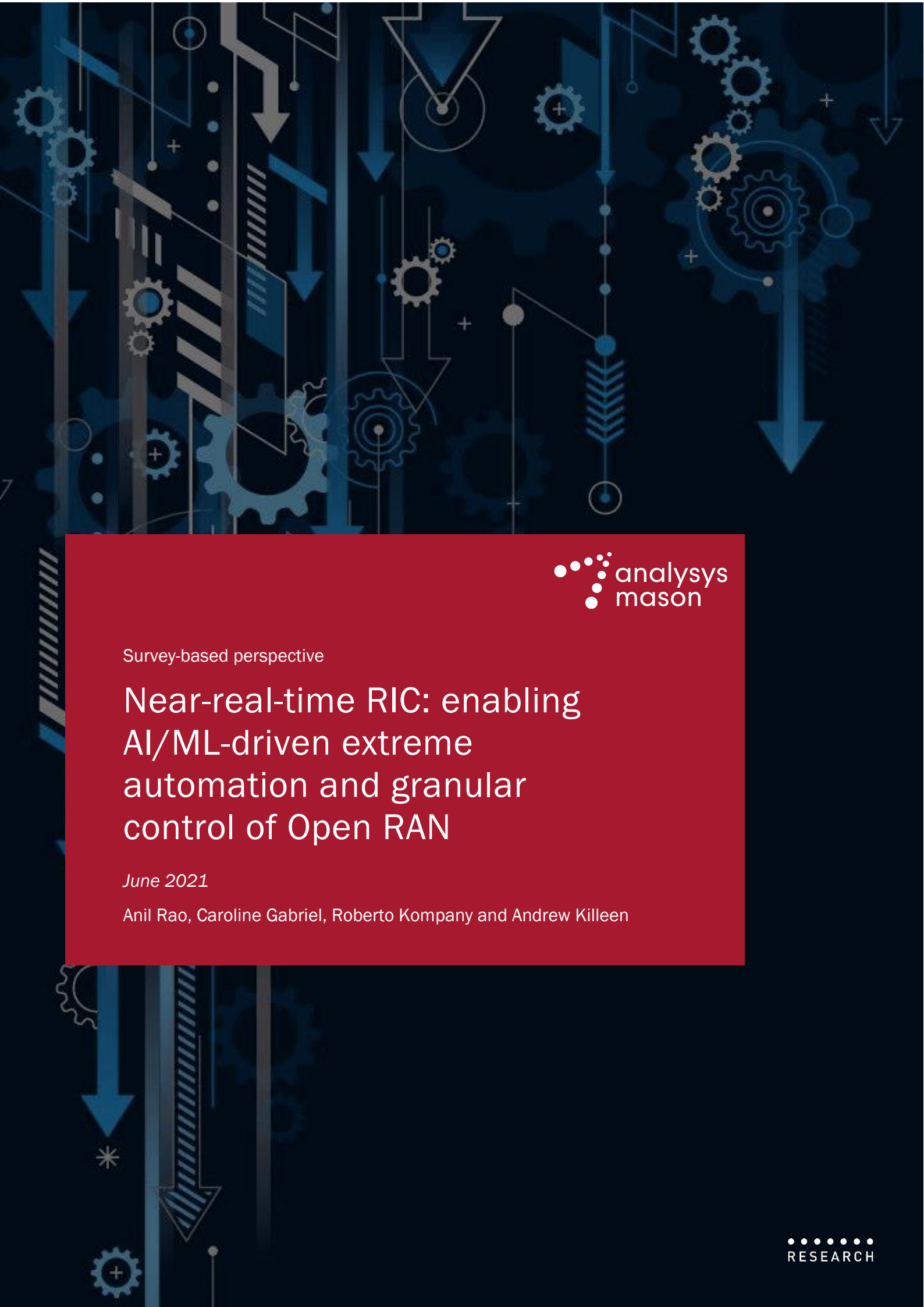


analysys mason

Survey-based perspective

Near-real-time RIC: enabling AI/ML-driven extreme automation and granular control of Open RAN

June 2021

Anil Rao, Caroline Gabriel, Roberto Kompany and Andrew Killeen

RESEARCH

Contents

1. Executive summary 1

2. Open RAN provides the basis for a significant rethink of the control and management of mobile networks 3
2.1 MNOs expect Open RAN to significantly reduce network TCO and diversify the supply chain 4
2.2 Open RAN needs a new approach to control and management 5
2.3 The industry is coalescing around the RIC architecture for controlling and managing the Open RAN 6

3. The RIC is foundational for MNOs to achieve the goals of Open RAN 8
3.1 MNOs plan to deploy the RIC to operationalize Open RAN 8
3.2 Industry stakeholders are working to accelerate the adoption of Open RAN and RIC 12

4. The near-RT RIC provides automated and programmatic control of the RAN 14
4.1 MNOs can achieve a broad range of business benefits with the near-RT RIC platform 14
4.1 The near-RT RIC will host existing low-latency use cases and more advanced, future use cases 15
4.2 MNOs are clear about the business rationale and portability of the xApps but are divided on the role of SON in RIC environments 16

5. AI/ML will bolster automation in the near-RT RIC 20
5.1 Architectural considerations for AI/ML in the RIC 21
5.2 MNOs are prioritizing the use of AI/ML for network optimization use cases 22

6. Ecosystems can help to overcome the challenges of commercializing the RIC 25

7. Conclusions 27

8. About the authors 28

List of figures

Figure 1: MNOs' approach to the deployment Open RAN or vRAN 4
Figure 2: Mobile data traffic and 5G's share, worldwide, 2018–2025 5
Figure 3: Logical architecture and interfaces for the RIC platform 7
Figure 4: MNOs' approach to the RIC platform to operationalize Open RAN 8
Figure 5: MNOs' timeline to the first deployment of the near-RT RIC 9
Figure 6: Type of network deployment where MNOs foresee the most demand for the RIC platform 10
Figure 7: MNOs' commercial drivers for the RIC platform 11
Figure 8: MNOs' expectations for asset utilization improvements with the RIC 12
Figure 9: MNOs' expected additional business benefits from near-RT RIC uses cases 14
Figure 10: Description of near-RT RIC use cases 15
Figure 11: Most important near-RT RIC use cases selected by MNOs 16
Figure 12: MNOs' business rationale for prioritizing the three near-RT use cases 17
Figure 13: MNOs' perception of the importance of xApps portability 18
Figure 14: MNOs' perception of the role of the SON in Open RAN RIC environments 19
Figure 15: Level of improvement expected from applying AI/ML to a near-RT RIC use case (over the base use case, without AI/ML) 20

Figure 16: The importance of AI/ML for implementing the near-RT RIC use cases 21
Figure 17: MNOs' approaches to applying AI/ML within the RIC platform 22
Figure 18: MNOs' top five near-RT RIC use cases for implementing AI/ML 23
Figure 19: Level of implementation of AI/ML to near-RT use cases among MNOs that plan to have deployed the near-RT RIC, by time period 24
Figure 20: The most severe challenges to deploying the near-RT RIC as selected by MNOs 25

1. Executive summary

Mobile network operators (MNOs) recognize the need to reduce the total cost of ownership of 5G networks and accelerate innovation, even as they look to increase network efficiency, rapidly roll out new sites and bring to market new revenue-generating services. To this end, MNOs are taking steps to take control of the 5G network and are considering new virtual and Open radio access network (RAN) architecture, which follows the trend of network disaggregation and openness to enable an open ecosystem of multi-vendor RAN solutions. However, to truly realize the benefits of Open RAN, MNOs are also rethinking how they control, operate, and manage the RAN. Extreme network automation is at the heart of this new thinking and the RAN Intelligent Controller (RIC) is at the heart of the new control and management architecture for RAN automation.

MNOs expect the RIC to give them granular control of the RAN resources, which would enable them to take intelligent, insights-driven closed-loop automated actions based on the evolving network conditions. In addition, the RIC is deemed as essential for enabling MNOs to operationalize a best-of-breed Open RAN. According to the widely accepted specifications published by the O-RAN Alliance, the RIC architecture consists of two key components: the near-real-time RIC with xApps and the non-real-time RIC with rApps within service management and orchestration (SMO).

Analysys Mason conducted a market study for the Telecom Infra Project (TIP) to assess the current state of the industry's thinking on the RIC platform, with a specific focus on the near-real-time (near-RT) RIC. This paper provides in-depth analysis based on the results of the study, which is based on a survey of 35 MNOs (Tier 1 and 2) and alternative network providers worldwide, and Analysys Mason's existing RAN research. The survey focused on many areas relating to deploying the near RT RIC, including the business and commercial rationale, use case priorities, deployment timelines and the role of artificial-intelligence and machine-learning (AI/ML) techniques. Key results of the study are summarized below.

For the RIC in general:

- About 35% of the MNOs in the survey are planning to use the RIC to manage all Open RAN operations, and a further 20% are considering specific Open RAN use cases for the RIC. This shows a wide acceptance among MNOs that the RIC will be essential for the success of Open RAN.

- Survey respondents chose RAN total cost of operation (TCO) reduction as the top commercial driver for deploying the RIC. Analysys Mason has forecast that network opex worldwide will decline at a CAGR of just 0.94% during 2019–2026, which suggests that MNOs must do more to reduce TCO, and the RIC is likely to be part of that strategy.

- About 74% of the MNOs expect to increase asset use efficiency by 10%–30% by deploying the RIC, suggesting that MNOs expect real benefits from the technology.

- About 83% of the MNOs said they will deploy the RIC in new primary, macro networks, and 57% said they will deploy it in the new secondary, rural, or smaller local, networks. This is expected because MNOs will be cautious about entrusting their established 5G macro RANs to the new Open RAN and RIC architecture.

For the near-RT RIC in particular:

- About 40% of the MNOs stated that they expect the near-RT RIC to significantly reduce the cost of operations. This is further evidence of how important the RIC and particularly the near-RT variant, will be in achieving the TCO reduction targets.

- Real-time video optimization, quality of service (QoS)-based radio resource optimization and dynamic spectrum sharing were chosen as the top three use cases for near-RT RIC; and about 51% said that delivering superior customer experience was their top business rationale for prioritizing these three use cases. Video continues to be a killer app for mobile broadband and will represent a significant burden on the 5G network. Predictively allocating and optimizing RAN resources in real time to support excellent video and other QoS-dependent services will be fundamental for the success of 5G.

- About 31% of the MNOs are planning to deploy the near-RT RIC by 2023, and a further 31% by 2026. There is always uncertainty in the telecoms industry, over the real-world performance of a brand-new architecture, especially the Open RAN and RIC, so these timelines may prove to be optimistic.

- About 68% of the MNOs said portability of xApps across different near-RT RIC platforms is an important or very important capability. Multiple RIC platforms, both open source and proprietary, will probably emerge from different vendors and ecosystems. Highly portable xApps that leverage SDKs and APIs will allow MNOs to select the best xApp from the marketplace and deploy it to the RIC platform of their choice.

- With respect to the evolution of self-organizing network (SON) functions in the RIC environment, a slight majority of 57% of MNOs expect the distributed SON (dSON) functions to be subsumed into the RIC, and about 49% said that centralized SON (cSON) functions would be replaced by the RIC.

- About 23% of the MNOs said AI/ML is a critical enabler to automate the near-RT use cases, while about 46% are evaluating the role of AI/ML in near-RT RIC. MNOs chose QoS-based radio optimization, real-time video optimization and massive MIMO optimization as the top three use cases to use AI/ML. Analysys Mason research confirms that AI/ML will become a key capability to exploit the massive amount of data generated in the RAN significantly bolstering the efficacy of the use cases.

Most MNOs expect significant barriers to operationalize the RIC. About 87% of the MNOs selected, complexity of deployment, technology immaturity and integration with legacy systems as top three severe challenges to deploying the near-RT RIC. However, further research suggested that MNOs expect that the accelerating ecosystem collaboration and ongoing standards development initiatives may enable the ecosystem to develop well-engineered RIC platforms to not only overcome some of these barriers but also enable Open RAN to outperform the traditional RAN systems in the long term.

