reducing the time and risk to enable new services and revenue streams, through ease of operations

Cost reduction and ecosystem expansion are a key part of Open RAN discussions, but most operators are very clear that these drivers, on their own, are unlikely to be sufficient to justify a significant change in RAN architecture and supply chain. They also need to be confident that the resulting network will enable or facilitate new services and new ways to monetise 5G. The vision is that an Open RAN will accelerate operators' ability to emulate cloud companies by devising and delivering new services very quickly and responsively, and by harnessing a service platform that is flexible, but also automated and simple to operate. Many operators are already working on such a platform in other areas of their networks and operations, and are evaluating ways to ensure that the next-generation RAN optimally supports those efforts.

For many operators, according to our interviews, the benefits linked to commercial agility and efficiency are seen to be more rapidly achievable than those related to cost. TCO reduction is the most commonly cited driver for Open RAN, but it is also unproven in operators' own view (see Section 5.1). Many operators are more confident that the benefits of Open RAN for their service platforms are more readily within grasp. This confidence often comes from assessing the impact of open development and innovation processes on other industries, especially the cloud sector. The specific impact on RAN performance and cost has still to be evaluated in full.

There are several ways in which Open RAN could help to deliver a flexible service platform, according to the results of our survey. These are as follows.

- An open, mix-and-match platform, especially for small cells, would reduce the time to deploy multi-vendor networks to support new services, and, in particular, to support localised RANs for enterprise services.
- Open RAN platforms are easier to scale up in line with demand. New use cases can also be addressed by simply adding new open components.
- Open RAN platforms would integrate naturally with edge and cloud infrastructure and improve the ROI case for mobile edge services and network slicing, especially when interoperability with other networks is required.
- Lower deployment and management costs are perceived as a benefit, and these would give operators greater latitude to adopt flexible pricing and therefore increase their market share.

5. There are challenges for early Open RAN adopters

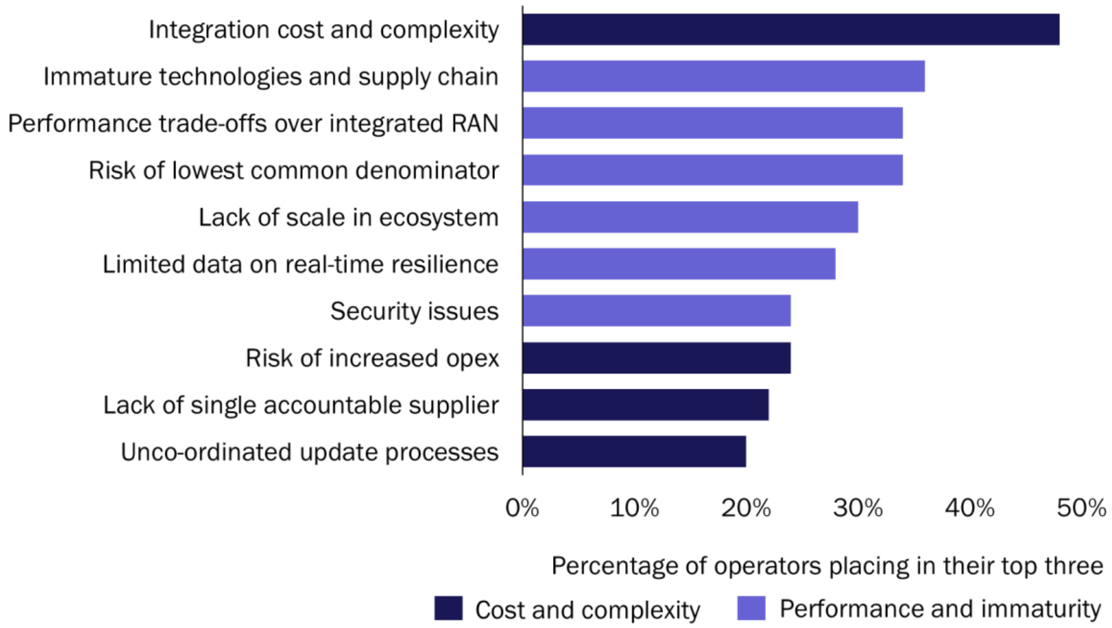
The previous section showed the aspirations that are driving interest in Open RAN. However, Open RAN represents a dramatic upheaval to the way in which operators plan, procure, deploy and manage their networks, as well as to their relationships with their suppliers. This inevitably introduces a note of caution amid the enthusiasm. For instance, 82% of respondents to our survey said that they are aiming to support open interfaces and a multi-vendor RAN in their 5G macro networks, but only 22% said that they are planning to procure equipment and software from more than two suppliers per geographic area in the first 3–4 years of roll-out.

