



**Moving to Open RAN
– The time is now**

Introduction

The introduction of Open RAN represents the biggest shift in radio access architecture we have seen during the last two decades. Network disaggregation and virtualization, with separation of control and user planes breaks apart the monolithic technology implementations which have been the basis of network design since the advent of mobile telephony.

We have seen similar shifts in other industries, such as when the app ecosystem broke down the integrated carriers' ownership of customer relations, when the introduction of operating systems in the early 90s separated software from hardware, when the advent of open source exploded developer ecosystems in the 2000, or when a decade later the virtualization of the IT stack lowered the barriers to entry for software services. Historically, in all these cases, systems costs and prices for consumers went down, and innovation followed.

Open RAN comes with the same great promise. Its promoters claim lower costs, scalability, faster and greater innovation, shorter lead times for deployment of new services, unprecedented flexibility in network deployment, and enablement of use cases that would otherwise not be possible.

At the same time, its opponents question whether the cost savings are real, claiming they will largely be eaten up by increased system integration costs, and highlight that increased complexity could lead to longer deployment times, as well as introduce network disruptions risks.

These differing points of view bred a certain degree of confusion among the operator community, leading to questions as to whether Open RAN is ready for mass market deployment. Is it time to deploy Open RAN now or should you wait and see?

In this white paper we try to answer these questions, build on our previous papers¹, and give an overview of the technical details of Open RAN. The conclusions in this document are based on our own technology research and development, and our discussions with operators around the globe.

Our findings are that there are merits to both sides of the argument. In summary:

- Open RAN lowers network total cost of ownership (TCO) on average of ~25% (~30% in the long run without initial deployment costs) compared to a legacy RAN setup (depending on the current network setup)
- Open RAN enables faster adoption of new services and new use cases, but only if the operator deploying Open RAN is properly set up to pursue them
- There are risks related to Open RAN deployment – potential disruption from an ill-conceived deployment and potential cost increases for system integration
- These downsides can be managed by operators through careful choices, i.e.,
 - Selecting interoperable components
 - Choosing partners with proven deployment track record
 - Structuring vendor agreements holistically to achieve the same accountability as in a single-provider system

¹ Open & Virtualized RAN – The Future of Radio (published in February 2020) and Building an Open vRAN Ecosystem (published in September 2020)

5G leads to a new industry imperative for cost and innovation

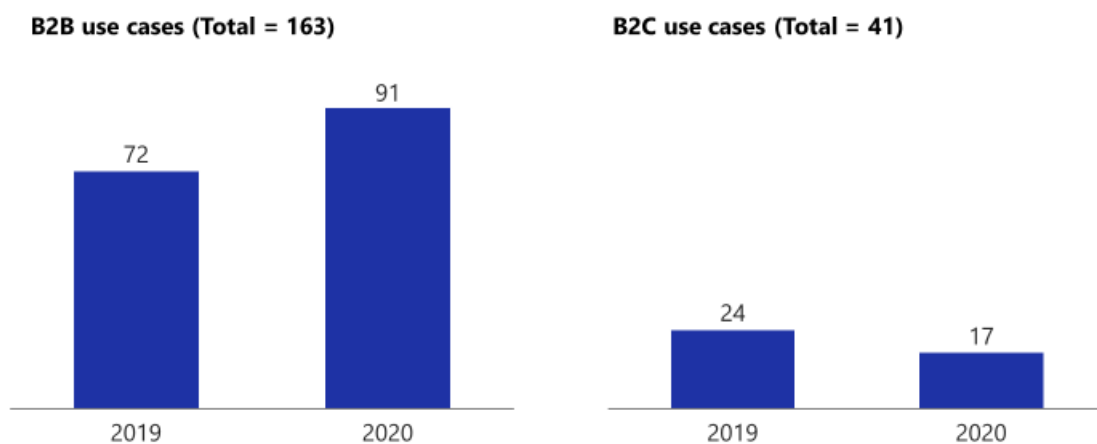
The telecom industry has been under continuous pressure over the last decade with their average revenue per user (ARPU) decreasing and the need to pursue new business models as the source of monetization to return its weighted average cost of capital².

Additionally, the mobile industry is facing unprecedented Capital Expenditure (CapEx) associated with the deployment of 5G. GSMA estimates a total of ~USD 1 trillion will be spent by the industry between 2021-25³. This is to be taken in a context where 4G rollouts did not generate the revenue uplift operators were expecting with revenues stagnating since 2015⁴.

In face of these historical developments, many operators are betting on revenue sources from new use cases to justify their 5G investments. Omdia's 2019 5G World Series Market survey indicates that only 25% of operators see B2C as having the potential to be the biggest driver of 5G revenue growth, while 57% see B2B and B2B2X having the most revenue potential⁵. In addition, operators have developed 3-5x more B2B use cases than B2C use cases in the past two years [Exhibit I].

Exhibit I

5G operator use cases by category (2019 - 2020)



Source: Publicly available reports of 30 MNOs (incl. AT&T, BT, Deutsche Telekom, Etisalat, KPN, KT, LG U+, Orange, Saudi Telecom, SKT, Telefonica, Telenor, Telia, Telstra, TIM, Verizon, Zain, etc.)

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The exact nature of these use cases is still unknown, just as they have always been. 3G was supposed to bring on an era of wide-spread video-calling – it did not, rather it was 4G that did. 3G did, however, bring us the iPhone, creating the notion of applications and the modern mobile devices as we know them.