However, MNOs are clear that they cannot do it alone and that the industry will need the key stakeholders to collaborate. Developing a truly multi-vendor interoperable RIC platform will require MNOs, new and traditional vendors, standards bodies, academic institutions, developer communities and others to collaborate. Furthermore, the industry will also require robust governance processes to ensure that the RIC is fit for purpose and delivered in a timely manner to accelerate adoption and commercialization. TIP's RAN Intelligence and Automation (RIA) subgroup is one such ecosystem that is engaging a range of industry stakeholders to collaborate on various activities such as use case prioritization, interoperability, and test and validation of the RIC platforms, xApps and rApps.

2. Open RAN provides the basis for a significant rethink of the control and management of mobile networks

MNOs are faced with the need to reduce the TCO of their networks as they plan their 5G deployments, deliver networks to meet the relentless growth in mobile data traffic, and support new revenue-generating use cases.

Open RAN initiatives, such as the O-RAN Alliance, Open Networking Foundation (ONF), Open RAN Policy Coalition, and TIP are working from various angles to accelerate the development and deployment of Open RAN technologies. The central aim of these initiatives is to enable architectural flexibility in the RAN and lower the barriers for new vendors to enter the market. Open RAN together with the hardware/software disaggregation, and the transition to cloud-native networks point to a trend where MNOs want to control their destiny and dictate the shape of the networks of the future.

Open RAN has received important backing from high-profile MNOs, such as Deutsche Telekom, DISH, Orange, Rakuten, Telefónica, and Vodafone. Additionally, Telecom Italia committed to deploying Open RAN solutions at the start of 2021,[1] and NTT Docomo announced its partnership with 12 vendors to accelerate the development of best-of-breed Open RAN components and software.[2]

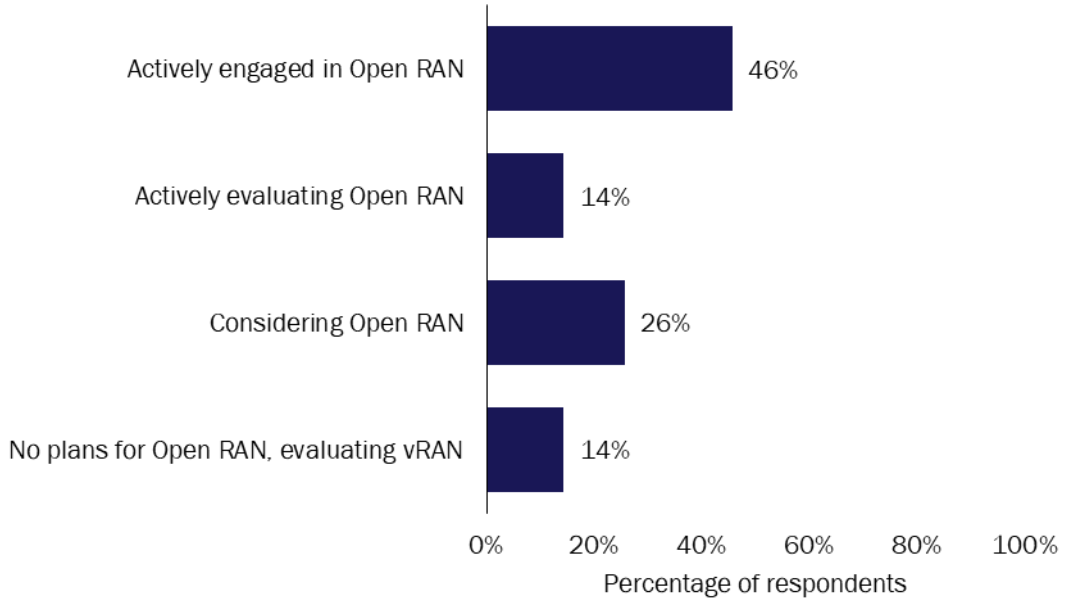
This is further evidenced by the results of the survey,[3] which found high levels of support for the idea of Open RAN, with 46% of those surveyed actively engaged in one or more activities and with a further 40% either evaluating or considering Open RAN (see Figure 1).

1 https://www.gruppotim.it/en/press-archive/corporate/2021/PR-TIM-ORAN-en.html

2 https://www.nttdocomo.co.jp/english/info/media_center/pr/2021/0208_00.html

3 Analysys Mason surveyed 35 worldwide Tier-1 and 2 MNOs, and alternative network providers that are considering Open RAN or virtualised RAN (vRAN) technologies. The survey was completed in February 2021.

Figure 1: MNOs' approach to the deployment Open RAN or vRAN



Question: "Do you have plans to deploy Open RAN?"; (*n*=35).

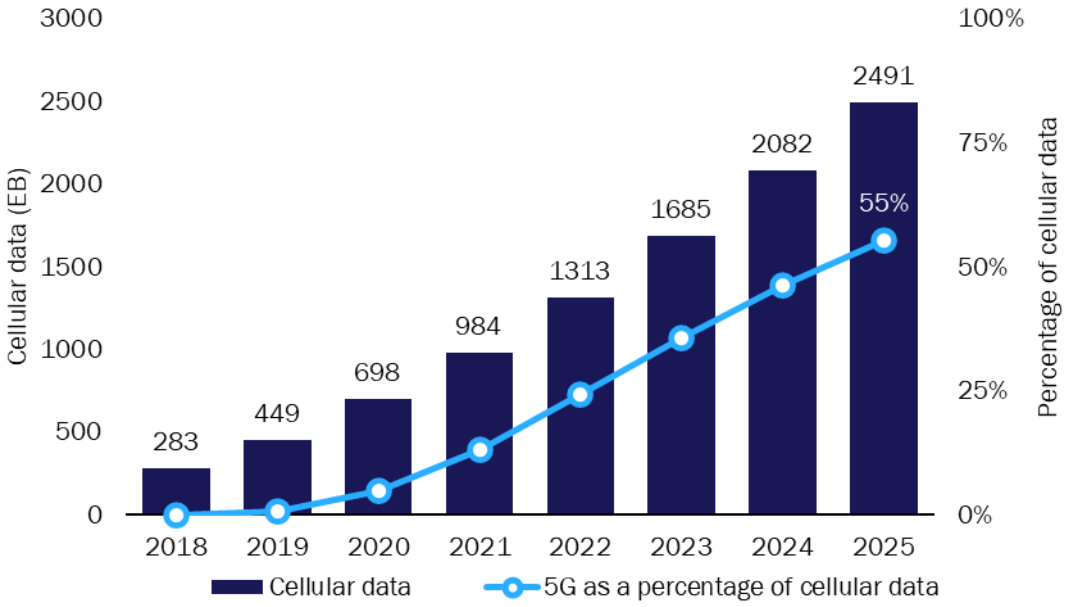
Source: Analysys Mason

The analysis and conclusions within this paper are based on this survey combined with our ongoing research in the areas of Open RAN and RIC. Specifically, the survey sought to understand the MNOs' approach to automating Open RAN-based networks, the need for a new control and management architecture, and the benefits and challenges of implementing this architecture.

2.1 MNOs expect Open RAN to significantly reduce network TCO and diversify the supply chain

Analysys Mason forecasts that the launch of 5G networks will drive growth in mobile data traffic to almost 2500EB worldwide in 2025, with 5G expected to account for more than half of this traffic (see Figure 2). This forecast represents a five-fold increase in data traffic worldwide compared to that of 2019. Traffic growth combined with flattening or declining average revenue per user (ARPU) puts MNOs' finances under pressure, which will encourage them to significantly reduce the TCO of their networks. MNOs expect to achieve some TCO reduction by implementing an Open or virtualized RAN. MNOs also expect these new networks to be cloud-based and automated, so that they can reduce the time-to-market for new revenue-generating services to offset declining mobile broadband and voice revenue.

Figure 2: Mobile data traffic and 5G's share, worldwide, 2018–2025



Source: Analysys Mason

Open RAN also promises a multi-vendor ecosystem with standard open interfaces between the different network elements, which means MNOs can procure the RAN components from different vendors. Furthermore, virtual, and cloud-native RAN components such as the virtual distributed unit (vDU) and virtual centralized unit (vCU) enable a higher level of architectural flexibility and provide the basis for software-driven control and management to achieve extreme automation in the RAN. Together, the virtualization of the RAN and the introduction of open interfaces are expected to facilitate the diversification of the supply chain. This will provide a more conducive ecosystem for new vendors and enable MNOs to deploy a more diversified best-of-breed RAN in their mobile networks.

2.2 Open RAN needs a new approach to control and management

Open RAN is an opportunity for the industry to rethink the way the RAN is managed and operated. The expected TCO benefits of 5G cannot be achieved without implementing significantly higher levels of automation in the Open RAN compared to the traditional RAN. Extreme automation is not just a 'nice to have' but an essential pre-requisite for the new operational architecture for Open RAN. Furthermore, the prevalent operations and management architecture was developed for proprietary RAN, which may not be fit for purpose for Open RAN.

Open RAN can benefit from a new control and management architecture because it:

- enables fine-grain programmatic control of the RAN resources based on evolving network conditions, and use cases based on quality-of-service requirements, network performance, service-level agreement (SLA) and latency demands
- applies latest innovations in AI/ML technology to automate the generation of insights and drive extreme automation of the RAN at various layers of the stack such as the cloud infrastructure layer, RAN resources layer and the RAN domain layer

- enables the horizontal disaggregation and orchestration of the RAN by placing the components (vCU and vDU) at far, metro, or aggregated edge sites.
- automates the lifecycle management of virtual and cloud-native RAN components using DevOps and continuous integration and continuous delivery (CI/CD) software engineering paradigms
- enables granular, use case-based feature development to satisfy a smaller subset of operators.

2.3 The industry is coalescing around the RIC architecture for controlling and managing the Open RAN

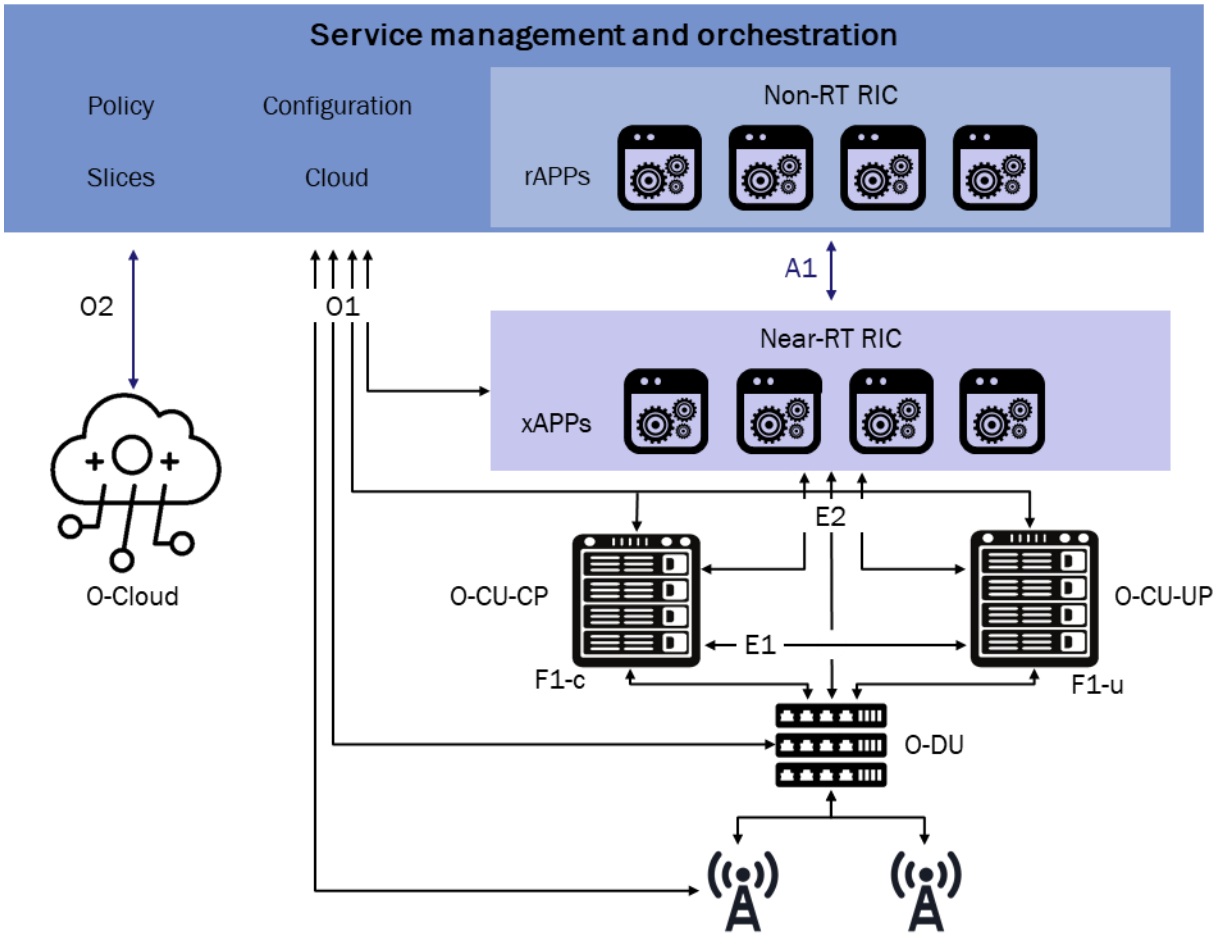
The RIC will use a combination of real-time network telemetry, offline contextual data, policy engine, network orchestration and a library of applications to drive the automated control and management of the RAN. The RIC architecture decouples high- and low-latency closed-loop operations, which allows a more intelligent and use case driven automation of the RAN.