This indicates the gulf between aspiration and reality that naturally opens up in the early days of implementing new and evolving architecture. History shows us that strong operator and ecosystem commitment and a collective effort can push a new approach over this barrier, but several factors have to align to ensure success.

Inevitably, there are uncertainties and risks associated with Open RAN at this early stage. Its level of future success will depend on how convincingly these risks can be addressed or mitigated, and over what timescale. The degree to which the benefits will outweigh the risks to operators will be heavily influenced by the types of business models and network build-outs that are envisaged. We will examine these variables in the next section, but here we set out the main challenges that need to be addressed before operators will embrace Open RAN with full confidence, especially in their primary macro networks.

In our survey, we took the same approach to establish the most important risks and barriers for operators with regard to Open RAN as was taken for the drivers. There were 10 factors that were placed in the top 3 by at least 20% of respondents (Figure 5.1). There was a greater degree of consensus around the key barrier (cost/complexity) than there was about the most important driver.

Figure 5.1: Primary challenges to the deployment of commercial Open RAN



Source: Analysys Mason, 2021

As with the drivers, the main perceived risks can be placed into several categories, and some of the risks mirror the drivers. Reduced cost and complexity, for example, is of high importance to operators as they plan vRAN and 5G, but they recognise the risk of falling short in these respects, thereby undermining their business cases. The biggest challenge in this category concerns the need to integrate hardware and software elements from many suppliers, while still achieving the same performance and time to market as an integrated, single-vendor network.

Concerns about the new supply chain are intertwined with those about cost and complexity. An open ecosystem is often cited as one of the chief drivers for Open RAN, but it also represents significant risks for operator executives that are accountable for network performance and ROI.

Other barriers cited relate more specifically to the features of the Open RAN specifications and architecture that have emerged so far from bodies such as O-RAN Alliance. Most of these concerns relate either to the immaturity of a fledgling platform and ecosystem, or to proven performance, at a time when there are very few large-scale trials or deployments to evaluate (Rakuten Mobile's build-out in Japan is the notable exception, though it does not yet use the final O-RAN specifications). There are also concerns about the lack of scale in an ecosystem, which looks quite fragmented thanks to the inclusion of several alliances and other interest groups. Operators may be critical of some of 3GPP's mechanisms, but they credit it with being a unifying force that has driven considerable scale into the cellular industry, thereby resulting in reductions in cost per bit over many years already.

In the remainder of this section, we summarise the key challenges to the implementation of Open RAN, which add up to a checklist of considerations that operators believe that they must address before they can commit to a large-scale Open RAN deployment. The degree to which the community lowers these barriers in the coming few years, and how quickly that can be achieved, will decide the future of Open RAN in the 5G deployment era.

5.1 Cost and complexity are key risk factors

The main risks perceived in this category are:

- deployment and integration cost and complexity
- the need to co-ordinate software updates from multiple sources and achieve efficient lifecycle management
- the lack of a single 'throat to choke'
- the risk of increased opex because of the large number of elements.

The cost and complexity of integration is seen to be the greatest risk for most operators. Indeed, almost half of the respondents to our survey said that this was one of the top three barriers to their 5G RAN deployment strategies. Other important barriers are immature technologies and supply chain and performance trade-offs compared to integrated RAN solutions.

Until now, NEPs have provided MNOs with fully integrated RAN stacks. They have also provided managed services and therefore take full accountability for network KPIs in the RAN and other network domains, such as the core and OSS (often provided by different vendors). However, Open RAN introduces a far more complex network architecture, where different vendors provide the software and hardware for the three RAN components. It must be recognised that industry bodies, such as 3GPP, and open initiatives, such as O-RAN, only define the specifications for the interfaces between network components, such as those between the CU and DU or between the DU and RU. These organisations do not define how the network functions at each component are implemented. It is therefore the role of the vendors to design and develop the necessary algorithms for each of the network components. For this reason, achieving and integrating a full multi-vendor interoperable architecture framework is challenging. Significant amounts of tuning and configuration will need to be carried out before the algorithms from vendor A's DUs can control vendor B's RUs.

Updates are also a significant issue. NEPs produce over 100 RAN features each and update them on an annual, and at times a semi-annual, basis. These features are complex, and a large workforce with years of RAN feature development expertise is required to design, develop and test them. Some operators expect it to take a few years before the open ecosystem will have the same skills base in place.