² A blueprint for telecom's critical reinvention. McKinsey & Company. April 2021

³ GSMA: The Mobile Economy 2021

⁴ GSMA: The Mobile Economy 2016-21

⁵ OMDIA: Monetization in the era of 5G

What we do know is that these new use cases are likely to rely more heavily on network features (e.g., slicing for prioritization of corporate users or computing capabilities at the edge to support next generation gaming). Furthermore, winners will not be the operators with the best foresight but will be the ones fastest to adapt once it manifests.

However, even with the most optimistic projections, bringing industry economics back to a level acceptable by capital markets must also come with a **substantial reduction of network costs**.

Open RAN is the only currently viable option for achieving both objectives: acceleration of revenue generating use-case deployment as well as a step-change in the cost structure required to provide them.

Open RAN is a critical enabler of the 5G innovation promise

Open RAN changes the nature of how networks are designed, built, and procured. Instead of relying on one vendor for end-to-end provisioning, customers have the option to choose multiple best-of-breed or fit-for-purpose vendors for different parts of the network. This also means that operators can swap out individual components without having to replace the entire network. When coupled with virtualized Radio Access Network (vRAN), the barrier to switching gets even lower as costly in-field replacement of equipment is replaced by automated software deployment on common hardware.

On top of this, Open RAN combined with vRAN allows for a new type of vendors to enter the game – highly innovative players that can provide specialized solutions for specific use cases, but who do not have the desire to compete on general contracts requiring the provisioning of the whole network.

The nature of these changes makes Open RAN so much more suitable than traditional networks for delivering the imperatives associated with operators – being able to create and deploy use cases customers come to demand at the time they do so.

Specifically:

- **Network based functionality:** Although some of the network features that are meant to enable the new revenue-generating use cases are standardized (e.g., 3GPP), many are yet to be defined. Pre-defined protocols do not fully cover what will be required by application developers at the edge of innovation, just as the rudimentary architecture of the original iPhone APIs did not allow for most of the features we now take for granted in our applications.

Different vendors have different roadmaps, but no one can say with confidence what will be critical come a year or two from now when application development starts to take off. The best hedge against this uncertainty is to have a network setup that allows swapping vendors in and out based on their ability to fulfill the requirements of players that develop the services. Open RAN allows for this, while a traditional integrated network does not.

- **A higher pace of innovation:** Matching the pace of market innovation has always been a challenge for operators. The fundamental driver of this is that software evolves faster than hardware, and all traditional Telco innovation has been intimately tied to hardware. Through the experiences over the past decade, we are confronted by the fact that keeping the pace of front-end innovation must be supported by

software-based solutions that can be upgraded with the touch of a button, rather than deploying a small army of field technicians. It is very difficult to imagine a situation where an operator could truly benefit from the innovation of small startup companies if the prerequisites for their solutions would be to replace the whole system. The horizontal disaggregation is a key enabler for vRAN to give the industry the flexibility it needs. Open RAN allows vendors to focus exclusively on part of the RAN solution rather than having to develop the whole. This uniquely favors the emergence of specialist vendors.

Open RAN is the most viable way to materially cut industry costs

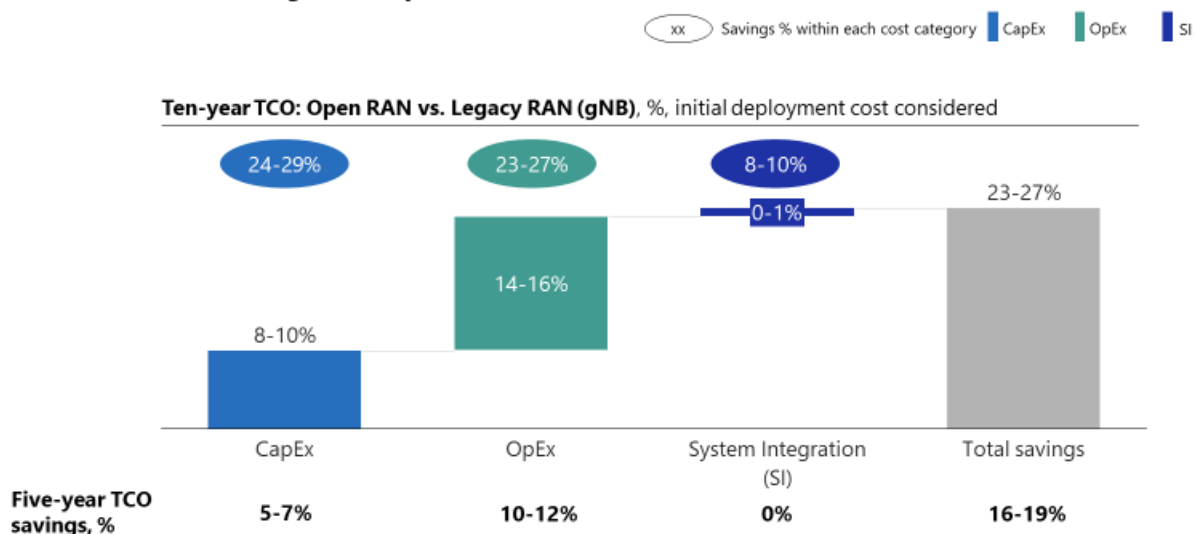
Although most operators would agree with the statements above about the need for innovation and an infrastructure that allows it, the exact level of priority could differ. When it comes to cost, however, one would be hard-pressed to find an operator that would disagree that the CapEx requirements they are facing for the continued 5G roll-out would be a strain. Reducing this cost is a must to bring the industry back to levels of profitability that can sustain growth/innovation. This might be the most important benefit Open RAN brings – a fundamental shift in the cost structure of the entire industry.

