Nokia response:

Inquiry into co-investment in multi-carrier regional mobile infrastructure

November 2022

About Nokia

We create technology to connect the world. We develop and deliver the industry's only end-to-end portfolio of network equipment, software, services and licensing that is available globally. Our customers include communications service providers whose combined networks support 6.1 billion subscriptions, as well as enterprises in the private and public sector that use our network portfolio to increase productivity and enrich lives.

With an end-to-end portfolio that is unique in the industry, Nokia can work in partnership with operators to deliver "real 5G". Nokia's in house 5G mmWave Small Cells and AirScale BTS provide in-building and outdoor coverage, while our Microwave Anyhaul, Cloud native RAN, antennas, and 5G cloud-native core are part of approximately half of our agreements to date. Beyond our mobile networks portfolio, Nokia has excellent FP5 network processor-based IP routers and PSE-4 chipset powered optical networking - our customers can use the Nokia Network Services Platform to make this into full-5G-strength software defined connectivity 'smart network fabric' secured by Nokia Security Orchestration, Analytics and Response (Nokia SOAR) to ensure resilient 5G. Globally Nokia has been selected by more than 230 operators to supply 5G networks.

Nokia is a global leader in 5G standardization and technology innovation with a strategy specifically designed to support the Australian market – with Nokia’s 5G mmWave technology supporting high-capacity areas together with low band 5G supporting rural and regional areas. In 2021 Nokia together with TPG Telcom set a 74km 5G cell range world record in regional NSW, a record that still stands today. Nokia is proud to be a strong partner in the current roll-out of 5G in Australia, continuing our 120-year presence here.

Because the security of our technology is integral by design, Nokia has always undertaken extensive monitoring and testing (including independent validation) of our products, at all stages from inception, development, manufacturing, deployment and maintenance. All Nokia products and our supplies are subject to the same security verification procedures to ensure their integrity, regardless of their place of development, manufacture or operation.

Through our research teams, including the world-renowned Nokia Bell Labs, we are leading the world to adopt end-to-end 5G networks that are faster, more secure and capable of revolutionizing lives, economies and societies. We have invested in two state of the art 5G experience centres in Australia, the 5G Futures Laboratory in Sydney and the 5G Industrial Incubation Laboratory in Adelaide.

Nokia adheres to the highest ethical business standards as we create technology with social purpose, quality and integrity. For more information: https://www.nokia.com/networks/5g/

Disclaimer: This response is based on Nokia's current understanding of the market dynamics and various standards bodies; these dynamics are changing and hence our views may update with these changes

Introduction and submission summary

Nokia welcomes the opportunity to respond to the Australian Government's House of Representatives Standing Committee on Communications and the Arts on its inquiry into co-investment in multi-carrier regional mobile infrastructure.

Nokia acknowledges that the Committee will:

1) Report on the costs, feasibility and public benefits associated with the deployment of

a. infrastructure which supports a single mobile carrier, and

b. the various models for infrastructure which supports multiple mobile carriers;

2) Report on community views on single carrier vs multi-carrier outcomes; and

3) Report on examples of successful multi-carrier outcomes and their applicability in the Australian context.

With an end-to-end portfolio that is unique in the industry, Nokia is a trusted partner for customers and governments globally for the deployment of critical networks across mobile, fixed and cloud networks.

In Australia, Nokia has been selected by both Optus and TPG Telecom as a key supplier for their network deployments of 3G, 4G and 5G, as well as a being the major supplier to the National Broadband Network for fixed network technology solutions. Nokia is also a supplier to various enterprises which have deployed Nokia Private Wireless networks using apparatus licenses, including 27 mines across in Australia.

As such, Nokia is pleased to support the Australian Government as a global agnostic technology partner and assist with the development of government's telecommunication policies to provide equitable connectivity particularly communities in regional Australia.