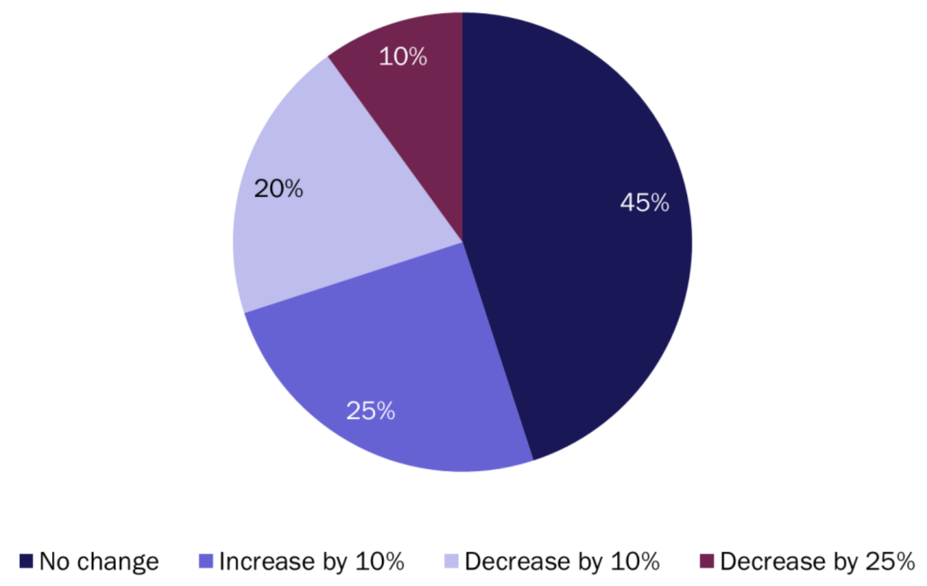
Another concern is operators' aim to move towards a far greater degree of continuous updating, as in other cloud markets. This can provide another set of co-ordination challenges if strong multi-vendor processes are not put in place and agreed widely. In a multi-vendor environment, this can lead to the challenge of lifecycle management, because of the ongoing effort to co-ordinate releases, upgrades and correction packages from different sources, and to align roadmaps. This can add complexity and cost to the operation of the network.

Operators also express concern that system integrators (SIs) will address their need to reduce the deployment effort and act as a 'single throat to choke', but will generate a new type of lock-in by doing so. O-RAN members are working to create standards and application programming interfaces (APIs) so that DU features from vendor A can access RU features from vendor B. Given that each vendor uses its own 'secret sauce', the integration activities can be both arduous and costly, and may require the support of SIs. However, in the early stages of Rakuten's deployment, the detailed radio knowledge and capabilities meant that Open RAN was too challenging for established SIs, and it had to carry out its own SI work in-house.

Even when the platforms allow for vendor-neutral SIs, there is a risk that each SI will develop its own network templates based on its preferred list of vendors, which will create new closed ecosystems. This may be an attractive proposition for some MNOs that want to fast-track their Open RAN deployments but do not have the scale, resources or skillsets required to carry out large-scale integration and testing in-house. However, more broadly, it will be a risk to MNOs and new vendors and to the goals of Open RAN. In scenarios where the operator relies on a single integrator, MNOs must accept the risk of being locked in with the vendors that their SIs have used thus far. Their future access to new RAN features and innovations will also be limited to the roadmaps that the SIs have developed together with their vendor partners. This is therefore likely to lead to new RAN ecosystem fragmentation and limit market access to some vendors, which could in turn undermine the aim of having a more competitive ecosystem.

The final concern about using complex multi-vendor systems is that the operating costs to manage and maintain equipment and software from many suppliers will increase. Automation and agile updates are increasingly supported for the software elements of the RAN, but do not affect the opex of physical radio/antennas and distributed unit hardware. Indeed, only 30% of the operators in our survey expect their RAN opex to decrease in the first 3 years of open vRAN deployment (Figure 5.2). It is therefore important that the ecosystem builds confidence that opex will indeed decrease in the second phase of deployment as emerging platforms become more automated.

Figure 5.2: Expected impact of Open RAN on RAN opex costs in the first 3 years of deployment, 3Q 2020



Source: Analysys Mason, 2021

5.2 Potential trade-offs in performance are another major concern

It is natural that, at a time when 5G will make unprecedented demands on operators' networks, MNOs are keen to understand any potential trade-offs in performance. In these early stages, this aspect of new architecture is, necessarily, unproven. Some concerns are connected to vRAN in general, and some to the immaturity of Open RAN platforms in particular.