We have explored the cost impact of Open RAN both from a techno-economical point of view, building TCO-models based on the few past deployments, as well as surveying industry executives. The outcomes are unanimous and the conclusions incontrovertible. Open RAN lowers cost substantially.

The exact savings vary by operator depending on local factors such as availability of fiber, current front-haul capacity, price level for RAN hardware/software, and network performance requirements; under all circumstances, costs are lower. Our modelling puts TCO reductions over a ten-year period at 23-27% depending on the starting point. Most of the absolute savings come from Operating Expenses (OpEx) and the savings increase over time [Exhibit II].

Exhibit II

Cumulative TCO savings with Open RAN, % (Net cashflow basis)

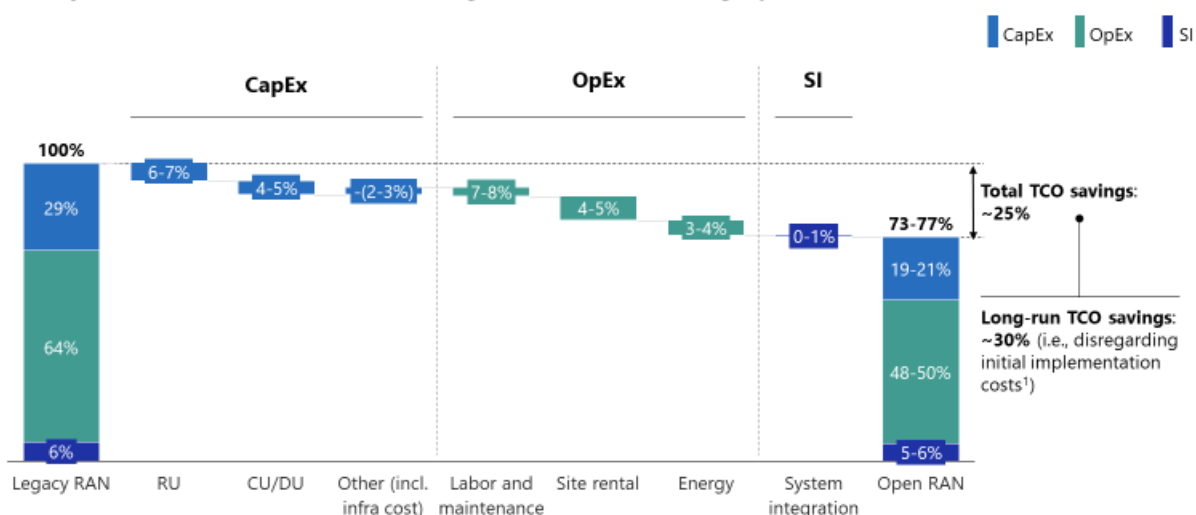


Source: NEC Open RAN TCO analysis

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Ten-year cumulative TCO with savings breakdown, % (Legacy RAN as 100%)



1. ~5% implementation cost is comprised of Infrastructure investment cost (2-3%), Energy cost (~1%), and System integration cost (~1%)

Source: NEC Open RAN TCO analysis

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There are multiple sources of savings [Exhibit III] and they can be split into three categories:

1. **CapEx**

Cost savings from increased competition: It is a well-observed phenomenon that prices for network equipment are significantly higher in markets with fewer players competing (up to 30% in a two-players vs. three-players market). Considering that Open RAN increases competition from two or three to a dozen, we conservatively assumed a 30% lower CapEx for Radio Units (RUs; a more standardized product) and ~15% in the Distributed Units (DUs)/Centralized Units (CUs) layer over time.

Connectivity fit for purpose: As Open RAN shifts computing from locally deployed gNBs to more centralized DUs/CUs, compute capacity can be optimized to meet requirements in areas with less performance demand (e.g., rural) without affecting capability (depending on fiber front-haul availability). As a result, cost for DUs/CUs (i.e., BBUs for Legacy RAN) will decrease. For a typical developed Western Europe operator, a cost reduction of 30% in rural/semi-rural areas is expected.

Sharing of compute capacity: The main driver of network compute capacity requirements is not average, but peak capacity for each area. Shifting computing to CUs/data centers and placing them in servers shared by other areas, whether in the cloud or locally shared server farms, allows operators to pool capacity among different areas whose peaks are at different times of the day. In addition to that, in longer term of 2-3 years Open RAN will enable cross-industry capacity sharing even for cellular network. Doing so removes redundancy in the system that is currently priced in by vendors. The actual cost savings depends on the location of the server and presence of industries with complementary capacity needs. Cost savings is expected to be 5-20% compared to current baseline DUs/CUs costs.

Synergies with edge computing: As demands for applications relying on processing ‘at the edge’ grow, so will the need for computing among these instances. Open RAN opens the door to the same ‘cloudification’ that we have seen in the core to take place closer to the edge too, allowing the industry to capitalize on the scale benefits specialized players can provide. Although this is the most speculative

among the levers presented in this paper as processing requirements at the edge are difficult to forecast, our best assessment put savings at 5-20% for DUs/CUs in the longer-term.