Our submission covers areas of interest to the inquiry, as follows:

- Network sharing and various models supporting multi-carrier outcomes
- Successful examples and their applicability in the Australian context
- Connectivity during natural disasters: advancing a multi-carrier Public Safety Network
- Impact connectivity can have on climate change

Network sharing and various models supporting multi-carrier outcomes

Nokia is the world leader when it comes to mobile network sharing with more than 50 shared networks globally. Nokia has always been at the forefront of network sharing technology, supported by the fact that we supplied the world's:

- First commercial shared network
- Largest commercial shared network
- Only commercial GSM-WCDMA-LTE MOCN

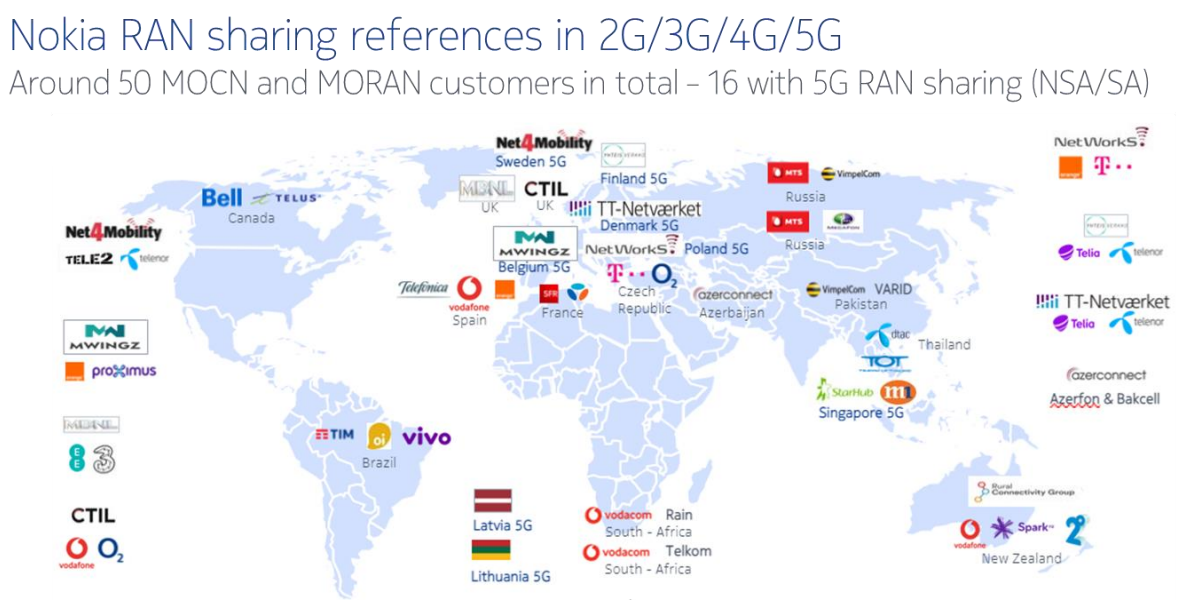

Figure A. - Nokia shared networks around the globe.

Many experts believe network sharing will become a necessity for most Mobile Network Operators (MNOs) as they face soaring 5G and 6G deployment costs as the need for expanded coverage, new network technologies and network capacities increases. Typically, network sharing is broken into two categories: *active sharing and passive sharing*, but there are also other alternatives to this such as *geographic network sharing* or *national roaming*.

It does not always have to be the MNOs that provide the network, a network provided by a third party for use by one or more MNOs is referred to as a *neutral host network*.