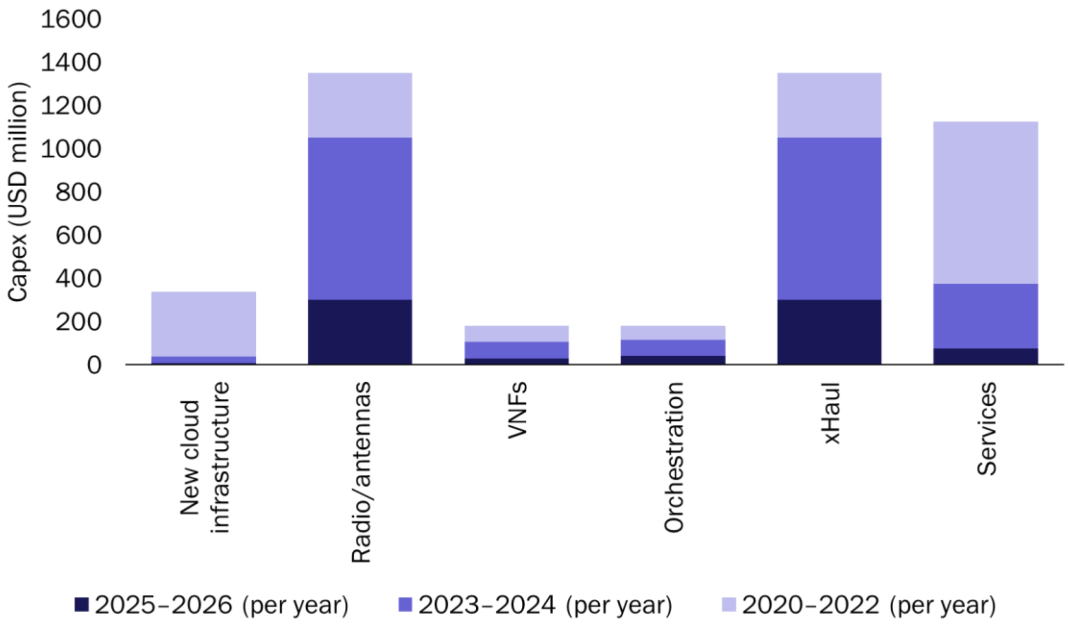
The main risks perceived in this category are as follows.

- **The nascence of technology, standards and the supply chain.** The immaturity of the current open specifications and ecosystem is the second most important barrier to deployment: 36% of respondents placed it in their top three. Only the fronthaul specifications have been completed so far, despite the efforts undertaken over the last several years by O-RAN members in delivering open and interoperable interface specifications. The work is ongoing and other open initiatives, such as Open Networking Foundation (ONF) and Telecom Infra Project (TIP), are also contributing to this effort. Nonetheless, there are still many 3GPP-specified interfaces that the open initiatives must work on and develop open solutions for. Operators are also concerned about how quickly solutions from new vendors will reach maturity and be able to compete with integrated RAN solutions from the NEPs. The level of this concern, of course, relates to the timeframe in which the operator hopes to deploy at scale.

- **Risk of the lowest common denominator.** For instance, there is a balance between consensus around a given interface, and forcing MNOs into a single solution that may not suit all deployment scenarios. Critics argue that the O-RAN Open Fronthaul specification (which supports 3GPP Option 7.2 for the split between RU, DU and CU) is only optimal where plenty of high-quality fibre is available, and will be a compromise in other situations.

- **Potential lack of scale in the ecosystem in the early days, which may delay the availability of low-cost solutions.** A move to a software-centric network and COTS hardware reduces costs in some areas, but the physical elements of a vRAN, which account for the biggest share of capex, rely on large ecosystem scale to drive down cost. Figure 5.3 shows the expected capex breakdown for a vRAN and highlights the dominance of physical elements such as radio/antennas and xHaul, as well as systems integration/services.

Figure 5.3: Annual capex breakdown for a typical macro vRAN (consensus estimate of 48 MNOs)



Source: Analysys Mason, 2021

- **Limited proof points related to resilience or real-time processing.** For instance, the development of the near-real-time RIC is a central effort within O-RAN, but operators will need extensive trial data before they will be willing to replace embedded control functions that handle mission-critical RAN processes.