2. OpEx

Energy: In the very short-term, Open RAN deployment might raise energy costs by up to 10% (in a typical developed market) as the optimization point is set at higher traffic levels than we what are seeing today. Once traffic grows and scale is achieved, energy costs should fall to 20% below comparable Legacy RAN solution.

Site rentals: Open RAN equipment has smaller on-site footprint, as most of the computing is centralized at the DUs/CUs, leading to lower site-rentals. Open RAN vendors are also developing RAN solutions with smaller form factors to enable RAN with less space required. This is especially true for operators that are densifying their network to raise capacity. We believe a 20% site rental reduction is achievable on average.

Site maintenance: Open RAN (in combination with vRAN) promotes higher level of virtualization, and simplification of hardware deployed at site. This enables automated zero touch software upgrade to reduce site visit frequency, cost for forklift upgrades, and hardware maintenance. As a result, we expect ~20% savings for site maintenance.

3. System integration (SI)

There is no denying that SI costs will increase (as much as 25%) during the first phase of Open RAN deployment. The initial setup will involve integrating new components in a novel way with complexities that naturally follow.

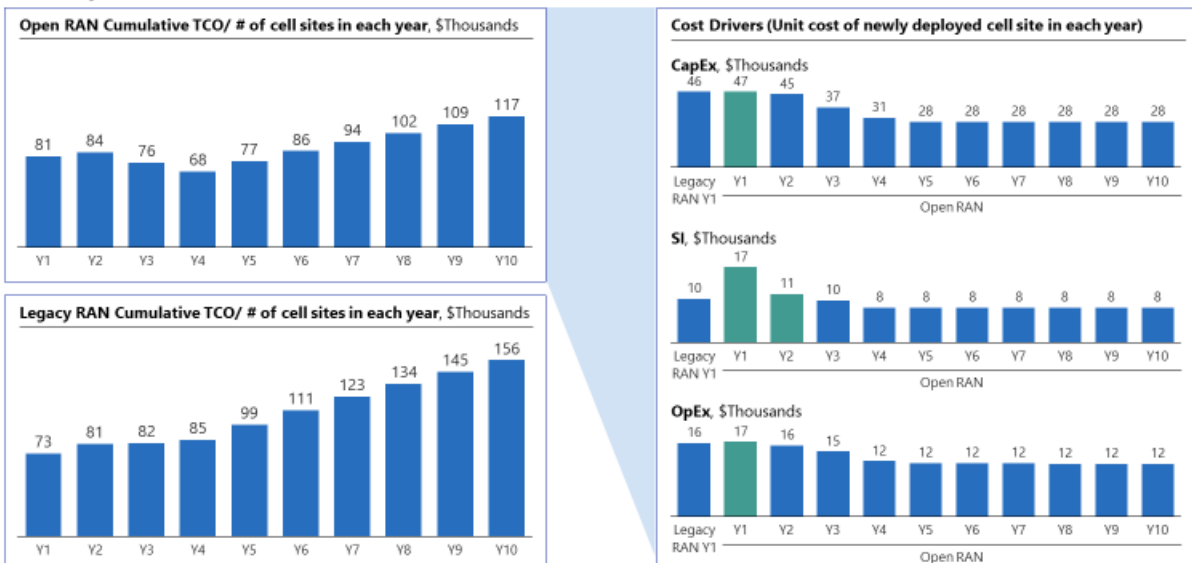
However, we expect this to fall to 10% below initial levels in the first five years as standardization sets in and components are swapped, following the precedent of many standardized common interface systems [Exhibit IV].

Our modelling is based on experiences and measurements from actual deployments in the real world. We have also turned to industry executives to verify the cost savings expected. The average cost savings from 33 operator executives with marketing/engineering background land at 25% and some believe higher savings percentages [Exhibit V]. It could be due to a skew in the panel towards traditional developed markets, as opposed to an average global operator. This resulted in the panel having higher confidence in Open RAN, all planning to deploy Open RAN by 2030, and having more visibility on detailed cost reduction potential.

Our industry survey of experienced professionals indicated savings levers similar to our modelling [Exhibit VI], with the lower prices stemming from increased number of suppliers as the number one driver, followed by sharing of compute capacity and other sources of savings that we have yet to fully account for (i.e., network automation potential).

Ten-year cumulative TCO, \$Thousands

■ Comparable cost increase



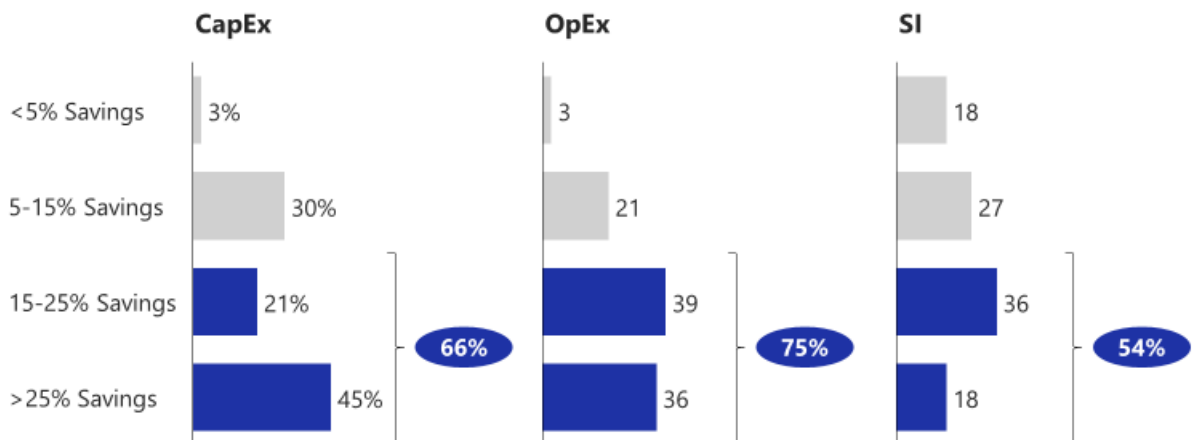
Source: NEC Open RAN TCO analysis
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Estimates on ten-year Open RAN TCO savings % compared to Legacy RAN