The O-RAN Alliance has envisioned the RIC architecture (see Figure 3). According to this architecture, the RIC is sub-divided into key two components as follows.

- SMO and the non-RT RIC to manage use cases with more than 1-second latency. The non-RT RIC forms part of the SMO function, which is responsible for the overall management and orchestration of the RAN domain for non-latency sensitive use cases such as AI/ML training and modelling, policy, cloud automation, and slice management. The A1 interface between the non-RT RIC and the near-RT RIC allows interaction between the RIC sub-modules. The SMO also interacts with the RAN via the O1 and O2 interfaces, which are reserved for the SMO-only management of each O-RAN function, and O-cloud resources and workloads. The non-RT RIC hosts rApps to support use cases such as intelligent RAN optimization (for example, centralized self-organizing networks (cSON)) and energy optimization, which can also leverage the SMO's data collection, O-RAN provisioning, and AI/ML models. In addition, any information may be passed to the near-RT RIC for timely management of resources.

- The near-RT RIC hosts applications called xApps support use cases that require less than 1-second latency. It interacts with the non-RT RIC using the northbound A1 interface, while the southbound E2 connects it simultaneously to both the control plane (CP) and user plane (UP) for the Open RAN central units (O-CUs) and the Open RAN distribution units (O-DUs). This interface allows it to collect specific, near-RT information. The xApps within the near-RT RIC cover the real-time control and optimization functions (for example, distributed SON (dSON)) that vendors have begun to develop, such as load balancing, radio bearer management and interference mitigation. MNOs will be able to deploy a range of xApps for specific purposes, such as radio resource management (RRM) or quality of experience (QoE) for individual applications or services (for example, voice, video, or augmented/virtual reality). More complex xApps such as massive MIMO antenna and beamforming optimization will have a longer-term development timeline. These xApps will be necessary to improve the MNOs' quality of service (QoS) levels and reduce costs in a complex multi-radio access technology network, where 5G will be the latest addition to other RAN generations.

Figure 3: Logical architecture and interfaces for the RIC platform



Source: O-RAN Alliance, Analysys Mason

The essence of the RAN disaggregation in Open RAN is carried through in the RIC architecture too. The separation of duties between the SMO, non-RT RIC, near-RT RIC, and applications (xApps and rApps), allows MNOs, in theory, to deploy standards-compliant multi-vendor Open RAN. This architecture allows MNOs to deploy best-of-breed RAN and RIC technologies in a multi-vendor environment, addressing the MNOs' needs for an open ecosystem approach to fostering innovation, increasing service agility, and reducing the TCO of 5G networks through extreme automation.

The rest of the paper will focus on the value of RIC in operationalizing Open RAN and present a deeper analysis of the near-RT RIC, discussing a range of themes such as the business and commercial value of deploying near-RT RIC, use case priorities, timeline, and the role of AI/ML in enabling extreme automation of the RAN through the near-RT RIC.

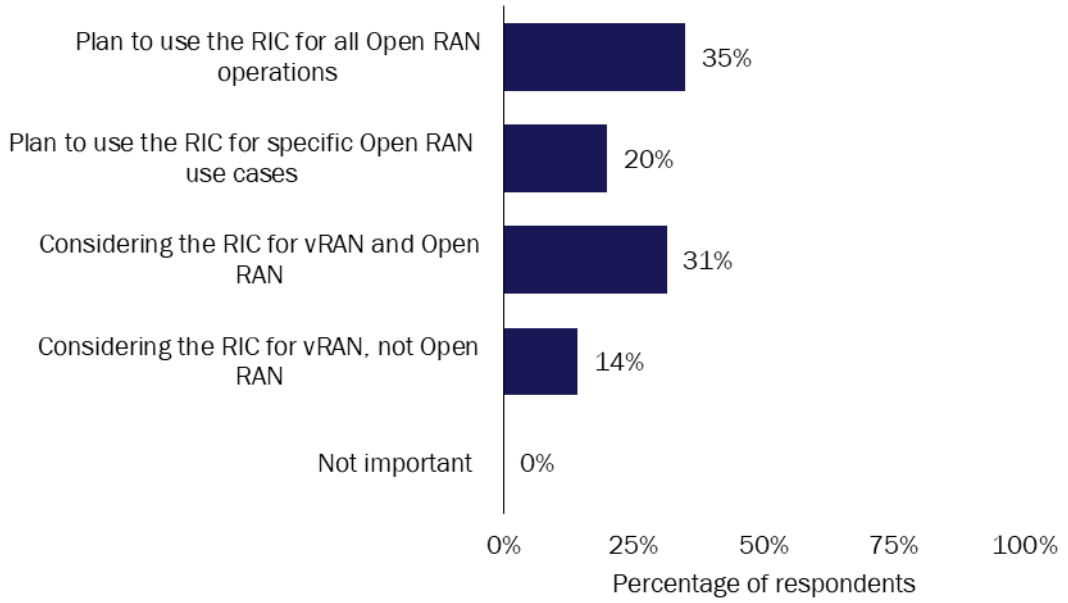
3. The RIC is foundational for MNOs to achieve the goals of Open RAN

3.1 MNOs plan to deploy the RIC to operationalize Open RAN

Most MNOs accept that the RIC will be essential for the success of Open RAN. According to our survey, all MNOs that have an active interest in virtual or Open RAN are planning or considering deploying the RIC (see Figure 4). Although the technology is in its early stages, a third of MNOs in our survey already plan to use the RIC for all their Open RAN operations. Some MNOs are considering the RIC not only for Open RAN deployments but also vRAN deployments. Analysys Mason research corroborates that the RIC may be developed to be backwards compatible with 4G networks.

The RIC goes beyond opening the vRAN architecture to a wider group of vendors. It also introduces a new approach to automating the management and control of the RAN, including processes that are critical for 5G use cases, such as handling of massive amounts of traffic. By automating control functions in software, rather than embedding them in the base station itself, MNOs see a potential opportunity to accelerate the automation of their networks and simplify support for demanding 5G functionality, such as ultra-low latency response.

Figure 4: MNOs' approach to the RIC platform to operationalize Open RAN



Question: "How do you see the role of the RIC platform to operationalize Open RAN?"; (*n* = 35).

Source: Analysys Mason

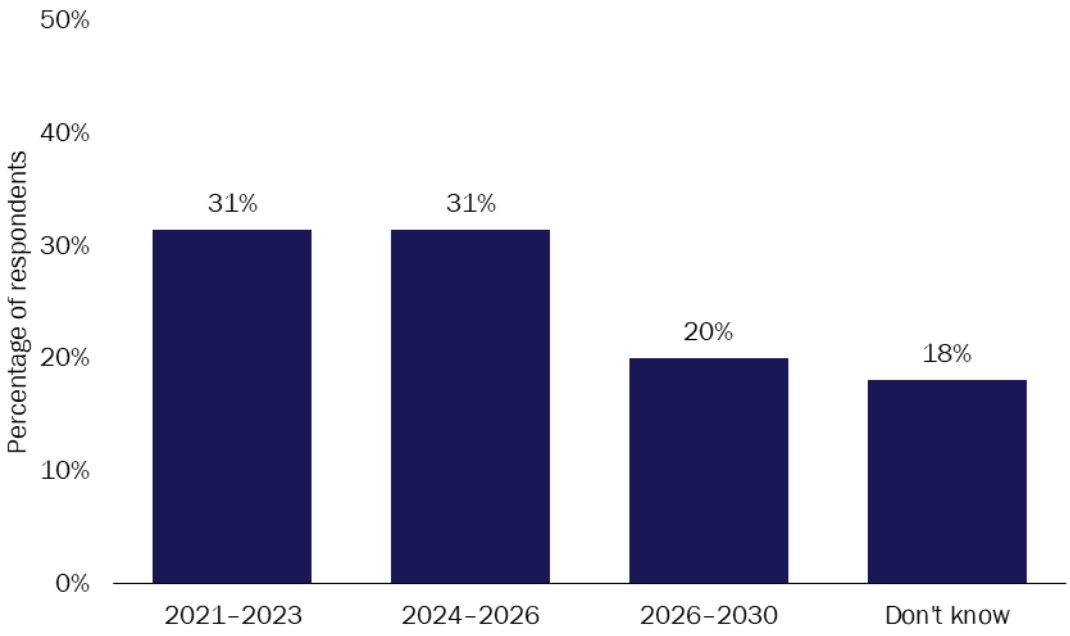
RIC deployment timelines and the nature of the demand

Early deployments of the RIC will start within 5 years, focusing on new primary macro networks, or secondary, smaller rural or local, networks, whether deployed by new entrants or by existing MNOs. MNOs' timelines for this first deployment of the near-RT RIC are ambitious, as with all highly anticipated technologies, with a third of MNOs expecting to begin the process before the end of 2023 (see Figure 5). Of course, it is important to

remember that this survey sample targets MNOs that are interested in virtual or Open RAN. Given vendors' plans for Open RAN products and current specification efforts, these early deployments may focus on basic SON use cases and pre-standard solutions. Overall, this result shows MNOs' urgency to adopt a flexible and automated RAN control architecture.

These plans to first deploy the RIC appear in line with MNOs' broader Open RAN deployments. Since its first conception, the RIC has been widely discussed as part of the second phase of Open RAN development and to be implemented when mature Open RAN interfaces are established. During the initial stages of Open RAN deployments, some MNOs may decide to deploy RAN interfaces without a RIC using an embedded control layer. However, our results also suggest that 62% of MNOs may begin to deploy the near-RT RIC before 2026, and 80% of MNOs before 2030 (see Figure 5).