- **Security concerns.** Some Open RAN security concerns are common to any virtualised, disaggregated architecture, namely that separating many elements introduces potential breaks in the chain of trust. Operators are also concerned that open, and open-source, interfaces are more vulnerable to attack because their code is widely shared, and they may not have been secured using industry gold-standard mechanisms. Some of these concerns relate to the immaturity of the system and will be addressed in time. The O-RAN Alliance has a Security Task Group, which includes members from 19 companies such as Ericsson and is working to define and implement best practice.

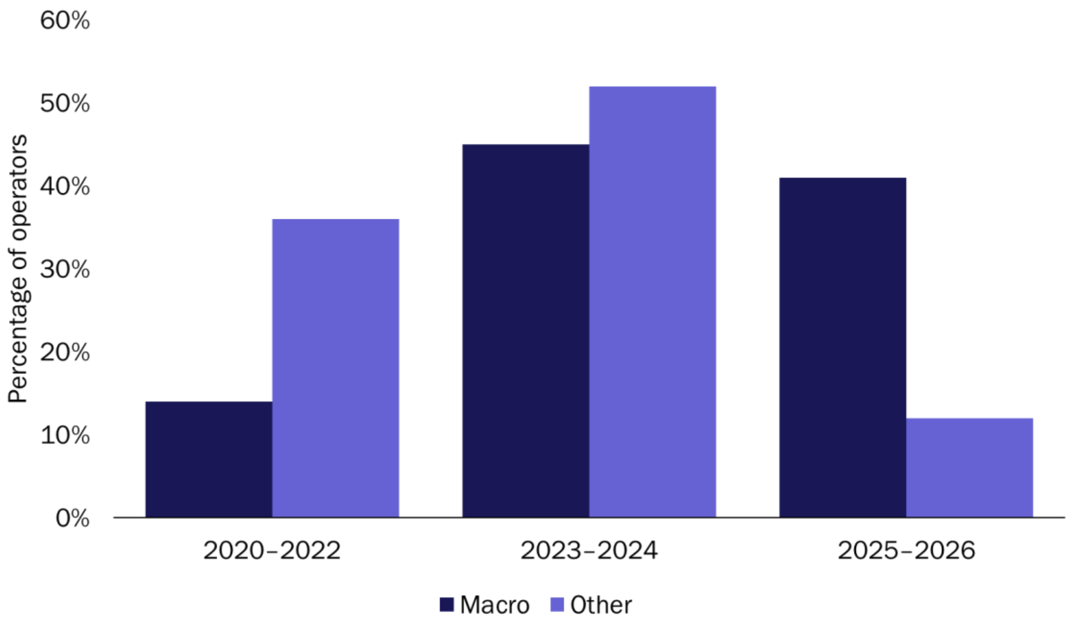
- Performance trade-offs compared to integrated RANs. MNOs depend on carrier-grade solutions to ensure that their networks continuously meet the key performance indicators (KPIs) that have been set. MNOs will therefore look for Open RAN solutions that deliver high KPIs, yet most of the chips used to date in the CUs and DUs are general purpose processors (GPPs). These are well-suited to a CU, but there are limitations when handling the intensive compute operations that the DUs must perform (which will only get more demanding with 5G due to applications such as dynamic spectrum-sharing. NEPs have decades of experience in producing systems-on-a-chip (SoCs) that are optimised for such processes, based on efficient and lower-power application-specific integrated circuits (ASICs) that serve all types of use cases from low-population-density rural areas to ultra-high-population-density urban areas. Existing virtual DUs based on GPPs may serve low-population-density rural areas and small cell use cases, but the power consumption of this type of processor is at least an order of magnitude higher than that of ASICs. This, together with the far higher number of servers that is required to deliver services in high-density urban areas (especially those that require CA and high bandwidths using massive MIMO antennas), will quickly make the business case for deploying Open RAN solutions in such environments challenging. There is intensive industry work on developing high-performance, energy-efficient processors to support very demanding DU use cases, but these efforts remain at an early stage. It is too early to tell how many of these uncertainties about performance will be addressed by platform maturity.

6. The time to reach Open RAN maturity will vary in different scenarios

As seen in Section 5, most of the concerns about deploying Open RAN relate to potential trade-offs in performance at a time when 5G will make unprecedented demands on operators' networks. Operators must recognise that there are currently very few firm proof points of Open RAN performance in challenging scenarios. Indeed, some trade-offs may be an inherent feature of emerging RAN platforms.