% of respondents (n = 33)

■ % of savings equal or higher than NEC's TCO modeling projections
■ % of savings lower than NEC's TCO modelling projections



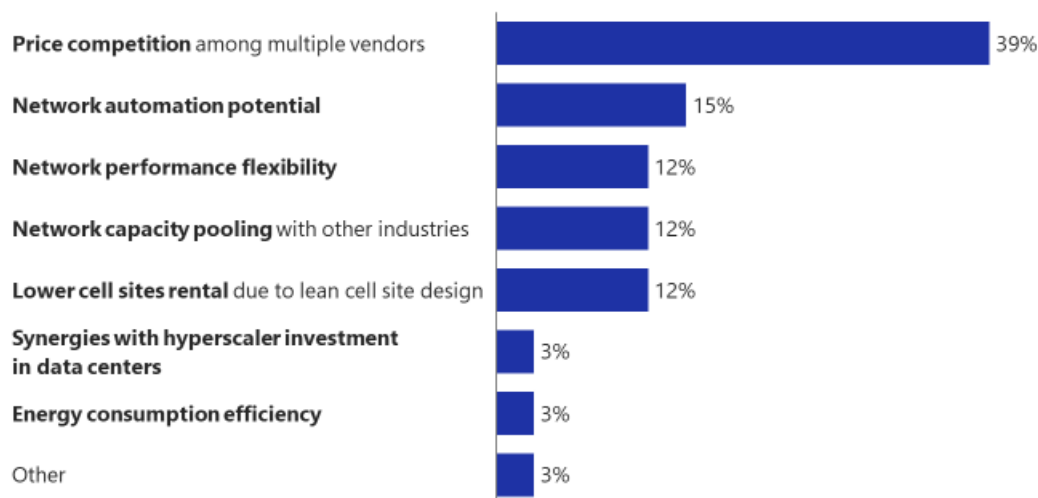
Source: NEC Telco CXO Open RAN survey 2021 with 33 current and recent past CXOs from North America, Latin America, Middle East and Africa, Asia and Oceania

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What is the top key driver for TCO reduction from Open RAN?

% of responses (n = 33)



Source: NEC Telco CXD Open RAN survey 2021 with 33 current and recent past CXDs from North America, Latin America, Middle East and Africa, Asia and Oceania

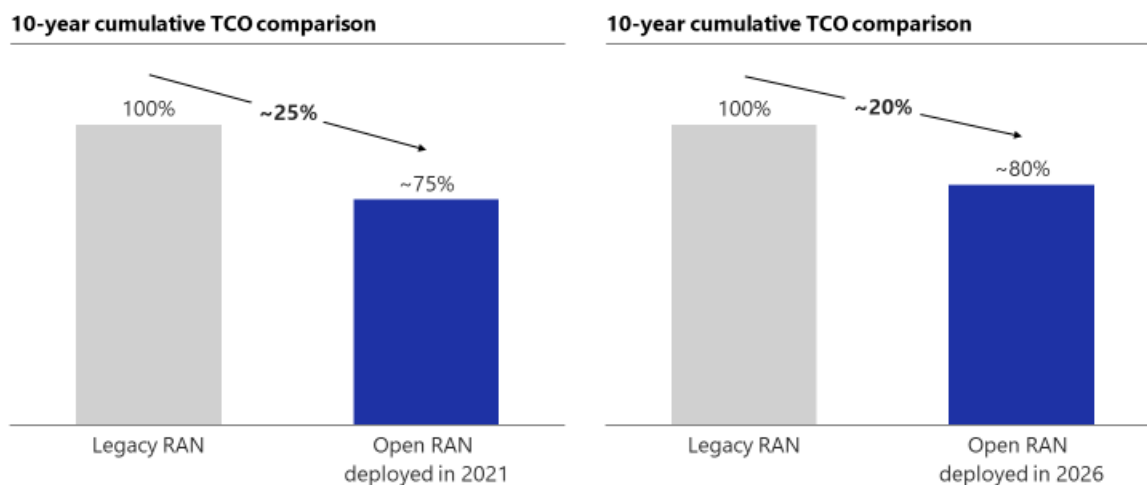
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Orchestrating a brighter world **NEC****Early adopters of Open RAN have considerable benefits**

Even among operators that firmly believe in the Open RAN concept for the long term, some are hesitant to make the move today. Their arguments carry merit. Questions about whether it is better to wait for it to mature further are perfectly reasonable, so do considerations around how to think about Open RAN upgrades given the existing technology and migration roadmaps.

However, there are strong reasons to make the move as soon as possible, given the realities of procurement cycles. The most predominant reason is cost. Our Open RAN TCO modelling shows that operators that move to Open RAN now save five percentage points (20% more in TCO reduction) more on TCO over the next ten-year period compared to those who wait five years (~25% TCO cost saving vs. ~20%) [Exhibit VII].