Figure 5: MNOs' timeline to the first deployment of the near-RT RIC

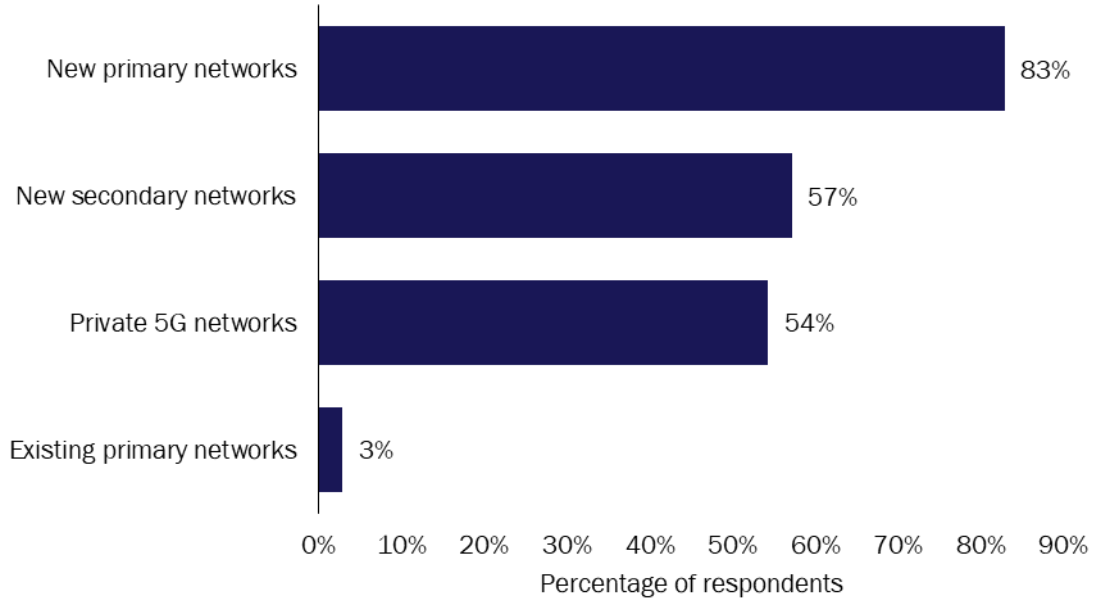


Question: "By when do you plan to deploy the near-RT RIC?"; (*n* = 35).

Source: Analysys Mason

There is always uncertainty over the real-world performance of a brand-new architecture and these timelines may prove over-optimistic. Despite their enthusiasm for the near-RT RIC and Open RAN, MNOs may be cautious about entrusting their 5G macro-RANs to the new Open RAN architecture until it is fully proven at scale, which may entail several years of trials. Figure 6 shows that most MNOs identified the demand for the RIC platform within new primary networks, specifically new 5G macro sites.

Figure 6: Type of network deployment where MNOs foresee the most demand for the RIC platform



Question: "Where do you foresee the highest demand for the RIC platform?"; (n = 35) [multiple choice].

Source: Analysys Mason

Most MNOs identified demand in greenfield primary networks – Rakuten Mobile is a prominent example – and more than half of MNOs may initially deploy the RIC in less demanding environments such as new secondary networks, small greenfield cell networks being built to serve rural extensions, smart cities, or large venues. By contrast, just one MNO reported demand for the RIC platform in existing macro networks. This reflects the challenges of introducing new architecture to networks where a significant amount of traditional equipment and software is in use, some of it only recently deployed for 5G or for 4G expansion. Tier-1 operators are likely to lead from the front driving innovation and developing ecosystems but deploying more slowly because of their existing large installed base of legacy networks. However, Tier-2 and smaller operators may be able to operationalize their Open RAN more quickly given the smaller scale of their networks and their ability to be more agile in trying out the new architecture.[4]

Large enterprises are increasingly deploying private 5G networks, and these will probably be a strong proving ground for Open RAN and the RIC. 54% of respondents expect to see demand in this environment. Open networks can also lower barriers for new service providers to build greenfield private 5G networks, and with no legacy or macro networks to consider, these new entrants are expected to be early adopters of new open architecture such as Open RAN.

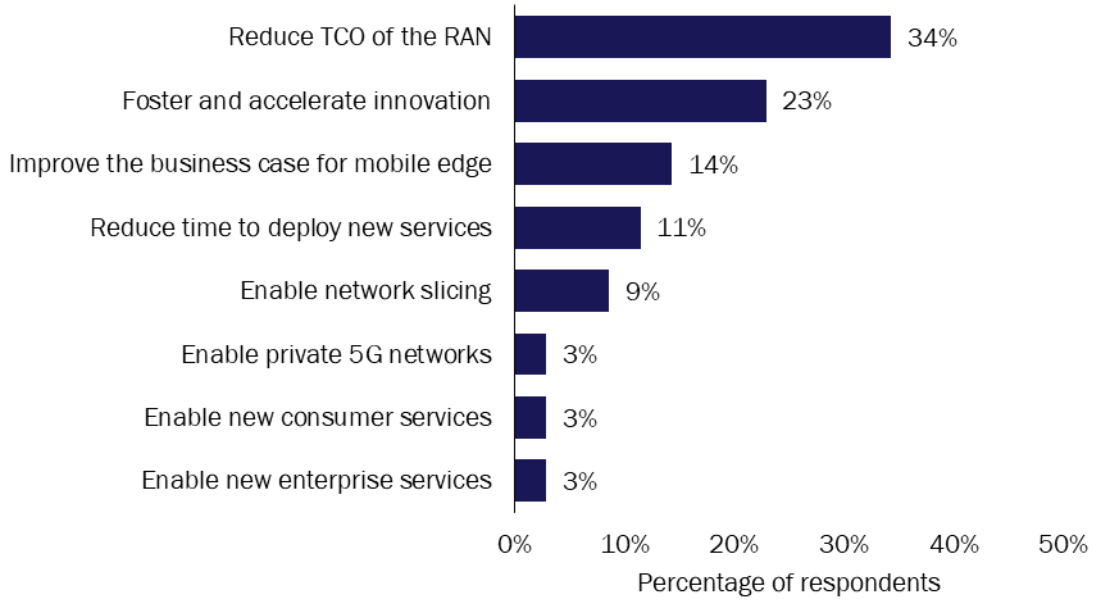
Commercial drivers for RIC

MNOs have ambitious goals for reducing their network opex and the TCO of the RAN. These goals are reflected in our survey results – a third of MNOs identify reducing the TCO of the RAN as a key commercial driver (see Figure 7). However, Analysys Mason has forecast that if the current pace of network opex reduction

4 https://cdn.brandfolder.io/D8DI15S7/as/qac4v1-31ugc8-8w3wc5/Analysys_Mason_5G__Open_Networks_White_Paper_may2020.pdf.

were to continue, the network opex worldwide will reduce at a CAGR of just 0.94% during 2019–2026.[5] MNOs will need to accelerate automation if they are to achieve the higher network opex reduction targets and meaningfully reduce the TCO of the 5G networks.

Figure 7: MNOs' commercial drivers for the RIC platform



Question: "What are the key commercial drivers to deploy the RIC?"; (*n* = 35).

Source: Analysys Mason

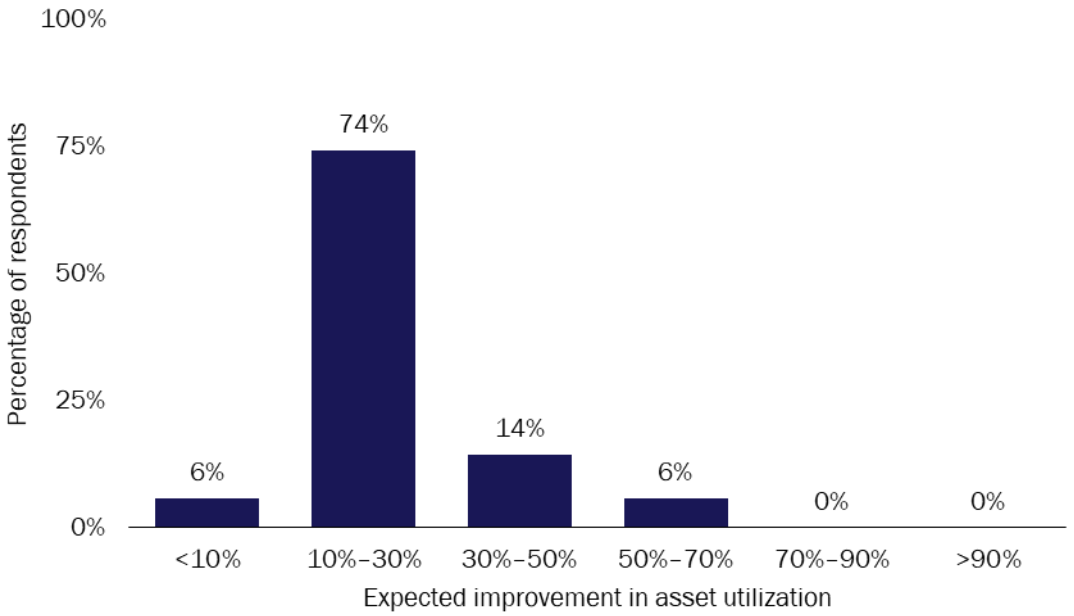
MNOs chose fostering and accelerating innovation as the second most important commercial driver for the RIC, reflecting the ambition of Open RAN and the RIC to support open ecosystems and diversified value chains. Some MNOs chose drivers such as improving the business case for mobile edge, network slicing and private 5G, which are important 5G use cases. The 5G Standalone core together with the mobile edge cloud enables new network-as-a-service business models such as network slicing-based on-demand delivery of network services. Together, these technologies also allow MNOs to deploy self-contained private mobile networks for enterprises and offer differentiated services with high bandwidth and low-latency QoS. The RIC platform is likely to enhance the longer-term feasibility of these drivers, but the survey results show that they may not be an urgent priority for MNOs compared to TCO reduction and innovation.

Asset utilization improvement using RIC

MNOs agree that the RIC will improve asset utilization by 10%–30% (see Figure 8). Two-thirds of MNOs specified that this would affect spectrum use, and one-third of MNOs specified site utilization, which may include traffic steering and predictive load balancing between sites. This result shows that MNOs may expect significant but realistic benefits from the technology. Most MNOs that selected improvements of more than 30% are alternative network providers, which are estimating the benefit from their greenfield deployments.

5 For more information, see Analysys Mason's *Telecoms opex: worldwide trends and forecast 2017–2026*. Available at www.analysysmason.com/research/content/regional-forecasts-/telecoms-opex-forecast-rdns0/.

Figure 8: MNOs' expectations for asset utilization improvements with the RIC



Question: "By implementing the RIC, what level of improvements in asset utilization efficiency do you expect to achieve?"; (*n* = 35).

Source: Analysys Mason

3.2 Industry stakeholders are working to accelerate the adoption of Open RAN and RIC

Open RAN is being actively developed by a range of industry bodies working together to move the RAN towards more open and interoperable networks. The key groups are the O-RAN Alliance, TIP, and the ONF.

The O-RAN Alliance is focusing on developing standards for open standardized interfaces for RAN components. Ten working groups of the Alliance cover specific areas of the Open RAN architecture: specifically, the working groups 2 and 3 focus on defining the architecture and interfaces for the non-RT RIC and the near-RT RIC, respectively.

TIP's OpenRAN Project Group is more focused on defining and developing Open RAN use cases and works to foster a collaborative ecosystem as well as facilitate trials and tests to ensure interoperability. TIP's RAN Intelligent Automation (RIA) subgroup is focusing on accelerating the development of RIC use cases and pertinent E2 service model definitions, RIC platforms and portability between those, and to date, RIA participants have defined 10 priority use cases, 5 each for the near-RT and non-RT RIC. These use cases consider substitute SON scenarios, such as traffic steering, predictive load balancing, and coverage and capacity optimization, massive MIMO scenarios, interference mitigation and energy use optimization.

The ONF's Mobile SD-RAN project is developing and trialing O-RAN Alliance compliant RAN components, including a near-RT RIC platform with a number of example xApps.

There is industry fragmentation with respect to the ongoing work on use cases despite the organization of efforts by the O-RAN Alliance and TIP. For instance, Rakuten Mobile and Telefónica's partnership, announced in September 2020, to co-develop Open RAN reference blueprints, may accelerate their deployments but rely on an ecosystem that is limited to the vendors that they have selected. A similar case may be applicable to NTT

Docomo's more recently announced '5G Open RAN Ecosystem' of 12 vendors. Disparate, MNO-led ecosystems may ultimately limit the development of technologies that the leading MNO does not prioritize, as well as limiting the access to the market for alternate vendors. This may fragment the ecosystem, forcing MNOs to choose between distinct pre-integrated platforms, and limiting the choice in vendor selection.

Therefore, the industry needs a more concerted approach to benefit the entire ecosystem, adhering to the disaggregation principles and developing a truly multi-vendor Open RAN. The following section discusses the broad use cases for the near-RT RIC, identifies those that MNOs are prioritizing and their business rationale, and assesses how MNOs plan to approach these use cases.