The biggest risk for Open RAN is that the challenges that we have outlined will not be effectively addressed before operators deploy 5G vRAN at scale. Operators have many reasons to move to vRAN and will adhere to their timescales in most cases, even if Open RAN platforms are not ready. However, virtualisation may provide a foundation stone for moves to open architecture in the future. Our forecasts indicate that the timing to migrate to a vRAN (whether open or not) is the critical decision for most operators as this will have a significant impact on factors such as equipment availability and maturity. Figure 6.1 shows that 45% of operators surveyed plan to deploy a vRAN for their macro 5G network in 2023–2024, and Open RAN must therefore achieve sufficient maturity and resilience in the macro RAN (which will account for about 80% of 5G RAN capex in the first 5 years of the life of a network) by this time to capture the biggest wave of investment in 5G vRAN. The starting point is earlier for secondary networks such as enterprise RANs.

Figure 6.1: Expected first year of commercial deployment of a 5G vRAN at scale, 3Q 2020



Source: Analysys Mason, 2021

As noted in Section 2, operators that are primarily deploying in lower frequency bands, with fewer MIMO antennas and lower capacity demands, will have fewer performance-related challenges when implementing Open RAN radio units and interfaces. The first macro 5G Open RANs deployed by established operators are therefore likely to use lower-frequency (sub-3GHz) FDD spectrum.

Greenfield operators are likely to deploy Open RAN and vRAN hand-in-hand, but there will only be a few such operators in the macro network market (too few to create economies of scale alone). Other operators will deploy Open RAN platforms if they are fully proven in time for their vRAN roll-outs, but will not otherwise risk their primary network performance, and will not significantly delay deployment to wait for open platforms to mature.

Only time and a far longer list of proofs of concept, lab tests, field trials and deployments will fully answer the question of whether Open RAN will be ready. Some challenges will be addressed quite rapidly by the collective effort of the industry, while others will take more time and work, and may impose permanent trade-offs.

Figure 6.2 illustrates when operators believe that their primary perceived risks will be removed or mitigated in time for their vRAN roll-outs. They are confident that the lack of scale and immaturity of standards can be overcome in the near term (1–3 years), but issues related to cost and complexity will take longer to address. Operators are the most uncertain about risks associated with the actual performance of the network.

Figure 6.2. Operator confidence about the time for the ecosystem to address the 10 main Open RAN challenges

Challenge	Near term (1–3 years)	Medium term (4–6 years)	Long term (7+ years/never)
Integration cost and complexity		✓	

Challenge	Near term (1–3 years)	Medium term (4–6 years)	Long term (7+ years/never)
Immature technologies and supply chain	✓		
Performance trade-offs over integrated RAN			✓
Risk of lowest common denominator			✓
Lack of scale in ecosystem	✓		
Limited data on real-time resilience			✓
Security issues		✓	
Risk of increased opex		✓	
Lack of single accountable supplier		✓	
Complexity of lifecycle management and update processes	✓		

Source: Analysys Mason, 2021

Certainly, there is plenty of industry effort and motivation to accelerate progress. A wide range of stakeholders is working across many groups in O-RAN to bring collective expertise to the challenges. Established NEPs such as Ericsson are working with operators, ecosystem partners and specialist experts to tackle challenges related to issues such as security, management and fronthaul.

As in previous generations of technology, the most important way to understand the new architecture in detail, and to address operators’ concerns, will be to conduct extensive tests and trials. The most important sources of progress in this respect will often come from smaller commercial deployments, which do not carry the same degree of risk or difficulty as nationwide macro roll-outs, but will nevertheless help to increase the understanding of the open platforms and how they can best be deployed and operated to support commercial success.

7. Conclusions and recommendations

Open RAN is quickly becoming an issue for operators to consider as they set out on the next stages of their RAN migrations. A few high-profile operators have been bullish about the architecture, but there are also challenges that the rest of the operator community should take into consideration. This report uses Analysys Mason’s survey of over 100 operators to deliver a balanced view of the challenges and opportunities that Open RAN presents.

The aspirations to reduce TCO and increase competition among suppliers are clear drivers of Open RAN, but upon closer examination, these alone do not justify the pursuit of an Open RAN architecture strategy. The importance of the RAN to the operators’ business and the necessity to meet demanding KPIs mean that operators must understand in detail what new services and revenue streams can be delivered using this new architecture to ensure an attractive ROI.

There are also uncertainties about potential downsides of Open RAN deployments, in terms of cost, complexity, performance and product maturity, which both operators and vendors are keen to mitigate. It may be difficult to reassure operators that Open RAN can support peak, mission-critical performance and this issue may remain only partially resolved for years to come. There are trade-offs between deployment timings and solution maturity, which are more or less serious depending on the scenario. The important question for operators is how to mitigate these risks. For some, this will entail planning and deploying Open RAN solutions in areas with the least impact on the business-critical macro network in order to develop learnings that may be applied more widely in future evolutions, and shared with the wider community via open fora.