Ten-year cumulative TCO with savings breakdown, % (Legacy RAN as 100%)



Source: NEC Open RAN TCO analysis

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The second reason is to avoid another cycle of vendor lock-in. Signing up to a new Single-RAN solution will inevitably hamstring choices well beyond a point where Open RAN is fully proven and is becoming widely adopted. Furthermore, future network developments (e.g., 6G) all point in the direction of open interfaces and Open RAN, as it becomes the *de facto* standard, will serve as a basis for these future specifications.

The commitment from operators is real – Open RAN will become the new normal

The support behind Open RAN is massive among the operator community. In Japan, NTT DOCOMO is making it the centerpiece of their network architecture for the future and Rakuten Mobile, with their greenfield network, has achieved previously unheard-of cost-savings from its benefits.

The phenomenon is not limited to Japan. Although at smaller scale, leading operators (e.g., Telefonica, Vodafone, and Deutsche Telekom) are already pursuing deployments. The list grows further if we add the operators that are pursuing trials. [Exhibit VIII]

Exhibit VIII

Open RAN adoption globally as of 2021¹

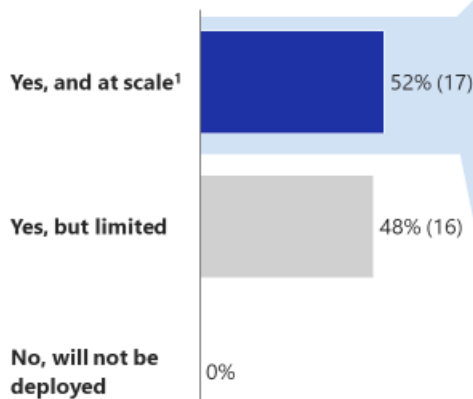


Among the Telco executives we have surveyed, all of them believes that Open RAN will be an integral part of their network, with more than half expecting these deployments to be 'at scale' (i.e., comparable in magnitude to current single-RAN setups) [Exhibit IX]. This is reflected in operators' plans. For Open RAN adoption on a limited basis, majority (~60%) are likely to adopt in a year. Even for Open RAN deployment at scale (i.e., covering <20% of RAN CapEx), ~60% of operators are planning for implementation by 2024 [Exhibit X].

Exhibit IX

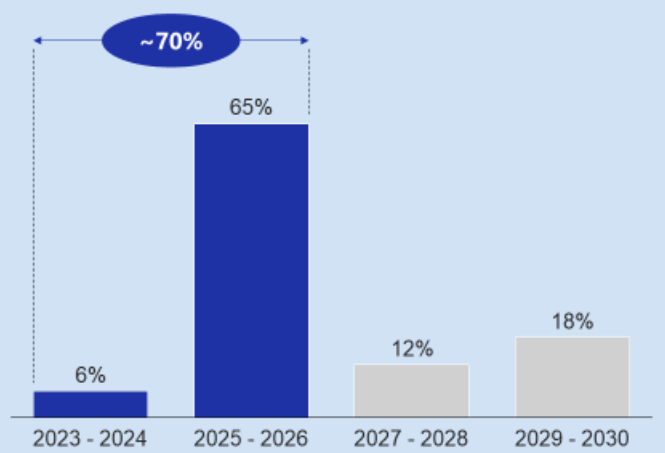
How will Open RAN be deployed globally?

% of respondents (n = 33)



If you believe in Open RAN deployment at scale, when will Open RAN be deployed at scale?

% of respondents (n = 17)

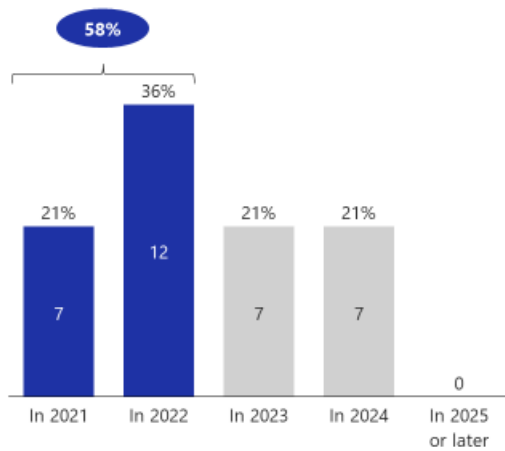


¹ Comparable in magnitude to current single-RAN setups. Source: NEC Telco CXO Open RAN survey 2021 with 33 current and recent past CXOs from North America, Latin America, Middle East and Africa, Asia and Oceania. © NEC Corporation 2021

Exhibit X

When is your telco likely to adopt Open RAN on a limited basis?

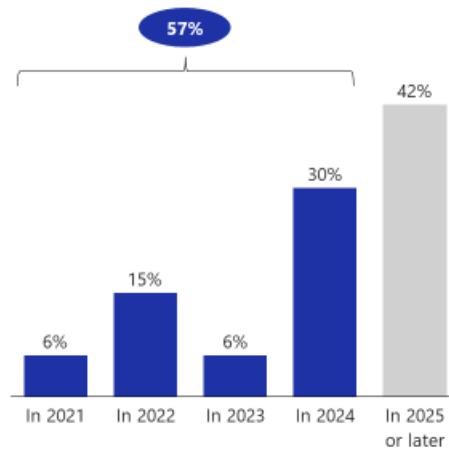
% of responses (n = 33)



1. To cover certain portion of actual commercial use (i.e., <20% of RAN CAPEX)
 Source: NEC Telco CXO Open RAN survey 2021 with 33 current and recent past CXOs from North America, Latin America, Middle East and Africa, Asia, Australia and New Zealand
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When is your telco likely to deploy Open RAN at scale¹?