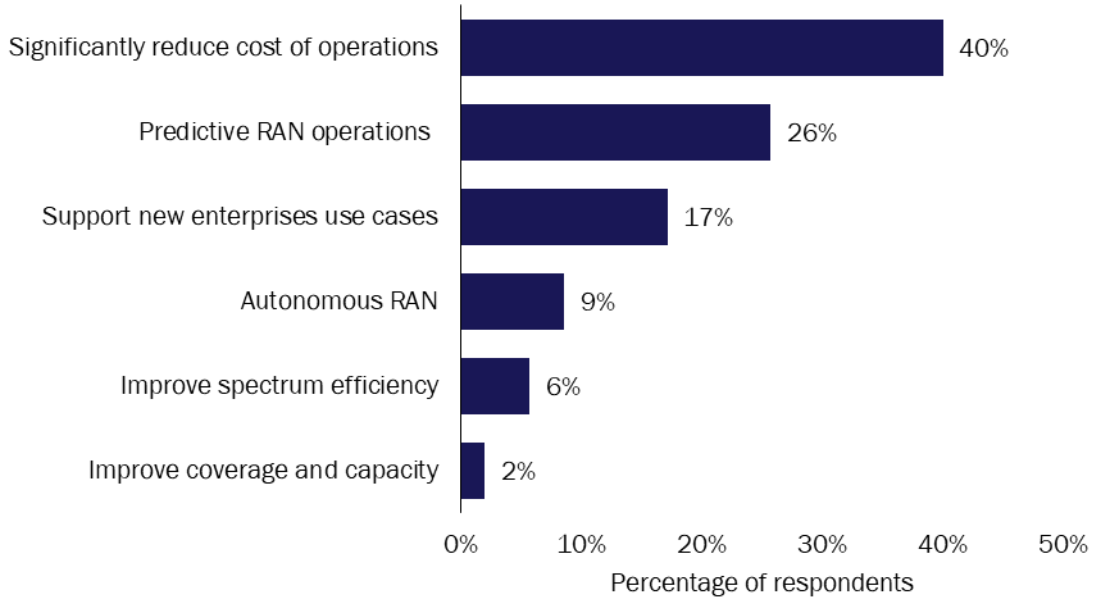
4. The near-RT RIC provides automated and programmatic control of the RAN

4.1 MNOs can achieve a broad range of business benefits with the near-RT RIC platform

Most MNOs selected a variety of additional business benefits for near-RT use cases. Reducing the cost of network operations was directly selected as the most important benefit by 40% of the sample (see Figure 9); when combined with the MNOs that chose predictive RAN operations (26%) and autonomous RAN (9%) – the number of MNOs that expect significant cost reductions increases to 75%.

MNOs expect to see benefits in the forms of predictive RAN operations and autonomous RAN, suggesting that many MNOs are evaluating the RIC as part of a broader move towards an automated network. This transition is seen as critical to reducing the cost of operating a complex network that must support massive traffic loads, user numbers and connected devices, as well as unprecedented diversity of use cases. MNOs recognize that an open platform that can directly, or indirectly using automation, reduce the cost of operations could be transformative in 5G economics.

Figure 9: MNOs' expected additional business benefits from near-RT RIC uses cases



Question: "What type of additional business value do you expect to achieve with the near-RT RIC use cases?"; (*n* = 35).

Source: Analysys Mason

Automating the RAN will drive opex savings by using real-time network data to manage traffic steering and load balancing. Predictive RAN operations will be enabled when the near-RT RIC can proactively implement a resolution before any detriment to the service quality manifests. Both predictive RAN operations and autonomous RAN will rely heavily on AI/ML, these two options were selected by a third of MNOs as the most important benefit implying the importance of AI/ML to the near-RT RIC.

4.1 The near-RT RIC will host existing low-latency use cases and more advanced, future use cases

To achieve the biggest return on investment by implementing the RIC, it will be important for MNOs to identify and prioritize the use cases that will deliver the most immediate operational and commercial results (see Figure 10).

Figure 10: Description of near-RT RIC use cases

Near-RT RIC use case	Description
Real-time video optimization	High-definition video data has significant network bandwidth requirements and failing to deliver will result in poor QoE for consumers on streaming services and a potential breach of SLAs or QoS for advanced mobile applications such as remote UAV control. The RIC is capable of monitoring high-value, high-bandwidth services in near-RT and managing radio resources to ensure that such applications maintain good QoE or QoS.
QoS-based radio resource optimization	QoS-based radio resource optimization will ensure the QoS for specific users, for example on an end-to-end network slice. The near-RT RIC will need to constantly report the performance of the RAN slice and optimize the RRM as directed by policies from the non-RT RIC to mitigate any potential service degradation on the slice.
Dynamic spectrum sharing	New spectrum resources allocated for 5G may suffer from propagation and penetration losses and MNOs may compensate for this by sharing the spectrum currently used for 4G services to boost 5G coverage. Dynamic spectrum sharing will allow the delivery of both 4G and 5G services sharing the same spectrum by varying the traffic load to minimize potential QoE degradation.
Massive MIMO optimization	Massive MIMO antennas are expected to be crucial for improving the performance of 5G services by offering optimal coverage and capacity managed between nodes. However, the optimal configuration requires the management of thousands of parameters and differs for each base station. Multi-vendor solutions will introduce further complexity. The near-RT RIC will use the MNOs' configuration and policies with AI/ML technologies to flexibly configure the optimal parameters used.
Mobility load balancing	Mobility load balancing aims to flexibly configure the network to reduce congestion, adhere to SLA requirements and improve QoS. Congested cells may identify under-utilized network assets, such as frequencies and radio access technologies, and configure the handover parameters to redirect traffic to the under-utilized asset. The near-RT use cases include inter-frequency and inter-RAT mobility load balancing.
Real time user location data	The RIC architecture opens the RAN management and control functions to new, external contextual data that may be used to improve RRM and the QoE of users. Real-time location data may be one such factor that can be used by the RIC's decision-making and AI/ML models to improve the customer experience.

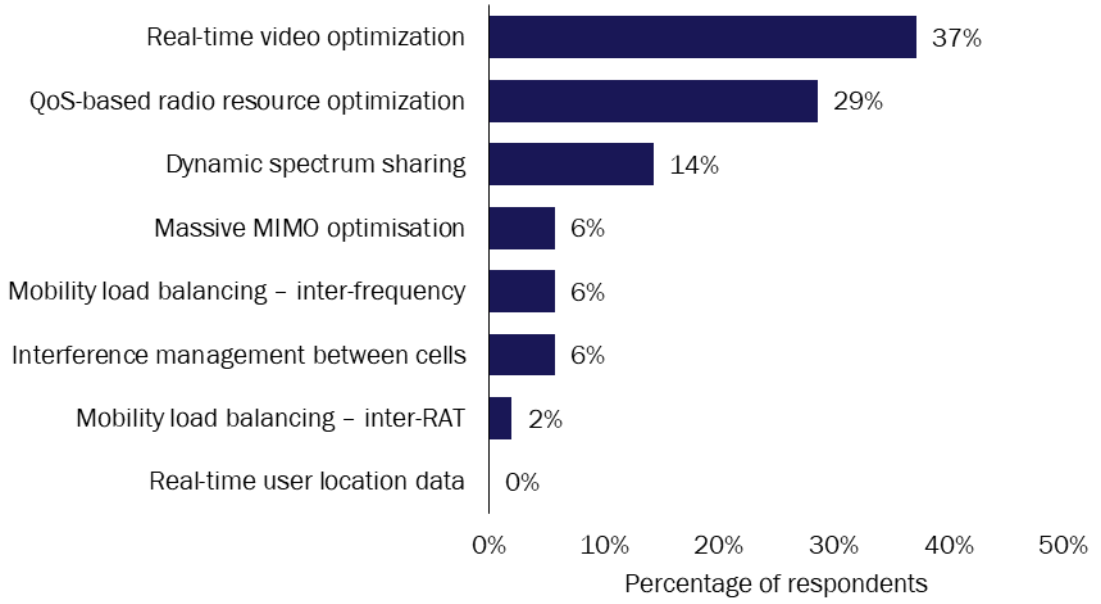
Source: Analysys Mason

Prioritized near-RT RIC use cases

Improving the customer experience for a wide range of consumer and enterprise applications appears the top priority of MNOs plans for the use cases of the near-RT RIC (see Figure 11). Real-time video optimization was recognized as the most important use case by 37% of MNOs. This was closely followed by the optimization of radio resources based on QoS criteria, ranked the single most important use case for almost one-third of MNOs. Dynamic spectrum sharing was the third most selected use case by 15% of MNOs. These top three use cases were selected by 80% of respondents and focus on ensuring a high QoE for high-value applications and users. Video is an increasingly common foundation of commercially significant 5G services and, given the increasing prevalence of high-definition streaming services, represents a significant burden on the network. Predictively

allocating and optimizing RAN resources in real time, to support excellent video and other QoS-dependent functions, will be fundamental to the competitive success of 5G services.

Figure 11: Most important near-RT RIC use cases selected by MNOs



Question: "What do you believe are the most important use cases for the near-RT RIC and the business rationale?"; (*n* = 35).

Source: Analysys Mason

There is a clear margin between these use cases and the rest. These top responses probably represent the most important or less complex near-RT use cases in the near term. The lower ranking use cases may be recognized as longer term or more conducive to the non-RT RIC. As the technology matures and Open RAN is proven, other use cases will become recognized as important. For example, massive MIMO optimization and mobility load balancing are thought to be critical to reduce the TCO of 5G networks but are considered more advanced and complex to deploy today.

4.2 MNOs are clear about the business rationale and portability of the xApps but are divided on the role of SON in RIC environments

Implementing an automated, predictive RAN is a challenging migration and must be fully justified in terms of tangible business benefits for the MNO. It is clear from the survey results that improved customer experience is the key commercial driver for the RIC. While the primary benefits for deploying near-RT RIC use cases is to reduce network cost of operations (see Figure 9 above), that does not mean MNOs are entirely focused on reducing cost.

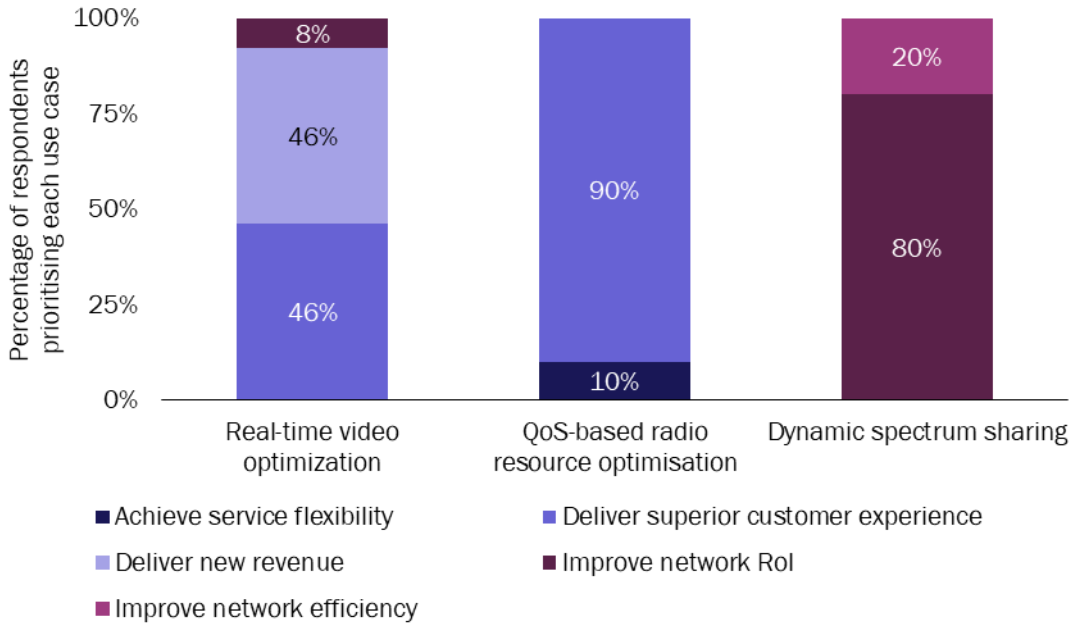
It is far more important to make the RAN cost-viable to support an enhanced quality of service and a variety of different consumer and enterprise applications. That in turn will improve the MNO's market share, revenue, and position in key value chains. For instance, supporting advanced augmented reality and virtual reality (AR/VR) experiences for large numbers of users and applications would place a massive cost burden on a traditional network, but will be far more cost-effective to support in an automated, software-driven RAN that can allocate resources just where they are needed on a predictive basis.