The degree of risk that an operator is prepared to take will be decided by its market position, commercial objectives, existing infrastructure and deployment scenario.

Figure 7.1 is based on inputs from our survey and indicates the risk/reward balance when addressing different deployment scenarios.

Figure 7.1: Risk/reward balance of deploying Open RAN before 2025 in different scenarios

Challenge	Primary macro network	Rural or enterprise network	Greenfield macro network (sub-3GHz)	Mission-critical network
Integration cost and complexity	Risks outweigh rewards until they are effectively mitigated	Neutral – there are significant rewards and operators feel able to mitigate the risks	Neutral – there are significant rewards and operators feel able to mitigate the risks	Risks outweigh rewards until they are effectively mitigated
Immature technologies and supply chain	Risks outweigh rewards until they are effectively mitigated	Rewards outweigh risks; risks are non-critical to the business case	Neutral – there are significant rewards and operators feel able to mitigate the risks	Risks outweigh rewards until they are effectively mitigated
Performance trade-offs over integrated RAN	Risks outweigh rewards until they are effectively mitigated	Neutral – there are significant rewards and operators feel able to mitigate the risks	Neutral – there are significant rewards and operators feel able to mitigate the risks	Risks outweigh rewards until they are effectively mitigated
Risk of lowest common denominator	Neutral – there are significant rewards and operators feel able to mitigate the risks	Rewards outweigh risks; risks are non-critical to the business case	Neutral – there are significant rewards and operators feel able to mitigate the risks	Risks outweigh rewards until they are effectively mitigated
Lack of scale in ecosystem	Neutral – there are significant rewards and operators feel able to mitigate the risks	Rewards outweigh risks; risks are non-critical to the business case	Neutral – there are significant rewards and operators feel able to mitigate the risks	Rewards outweigh risks; risks are non-critical to the business case
Real-time resilience	Risks outweigh rewards until they are effectively mitigated	Rewards outweigh risks; risks are non-critical to the business case	Risks outweigh rewards until they are effectively mitigated	Risks outweigh rewards until they are effectively mitigated
Security issues	Risks outweigh rewards until they are effectively mitigated	Neutral – there are significant rewards and operators feel able to mitigate the risks	Risks outweigh rewards until they are effectively mitigated	Risks outweigh rewards until they are effectively mitigated
Risk of increased opex	Risks outweigh rewards until they	Neutral – there are significant rewards	Neutral – there are significant rewards	Rewards outweigh risks; risks are non-

Challenge	Primary macro network	Rural or enterprise network	Greenfield macro network (sub-3GHz)	Mission-critical network
	are effectively mitigated	and operators feel able to mitigate the risks	and operators feel able to mitigate the risks	critical to the business case
Lack of single accountable supplier	Neutral – there are significant rewards and operators feel able to mitigate the risks	Rewards outweigh risks; risks are non-critical to the business case	Neutral – there are significant rewards and operators feel able to mitigate the risks	Neutral – there are significant rewards and operators feel able to mitigate the risks
Unco-ordinated update processes and lifecycle management challenges	Rewards outweigh risks; risks are non-critical to the business case	Rewards outweigh risks; risks are non-critical to the business case	Rewards outweigh risks; risks are non-critical to the business case	Neutral – there are significant rewards and operators feel able to mitigate the risks

Source: Analysys Mason, 2021

High-density Open RAN networks are less mature than those for other scenarios and we believe that operators should carefully assess the risks as described. For example, we do not expect to see Open RAN used in the highly challenging scenario of 5G macro deployments using 3.5GHz or millimetre wave, with large numbers of MIMO antennas and carrier aggregation combined with TDD, before 2023 at the earliest.

8. Appendix: disaggregated RAN architecture

In the traditional monolithic 4G architecture, the fronthaul interface is a high-bandwidth, high-reliability and low-latency interface called the common public radio interface (CPRI), which connects the signal processing DU to the RU. The constraints of this interface limit the distance between the DU and the RU.

For a successful cloudification and decomposition of the RAN architecture where the CU, DU and RU functions are split and placed at different locations, the constraints on the permissible distance and the high-bandwidth requirements between the RU and DU must be reduced, such that the DU functions can be placed at far-edge data centres.