% of responses (n = 33)

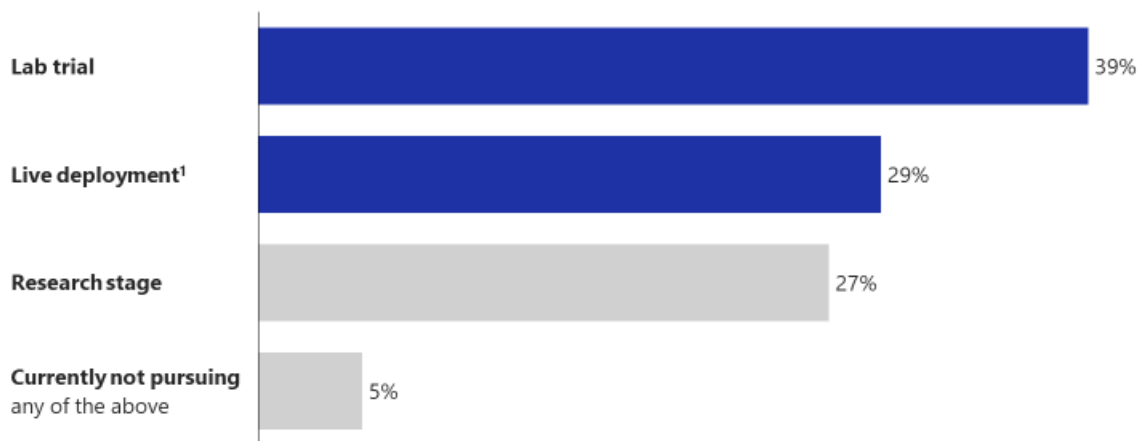


Around a third of surveyed Telco executives are conducting live deployments. Another ~40% are preparing for Open RAN deployment as they are currently are conducting lab trials [Exhibit XI]

Exhibit XI

What is the level of your current progress in Open RAN adoption?

% of respondents (n = 33)



1. Live deployment includes field trial, small scale and large scale deployment
 Source: NEC Telco CXO Open RAN survey 2021 with 33 current and recent past CXOs from North America, Latin America, Middle East and Africa, Asia and Oceania
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Furthermore, almost every industry body that is shaping the future of the industry is endorsing Open RAN (e.g., 3GPP, O-RAN Alliance, Open Networking Foundation, ETSI, Telecom Infra Project). The role of these industry bodies builds the foundation for Open RAN deployment, including promoting compatibility between 4G & 5G and compatibility among different vendors. Telco executives also believe that the success of Open RAN will be boosted by the progress made by these stakeholders.

Some will say that Open RAN is immature, as it is preempting industry standards yet to be defined under the structures governed by GSMA. This is intimately linked to the nature of Open RAN. It is not an idea conceived

by the equipment vendors, as it is not necessarily to their benefit. It is an idea that has come into existence as a response to requirements from *operators*; a technical solution to address their needs in a time of economic hardship, where a solution is required earlier than the natural process of our industry standard bodies would allow.

Many issues with Open RAN have been raised – some true, some exaggerated

With the emergence of Open RAN threatening the legacy telco model, some arguments (or myth and speculation) about Open RAN are raised in the industry. Some of these arguments are valid, some of them less so. Our response to some of the more commonly aired critical statements regarding Open RAN are as follows.

- *“Open RAN may not be interoperable with legacy functions and different RAN vendors”*

Firstly, there are already emerging *de facto* standards in place following the deployments made. Standardization will be more likely with more operators adopting Open RAN.

Secondly, the O-RAN Alliance, 3GPP and the leaders of the industry are collaborating to set compatible standards that provide unified guidelines for interoperability.

Thirdly, all parties that participate, or aim to do so, are continuously interconnecting to assure interfaces work cross vendors. It is clearly in their interest to do so, as Open RAN, on which they are betting their investments, would not work without it.

Fourthly, and most importantly, Open RAN standardization will be completed because a large enough group of operators are in demand and taking the initiative to make it a reality (e.g., Memorandum of Understanding signatories of Telecom Infra Project, incl. Deutsche Telekom, Orange, Telefonica, TIM, and Vodafone). The Telco industry has always provided standard to realize what operators desire, as long as the demand was high enough.

- *“Open RAN may introduce security risks as it requires new nodes and interfaces that can be exploited in cyber-attacks. Also, Open RAN will be composed of components from many vendors with various countries of origin, adding to security concerns”*

Firstly, contrary to current integrated solutions, Open RAN will allow for unlimited testing, with specific requirements, for each individual component. There will be testing labs to secure interoperability; any customer with specific concerns can add those to the test-suite and be assured the problems are addressed on a component level.

Secondly, most currently integrated solutions rely on hardware or software components produced by sub-contractors. There is indeed ‘one neck to choke’ if a security breach should happen, but there is no way to comfortably assure a customer that no breach will happen. Moreover, operators will be able to have better control over network security in a way that is consistent with their security policy with COTS hardware (whitebox) under Open RAN setup.