Business rationale for implementing the most important use case

Three use cases were selected by 80% of the MNOs; real-time video optimization, QoS-based radio resource optimization and dynamic spectrum sharing (see Figure 11). The rationale behind each priority use case differs:

- MNOs prioritizing the real-time video optimization use case were split almost 50/50 between delivering a superior customer experience and delivering new revenue as the business rationale
- the rationale behind prioritizing the QoS-based radio resource optimization use case was almost unanimous, with 90% of the MNOs choosing this use case to deliver a superior customer experience
- most MNOs prioritizing dynamic spectrum sharing have operational cost savings and efficiencies in mind and 80% said they aim to improve the network return on investment (RoI) with more efficient use of spectrum and 20% looking to improve the efficiency of network resources.

Figure 12: MNOs' business rationale for prioritizing the three near-RT use cases



Question: "What do you believe are the most important use cases for near-RT RIC and the business rationale?"; (*n* = 28).

Source: Analysys Mason

Of course, all these factors will be significant to any MNO weighing up the RIC business case, but when asked to select the single most important driver, customer experience – and the commercial success it should deliver – takes a higher priority than operational efficiencies for their own sake. Differentiating customer experience and delivering a high-quality experience for many challenging applications, will help MNOs to launch or enhance new 5G services. MNOs recognize the RIC as a direct enabler of new revenue streams for a limited number of use cases.

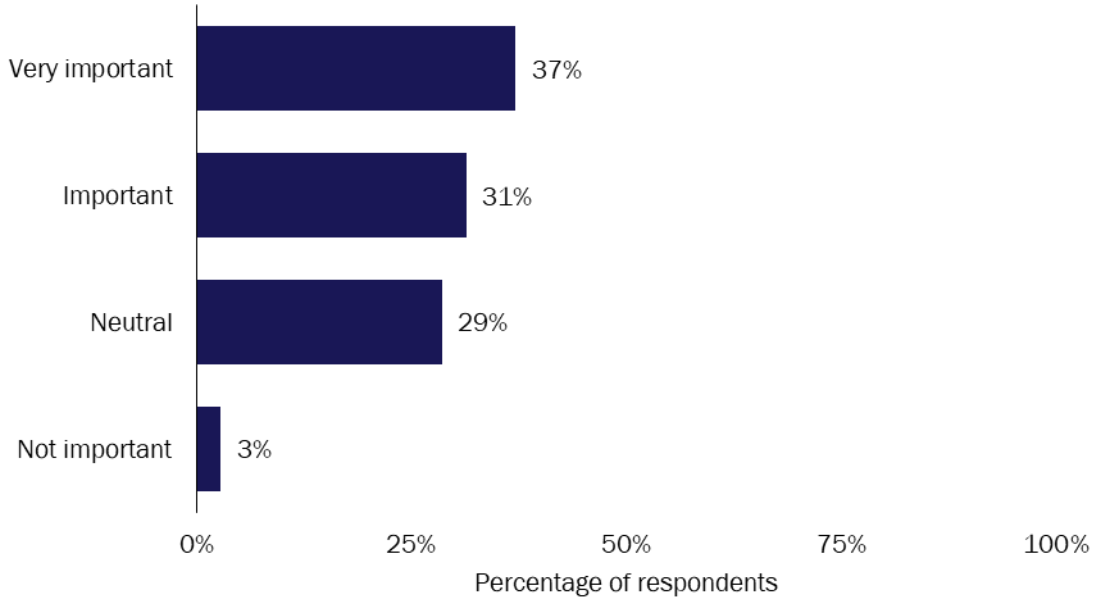
xApps portability

Application portability refers to the separation of an application to its system or environment, enabling a 'build once deploy anywhere' model. Multiple RIC platforms, both open source and proprietary, will probably emerge from different vendors and ecosystems. It is the portability of the xApps that will allow MNOs to select the best

xApp for their application from a range of vendors, regardless of the RIC platform of their choice. Likewise, xApp developers will need to develop their applications to be interoperable with multiple platforms, avoiding the need to redevelop or revise their code for interoperability. Standardization across the industry will be essential in supporting developers so that xApps (and rApps) can easily be made portable.

Most MNOs recognized xApps portability as 'very important' or 'important' (see Figure 13) with only one MNO suggesting that portability was not important. xApp portability is a key issue for the cost reduction of software development and can also reduce operational costs as they can be easily accessed by developers to be consumed in other microservices.

Figure 13: MNOs' perception of the importance of xApps portability



Question: "How important is xApp portability?"; (*n* = 35).

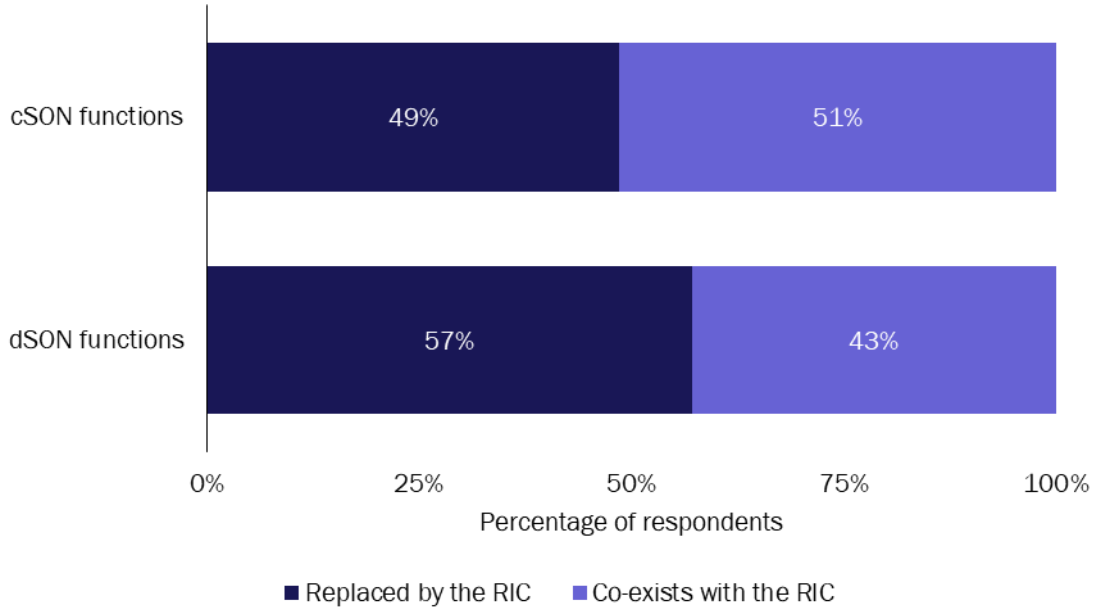
Source: Analysys Mason

SON in RIC environments

Most MNOs do not seem to decided on a clear strategy regarding deploying the RIC platform and the future role of the SON. Figure 14 shows MNOs' responses concerning the future role of the cSON and the dSON functions in Open RAN, RIC environments. A slight majority of 57% of MNOs expect that the dSON functions will be subsumed into the near-RT RIC and its xApps while MNOs were split almost evenly when asked if the cSON functions would be replaced or coexist with the RIC platform, specifically the non-RT RIC and its rApps. Not shown in Figure 14 is that few MNOs distinguished between the role of the cSON and dSON in RIC environments; 80% of MNOs selected the same answer for both dSON and cSON, specifying that both would coexist with, or be replaced by, rApps and xApps.

Further research by Analysys Mason also suggests that it is too early to point to a particular dominant trend regarding the SON and the RIC platform. However, it is clear that the well-defined and understood SON features are likely to be the first use cases implemented as xApps and rApps during the initial laboratory and commercial trials of the RIC platform.

Figure 14: MNOs' perception of the role of the SON in Open RAN RIC environments



Question: "How do you see the future role of the SON in Open RAN RIC environments?"; (*n* = 35) [multiple choice].

Source: Analysys Mason

The following section will discuss the value of incorporating AI/ML as part of the near-RT RIC and how this could supercharge the near-RT use cases, and MNOs' strategies and priorities.

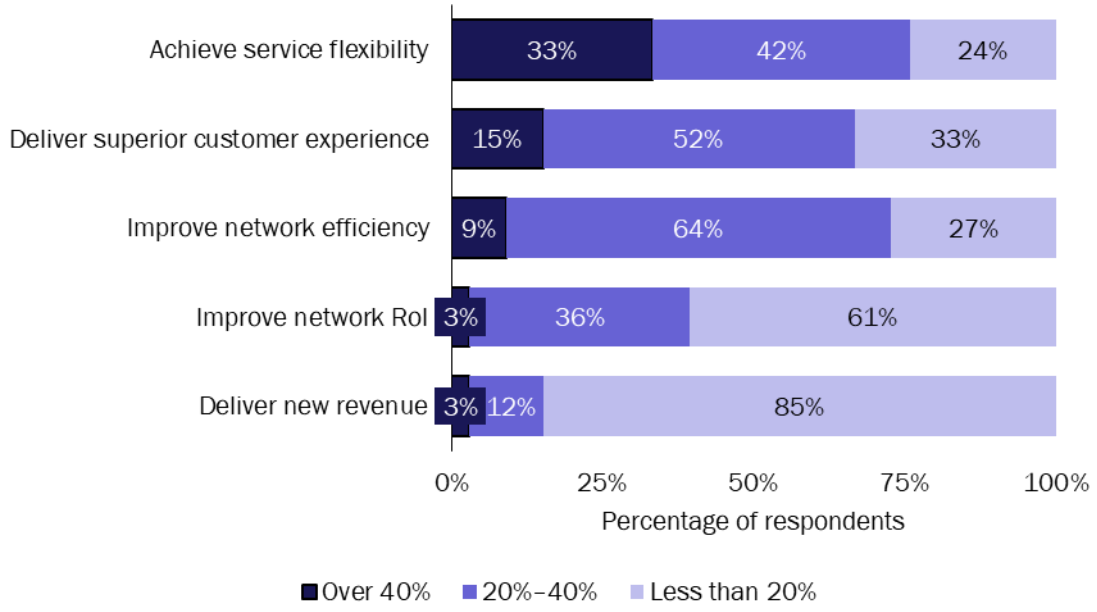
5. AI/ML will bolster automation in the near-RT RIC

AI/ML technologies are maturing and are increasingly being applied to solve problems in various industries. MNOs already apply AI/ML to various use cases such as customer care, sentiment analysis, customer experience analysis and customer churn prediction. AI/ML is poised to become even more important as it becomes a key enabler of extreme automation to manage the increasing complexity of 5G networks, including operationalization of Open RAN and vRAN.

Most MNOs recognize that customer experience, network efficiency and service flexibility can be improved by more than 20% by applying AI/ML to near-RT use cases (see Figure 15). This reflects the fact that the immediate benefits of the RIC platform are focused on two key goals – improving network automation and efficiency, and therefore improving customer experience, which is fundamental to most 5G commercial goals. One MNO even suggested that AI/ML technology could improve customer experience by as much as between 60% and 80%.

AI/ML capabilities such as classification, prediction and optimization will be the key drivers of this improvement, enabling MNOs to pre-empt service degradation, identify unexpected correlations, and enhance network simulations for network planning.