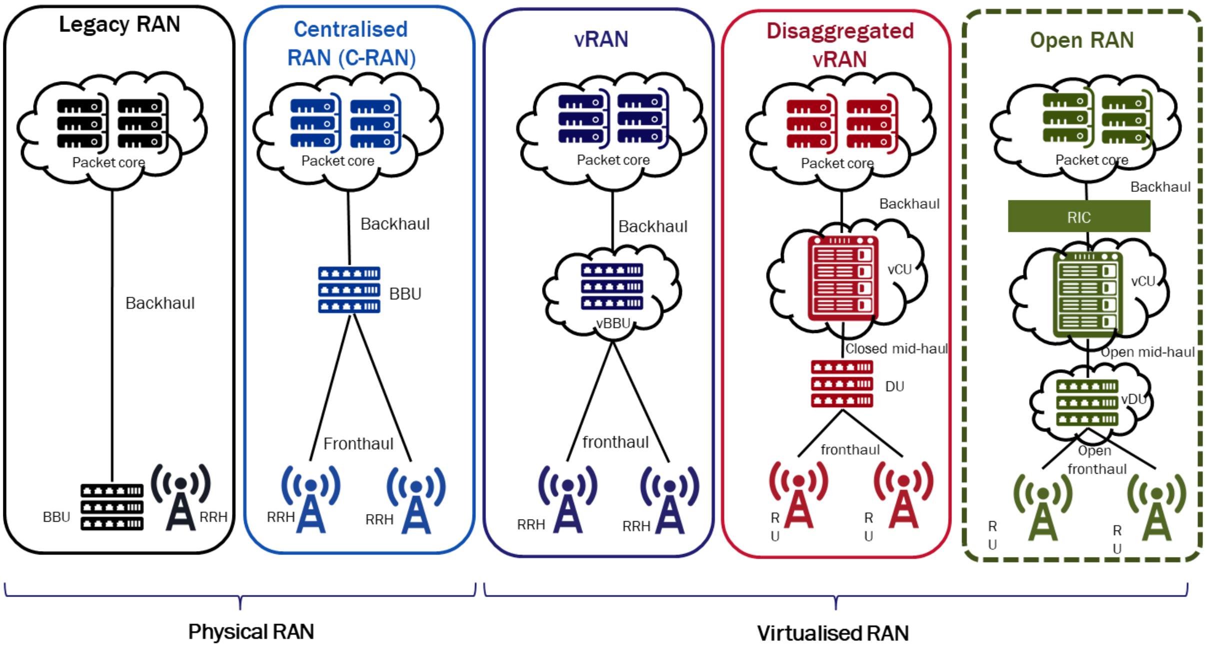
In the traditional 4G architecture, the split point between the DU and RU was such that up to 600Mbit/s of fronthaul interface was required per 10MHz of radio channel. The introduction of carrier aggregation (CA) only exacerbated the fronthaul bandwidth requirements. In 5G, the radio bandwidth will increase to 100MHz and above. The introduction of a large number of antenna elements on massive multiple-input multiple-output (mMIMO) antennas will lead to untenable fronthaul bandwidth requirements of 100Gbit/s–1Tbit/s.

To support this, the 3GPP has introduced a new, more efficient enhanced-CPRI (eCPRI) interface with an increased number of functional splits in order to reduce the overall fronthaul bandwidth. Functional splits refer to the points along the protocol stack where CU and DU signal processing can be separated from the RU. The 3GPP has defined eight functional splits for the eCPRI, where parts of the DU's functional electronics can be placed together with the RU.

The decision of which split to use has several ramifications, such as the cost of the additional DU electronics that are coupled with the RU, the distance between the two elements, the requirement for high-performance computing to process signals at the DU and the power consumption costs. Given the distributed nature of the RAN, the network TCO increases rapidly as more DU electronics are placed at the RU. Figure 8.1 summarises the main stages of evolution from traditional to open disaggregated RAN architecture.

More importantly, the eCPRI protocol contains elements that are vendor-specific. This will prevent DU and RU integration unless suppliers agree on the element. Indeed, the NEPs that participated in the Rakuten Mobile (Japan) network build-out in Japan were able to come to such an agreement.

Figure 8.1: The evolution of RAN architecture from fully integrated to open[5]



Source: Analysys Mason, 2021

5 Note that this does not represent a sequential progress. Operators may deploy multiple architecture types in parallel, or in any order. For more information, see Analysys Mason's Profiting from vRAN: vendor strategies for adapting to new MNO buying patterns.

9. About the authors

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