Thirdly, very few, if any, of the currently available network components are produced in a single country. On the contrary, Open RAN assures that customers can pick sub-components in a way that enables them to know *exact* the country of origin for all parts of their network. Furthermore, the issue of security is

mitigated by the multitude of suppliers available for each layer, reducing the geopolitical risks associated with relying on just one vendor. Security issues was raised so far primarily by the United States, but it is bound to become an issue in more countries.

- *“Commercial off-the-shelf (COTS) hardware may not fully support advanced 5G functionality (e.g., machine-to-machine, Ultra-Reliable Low-Latency Communication)”*

Leading hardware vendors, both for generalized hardware and specialized chipsets (e.g., graphics processing units) are providing Telco grade COTS hardware for DU deployment and are shifting considerable parts of their budgets towards development of optimized chipsets for Telco use cases to stay ahead of hardware demand.

Capturing the benefits of Open RAN and mitigating the issues that it brings requires choosing the right partners

Although, in general, the promise of Open RAN is clear in terms of the cost reductions and accelerated innovations it can bring, the specifics matter. A standard is not worth more than the implementations based on its framework.

As the Open RAN landscape is still forming, a plethora of vendors are stepping into the field. Just as the benefits of Open RAN rely on a new vendor landscape, the valid concerns around Open RAN relate to the potential immaturity parts of it.

Making Open RAN real requires an ecosystem. To get the full benefits, while minimizing the risks, these associates need to be chosen carefully. Specifically, we believe the desirable characteristics of a vendor for operators are that they:

- a. Are authentically committed to open interfaces, and take an active role in building the new ecosystem that will disrupt the current RAN market
- b. Do not have strong economic interests to sustain the status quo and/or support a market structure with long-term lock-in of vendors
- c. Should be viable in the long-term, i.e., have sufficient financial backing to be able to commit to the long-term and capital-intensive projects that will be required
- d. Should, to minimize the deployment risks, have experience in real field deployments (not just in the lab) of networks that people rely on day-to-day
- e. Have sufficient SI capability to minimally ensure their parts work together with the other parts of the solution, and preferably sufficient experience to take on responsibility beyond the supply of their immediate components (e.g., installation, maintenance, broader SI capabilities)
- f. Are sufficiently influential in the Open RAN standard setting bodies to be able to act as proxy for early adopting operators to shape the future of Open RAN

NEC's strengths as a partner to the industry in Open RAN adoption

The primary purpose of this white paper is to explore and elucidate the virtues and complexities of Open RAN. Still, it is no secret that some players in the industry are stronger proponents of Open RAN than others. We, as NEC, consider ourselves as the vanguard of this disruption to old traditional ways and methods of building networks.

We do, however, recognize that there are, with Open RAN, as with all other cutting-edge technologies, challenges to overcome during the first phase of adoption.

We believe that for any industry participant who is serious about Open RAN, we have a lot to offer as a partner, both to make sure that the promise of Open RAN (both cost savings and innovation) comes through, as well as de-risking its introduction to the industry.

Specifically:

- We are the only large-scale global industry player that **stands fully behind Open RAN** and has done so from the beginning. We have no vested interests in previous technology rollouts and 'nothing to lose'
- We have under our belt **real live deployments**, of networks that are working and provide service to customers every day
- We invest to be at the **absolute forefront** of Open RAN technology evolution, be it higher order Multiple-Input, Multiple-Output configurations or Multi-access Edge Computing and RAN Intelligent Controller solutions for the future
- We take **quality and reliability seriously** – anyone who studies the steadfastness of the networks we have built in Japan since the first 1G deployment will see that we stand true to our promise
- We **share your concerns** about Open RAN – SI is and will for some time remain an issue. We pledge to pre-emptively run interoperability tests with the partners we put forward, so that we can guarantee the same dependability of the solution as we do for all components we provide. As a result, this enhances the entire Open RAN ecosystem to grow and mature
- We are a core driving force behind making Open RAN robust and transparent to mitigate concerns of network security and interoperability through **extensive collaboration with governments and industry bodies** (e.g., Testing interoperability technologies in UK under NEDO Japan initiative; membership in Open RAN Policy Coalition, O-RAN Alliance, Telecom Infra Project; participation in O-RAN Town initiative led by Deutsche Telekom).

Conclusion

To sum up, the further roll-out of 5G is inevitable and it will therefore load the telecom industry with high CapEx levels. This proposition is presented to investors at a time where the monetization of network buildout is uncertain and historic examples (e.g., 4G) are not inspiring confidence.

In this context, Open RAN offers an alternative. Adopting it allows for structural cost-cutting on a significant scale (~20% on average), while at the same time gaining agility from the network which will be required to monetize the true 5G use cases that we have yet to imagine.

Open RAN is no longer a dream supported by a couple of startups, but also by established operators and network vendors. It is a movement of significance, with massive backing of both monetary and intellectual capital. Adoption is happening now across the Globe and if you believe in the industry executives, this wave has just begun. All leading operators will have a part of their network as Open RAN in a couple of years and for most of them it will be their predominant network strategy. At the same time, we acknowledge that the risks of Open RAN are real, especially when it comes to 'first-time' integration of disparate components from unproven vendors.

In order to lead and thrive in the industry, choosing the route towards Open RAN is all but given. Our hope, for those that tread that path is that they choose to do so in collaboration with a vendor that can deliver the promises of Open RAN (cost savings and innovation) while minimizing the risks (through experience and pre-emption).