Figure 15: Level of improvement expected from applying AI/ML to a near-RT RIC use case (over the base use case, without AI/ML)



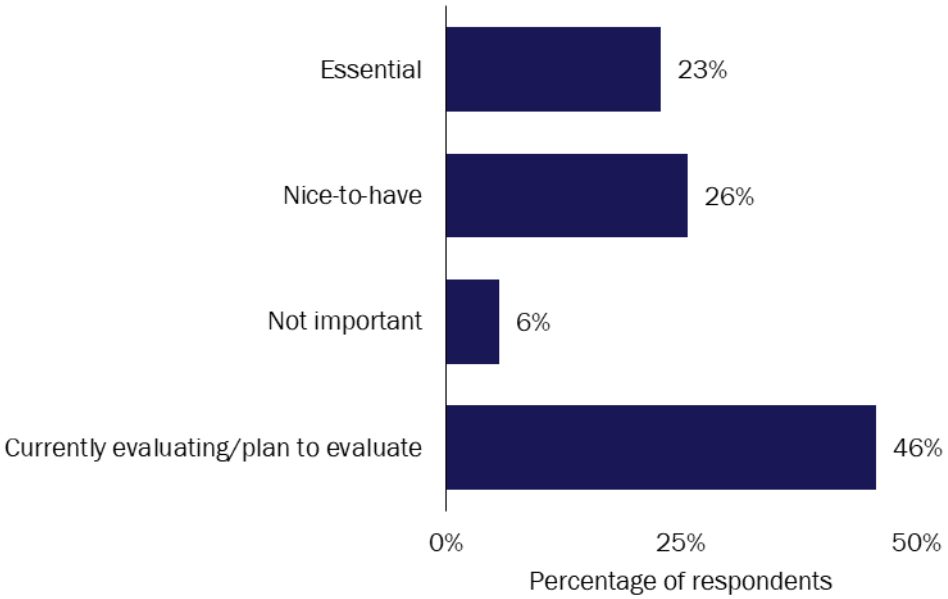
Question: "What level of additional business value do you think AI/ML will provide for the near-RT use cases (over and above the base scenario of implementing the use case)?"; (*n* = 33).

Source: Analysys Mason

AI/ML technologies in the RIC are less directly associated with delivering new revenue streams, which is reflected in the above result. Few MNOs (14%) think that the application of AI/ML will affect the RIC's impact on delivering new revenue.

Almost a quarter of MNOs in our survey recognized AI/ML to be essential for the near-RT RIC use cases (see Figure 16). Meanwhile, because the technology is new, half the MNOs are still evaluating AI/ML for the use cases. Furthermore, Analysys Mason research supports the idea that AI/ML will become increasingly essential to taking advantage of the volume of data generated by the RAN, and by opening the RIC platform, vendors and MNOs may be able to identify use cases that they have not yet imagined. Only two MNOs responded that AI/ML was not important in this regard and that they did not plan to implement AI/ML for the near-RT RIC, but it is likely both will turn out to be late adopters.

Figure 16: The importance of AI/ML for implementing the near-RT RIC use cases



Question: "How do you see the role of AI/ML to implement Near Real Time use cases?"; (*n* = 35).

Source: Analysys Mason

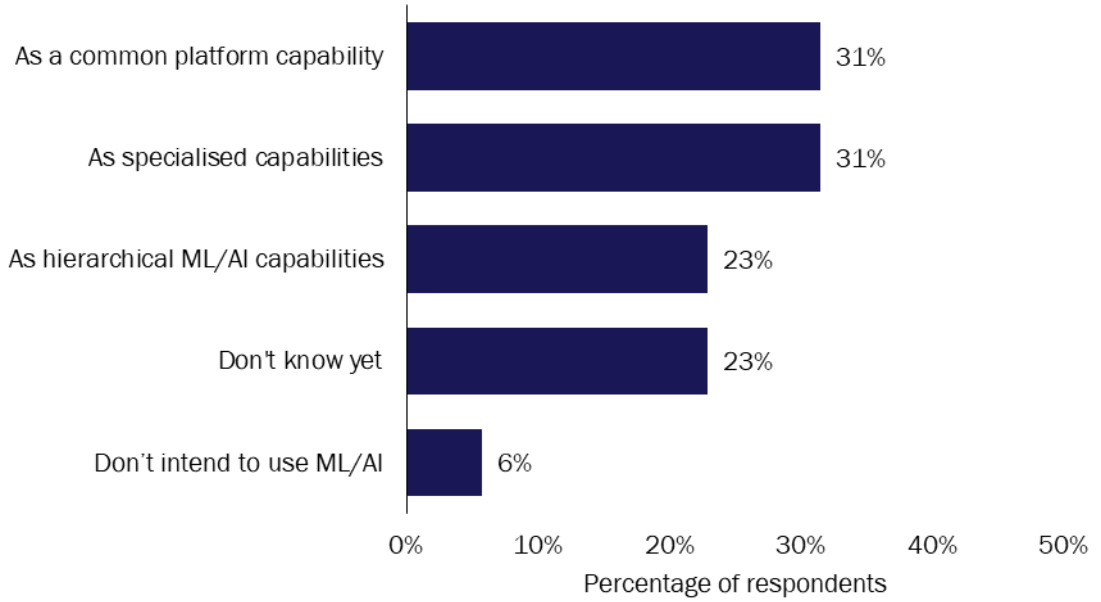
All the benefits that an automated, predictive RAN can deliver for customer experience and the MNO's commercial success are enhanced using AI/ML in RAN operations. AT&T's CTO recently said that integrating AI into RAN control was the primary method to derive commercial benefits from Open RAN.[6]

5.1 Architectural considerations for AI/ML in the RIC

AI/ML capabilities can be implemented in an Open RAN environment in many ways and MNOs are evaluating multiple options. However, most MNOs have a broad idea of how they will implement AI/ML within the RIC (see Figure 17).

6 https://www.telecomtv.com/content/open-ran-summit/the-impact-of-open-ran-on-the-telecoms-ecosystem-40208/.

Figure 17: MNOs' approaches to applying AI/ML within the RIC platform



Question: "Where do you intend to apply AI/ML in the RIC?"; (*n* = 35).

Source: Analysys Mason

A third of MNOs selected a common platform approach in which AI/ML capabilities will be reused across the near-RT and non-RT RIC. This is the most broad and flexible approach, and is in line with the move away from specialized, siloed network analytics towards a common platform that supports an ever-changing variety of capabilities, applications, and behaviors. Similarly, just under a third selected a hierarchical approach with common capabilities applied across the RIC platform and separate, more granular capabilities across the rApps and xApps.

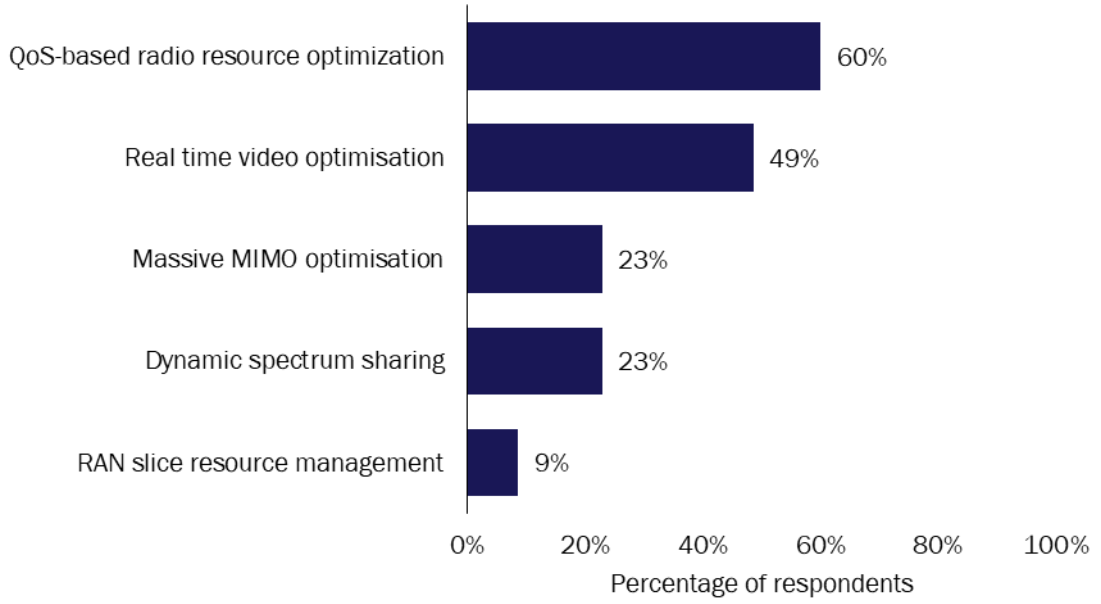
Alternatively, a third of MNOs opted for specialized AI/ML capabilities, with specific features embedded within the near-RT and non-RT RIC, or even embedded within individual xApps and rApps. This would limit the ability to view and control all network functions in a holistic way and make it harder to extend the capabilities in future.

5.2 MNOs are prioritizing the use of AI/ML for network optimization use cases

As with the implementation of the RIC overall, the focus is clearly on delivering the best customer experience over a range of applications. 60% of MNOs are prioritizing AI/ML to better manage RAN resources ensuring that the network delivers a superior QoS (see Figure 18). Other top use cases all relate to enhancing different enablers of QoE, such as real-time video, massive MIMO optimization, and dynamic spectrum sharing.

There are some differences of emphasis in terms of AI/ML support, compared to the use case priorities for the RIC overall (see Figure 11). Given the complexity of some of these use cases, such as massive MIMO, MNOs will certainly prioritize the use of AI/ML in the future when both Open RAN and the RIC are more mature and have been applied at scale. This result shows that MNOs recognize that the radio QoS is the use case where AI/ML may have the greatest immediate effect.

Figure 18: MNOs' top five near-RT RIC use cases for implementing AI/ML



Question: "Which of these Near Real Time use cases do you plan to apply AI/ML technology to?"' (*n* = 35) [multiple choice].

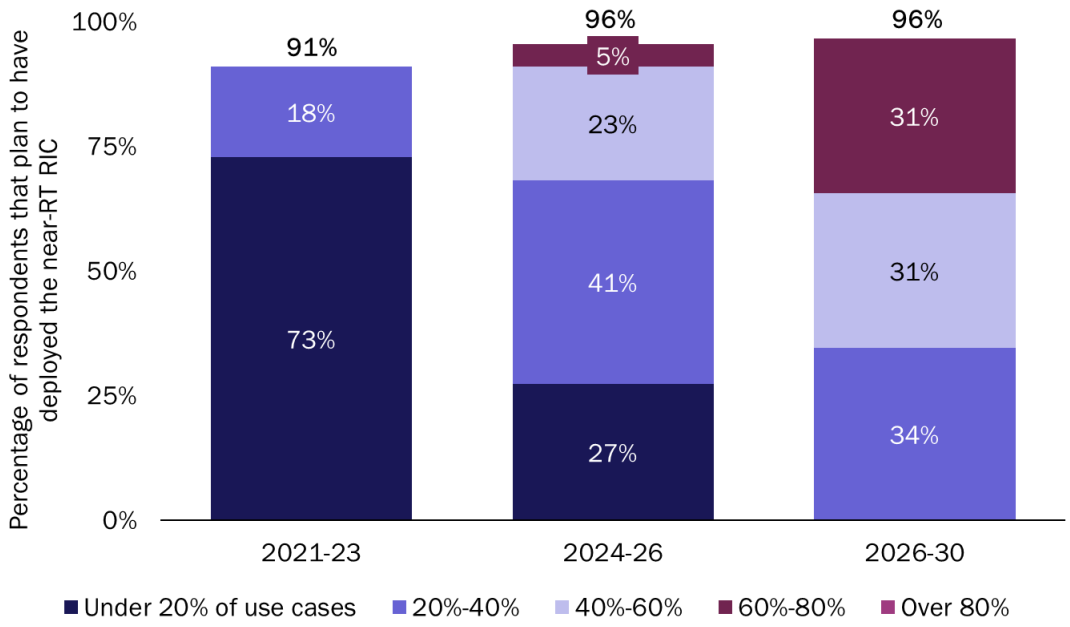
Source: Analysys Mason

Extent of application of AI/ML in near-RT RIC

MNOs appear to have aligned their plans to implement AI/ML to coincide with the deployment timelines for near-RT. 91% of MNOs that are planning to deploy the near-RT RIC during 2021–2023 expect to also implement AI/ML in some of their use cases within the same period (see Figure 19). These are the ambitious MNOs with early first deployments of the near-RT RIC during 2021–2023, but the trend continues until 2030. 96% of MNOs that are planning to deploy the near-RT RIC by 2026 foresee implementing AI/ML as well, and an equal number for all deployments by 2030. Analysys Mason's research suggests that AI/ML technology will be even more critical for use cases such as massive MIMO, which may include thousands of parameters to configure for optimization.

The plans and timescales to deploy the near-real time RIC are probably more concrete in MNOs' minds than for the application of AI/ML, suggesting that early adopters of the RIC may add AI/ML capabilities later. The first near-RT RIC deployments may only implement AI/ML in a small set of use cases; 73% of MNOs with plans to deploy the near-RT RIC by 2021–2023 may only implement AI/ML to 20% of use cases. MNOs will probably start slowly, and test and trial few AI/ML applications with prioritized use cases where they expect to see the most benefit from the technology. However, it is clear that as AI/ML applications are more broadly tried and tested, and the benefits become more apparent, MNOs foresee applying more AI/ML (see Figure 19). A third of MNOs expect to implement AI/ML in most of their use cases by 2026–2030.

Figure 19: Level of implementation of AI/ML to near-RT use cases among MNOs that plan to have deployed the near-RT RIC, by time period



Question: "To what extent of use cases do you foresee applying AI/ML in the near-RT RIC?; (2021–2023: *n* = 11, 2024–2026: *n* = 22, 2026–2030: *n* = 29). Respondents that suggested no AI/ML implantation are not shown (that is, 9% during 2021–2023).

Source: Analysys Mason

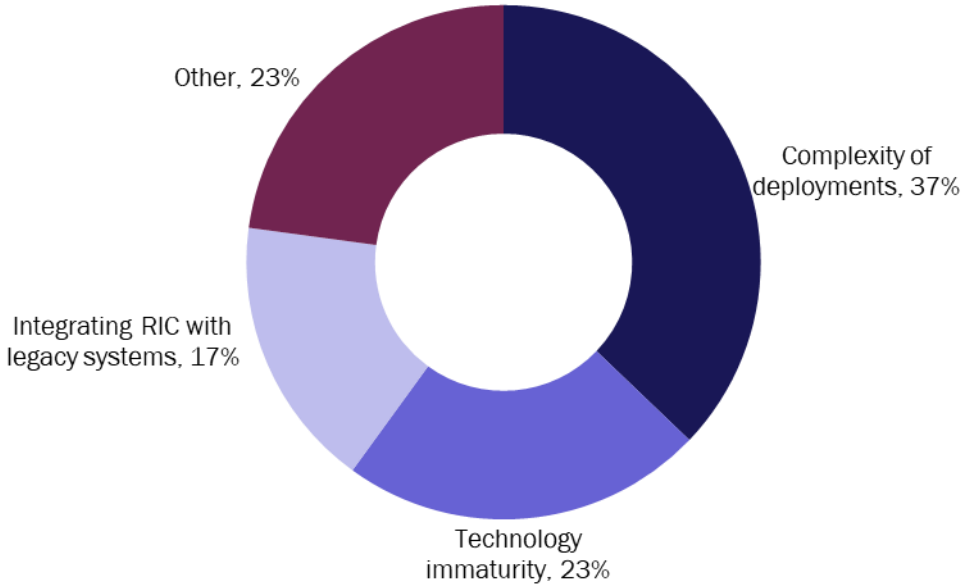
In the following section, we discuss the value of ecosystems and explain the role of TIP's RIA subgroup in bringing the near RT RIC use cases to reality.

6. Ecosystems can help to overcome the challenges of commercializing the RIC

Any new and disruptive technology comes with risks and uncertainties, and despite MNOs' enthusiasm about adopting the RIC, they are also aware of the challenges. Accounting for two thirds of the TCO of a mobile network and directly affecting the user experience, any disruption to the RAN carries a significant risk to an MNO's business.

Three-quarters of the MNOs selected the same three challenges as being the most severe, but no single challenge was selected by a clear majority of MNOs (see Figure 20). The complexity of deploying the near-RT RIC was commonly listed as the most severe challenge by 37% of MNOs. This complexity is a result of the new disaggregated RAN, which will be controlled and managed by a novel RIC architecture. Success will depend on the ease with which the near-RT RIC solutions can interwork with multi-vendor RAN components and deliver at least the same level of performance as existing RAN systems.

Figure 20: The most severe challenges to deploying the near-RT RIC as selected by MNOs



Question: "What do you believe will be the main challenges to deploy the RIC?"; (*n* = 35).

Other includes challenges that are relevant to systems integration include a lack of unified standards, lack of clarity on use cases, lack of backing from major vendors and a shortage in skills. No single challenge was selected by more than 10% of MNOs.

Source: Analysys Mason

Technology immaturity was chosen as the next most severe challenge by 23% of MNOs and reflects the fact that the industry is still in the early stages of developing a commercial grade near-RT RIC solution. Standardization efforts are progressing at a rapid pace with a high level of commitment from leading MNOs, telecoms software vendors, systems integrators, both established and new RAN vendors. The key stakeholders are confident that the technology will mature in the next 3 years, but they also accept that maintaining a high

level of interest during this period will require sustained investment and commitment from all the key industry players.

MNOs may have ranked other challenges less severe due to a generally high level of optimism and confidence that industry organizations such as TIP will be able to achieve consensus and progress in driving standardization, accelerating the deployment of use cases, and engaging the major vendors.

However, additional research also suggested that MNOs expect Open RAN to outperform the traditional RAN systems if these key challenges are overcome. MNOs expect that a well-engineered RIC in combination with AI/ML and xApps/rApps will not only compensate for any low performance of the RAN components but also deliver highly superior overall performance of Open RAN with fine-grain programmatic control and extreme automation that is not possible in current RAN systems. However, MNOs know that they cannot do it alone and that the industry will need deep collaboration among the key stakeholders.

A broad, co-operative ecosystem has a significant role to play in tackling these challenges and achieving the goals of Open RAN and RIC. Technology maturity, standards, use case development and commercialization will be most effectively achieved if all the stakeholders commit to working together. The more players that co-operate in this process, the more quickly unified, carrier-grade solutions will emerge, which will in turn give established and new vendors, and MNOs, the confidence to accelerate adoption. That will result in a wide variety of products, services and use cases to enhance the overall business case for MNOs and provide a wide choice of partners.

The ecosystem will also help to reduce complexity of deployment by ensuring that all elements are interoperable, which will reduce integration overheads. When stakeholders work together to run proof-of-concept trials, testbeds and interoperability tests, deployment challenges are collectively addressed, and best practices are established to reduce risks and accelerate the implementation for all MNOs. Knowledge sharing, particularly with incumbent MNOs that have experience of deploying and operating networks, will be essential for open technologies to achieve scale quickly and address the whole spectrum of MNOs' requirements for 5G services.

TIP's RIA subgroup is engaging a range of Open RAN industry stakeholders, including MNOs, vendors, new entrants, and academic institutions, among others, to collaboratively develop Open RAN and overcome the above challenges. Furthermore, a broad and diverse ecosystem will be essential for accelerating innovation and deployment. Industry bodies such as the ONF, O-RAN and TIP are all driving open standards to accelerate the commercialization of the RIC. By opening the ecosystem to smaller, niche partners and start-ups, all stakeholders will benefit from accelerated innovation.

7. Conclusions

- **MNOs are looking to Open RAN to take control of the 5G network** by transitioning away from the traditional single vendor RAN systems to a more flexible open network that allows them to deploy a 'best-of-breed' multi-vendor RAN that complies with open specifications. MNOs, including high-profile Tier 1s, are already engaging in Open RAN forums to define and standardize it because vRAN alone will not sufficiently diversify the supply chain. 46% of MNOs in our survey are already actively engaged with Open RAN and 40% are planning or evaluating it. The RIC is necessary to operationalize Open RAN, with 54% of MNOs planning to use it for some or all Open RAN use cases and 60% planning a deployment by 2026; no MNOs suggested that the RIC was not important for virtual or Open RANs.

- **Extreme automation of the Open RAN is essential** for MNOs to achieve the goal of significantly reducing the TCO of open 5G networks. This goal of TCO reduction was the most cited for deploying the RIC (37% of MNOs), and for deploying the near-RT RIC (40% of MNOs). MNOs believe that the new control and management architecture embodied by the RIC is going to be foundational for achieving the high levels of automation and for providing fine-grained, use-case-driven control and management of RAN resources. From the near-RT RIC perspective, MNOs are prioritizing real-time video and QoS-based optimization to deliver immediate benefits and set the stage for predictive and autonomous RAN in the future. The near-RT RIC use cases will be powered with AI/ML; more than two-thirds of MNOs expect improvements of over 20% in service flexibility, customer experience and network efficiency by implementing AI/ML. MNOs recognize that AI/ML will be critical for the near-RT RIC use cases; over 96% of them expect to implement AI/ML in some of the near-RT RIC use cases by 2026.

- **Ecosystem collaboration, control and governance is critical to accelerate the commercialization of near-RT RIC, and the broader Open RAN and RIC.** Interoperability is central to the challenges MNOs face to deploy the near-RT RIC, given the level of integration required for multi-vendor environments. For Open RAN and the near-RT RIC, deep ecosystem collaboration is necessary to define standards and commercialize use cases. The O-RAN Alliance, TIP and other bodies allow MNOs to partner with established and new vendors, developer communities and academic institutions, to define and proliferate the technology that will ultimately control the networks. The governance of the processes that underpin these efforts is essential to ensure that the near-RT RIC and the RIC in general is fit for purpose and delivers capabilities in a timely manner, which is critical to accelerate adoption and commercialization.

8. About the authors

Anil Rao (Research Director) is the lead analyst on network and service automation research that includes the *Network Automation and Orchestration*, *Automated Assurance* and *Service Design and Orchestration* research programmes, covering a broad range of topics on the existing and new-age operational systems that will power operators' digital transformations. His main areas of focus include service creation, provisioning, and service operations in NFV/SDN-based networks, 5G, IoT and edge clouds; the use of analytics, ML and AI to increase operations efficiency and agility; and the broader imperatives around operations automation and zero touch networks. In addition to producing both quantitative and qualitative research for both programmes, Anil also works with clients on a range of consulting engagements such as strategy assessment and advisory, market sizing, competitive analysis and market positioning, and marketing support through thought leadership collateral.

Caroline Gabriel (Research Director) leads Analysys Mason's *Operator Investment Strategies* programme, and leads many 5G-related research activities across multiple programmes. She is responsible for building and running Analysys Mason's unique research base of mobile and converged operators worldwide. She works directly with Analysys Mason's research clients to advise them on wireless network trends and market developments. She has been engaged in technology analysis, research, and consulting for 30 years, and has focused entirely on mobile and wireless since 2002. Her focus is on critical issues and trends related to mobile and wireless infrastructure, particularly operator deployment intentions for 4G, 5G, cloud-RAN and other technologies.

Roberto Kompany (Senior Analyst) is a member of Analysys Mason's Telecoms Software and Networks research team and is the lead analyst for the *Next-Generation Wireless Networks* programme focusing on strategy and market research. He is also a Cambridge Wireless Special Interest Group (SIG) mobile broadband champion. Prior to joining Analysys Mason, Roberto worked for Dixons Carphone, where he analyzed the effect on the business of shifts in the telecoms market – for example, in terms of mergers, operator KPIs and technology – in Europe and the UK. Previous positions included consultancy, where he helped a variety of clients worldwide with mobile-related projects, such as a capex reduction and developing a 5-year strategy for an incumbent's wireless infrastructure.

Andrew Killeen (Consultant) has worked with a wide range of clients worldwide, including network operators, vendors, and industry bodies. His work focuses on using market analysis, sizing and forecasting, and competitive benchmarking to inform clients' planning and strategy. His project experience has ranged from 5G and the internet of things to virtualization, cloud technologies and machine learning. Much of Andrew's work has used original, international research, including expert interviews and consumer and enterprise surveys.

This perspective was commissioned by the TIP RIA working group. Analysys Mason does not endorse the group's products, services, or market proposition.