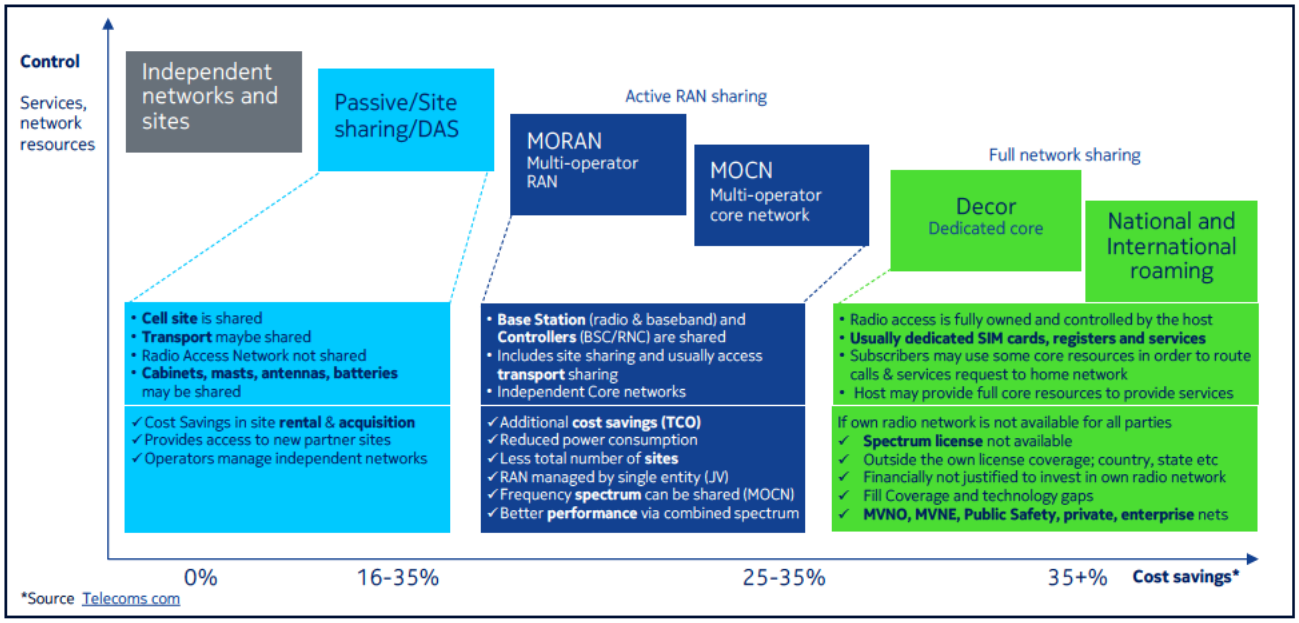

Figure B. – The different options for network sharing.

Passive or Site Sharing

In Passive Sharing the physical site and site-related passive elements, such as facilities, towers, feeders, antennas, power supplies, back-up systems and air conditioning may be shared. The mobile backhaul of the site may also be shared. The main benefits of this approach are lower site lease, construction and site operational costs. While passive sharing calls for independent investment by the MNOs for most of the radio and backhaul equipment, it gives each MNO full control of their network parameters.

Passive sharing is considered the simplest form of network sharing because operators can fairly easily share sites and still maintain their autonomy and strategic competitiveness. But the cost savings associated with passive network sharing is more limited compared to more involved methods of network sharing. Often passive sharing is the first step towards to more complex network sharing arrangements.

Active RAN Sharing

Active RAN sharing refers to the active layer of the network such as the radio access network (RAN), which consists of antennas, transceivers, base stations, and backhaul networks and controllers being shared.

There are two main types of active RAN sharing, these are Multi-Operator RAN (MORAN) and Multi-Operator Core Network (MOCN). The difference between MORAN with MOCN is whether the air interface/spectrum is dedicated (each MNO maintains its own frequency band) or shared (both MNOs pool some/all of their spectrum bands). Parts of, or the entire mobile backhaul and core

network may also be shared. This type of network sharing requires joint decision-making on investments and operational aspects between MNOs either directly or using a joint "network" company that sits between both MNOs. MNOs may also choose to split the deployment of Active RAN networks geographically.

Roaming-based Sharing

Roaming-based sharing allows customers of one operator to roam seamlessly onto a "host" operator's network and potentially vice-versa. National roaming is sometimes seen as an alternative to network sharing especially where one MNO may have a larger coverage footprint than the other. In the roaming-based approach, operators do not share any of the network infrastructure and customers simply "roam" onto the roaming network as is done when customers "roam" abroad.

From an operator's perspective it has several disadvantages, one being that some not all services offered in the HOME network may be available in the ROAMING network and also roaming customers may see their phones displaying the name/logo of the ROAMING network when these customers are roaming.

National roaming can also be used as a means of achieving agreed geographical splits between sharing operators, with each operator deploying its own network and using its own spectrum within its given area. In cases where national licenses are issued, not all the available spectrum can be used unless by prior agreement.

Neutral Hosts

Besides the MNO sharing models described above, there is another type of network sharing that is referred to as the Neutral Host model. Rather than resulting from a technological trend, the proliferation of Neutral Host model deployments is an element in the on-going transformation of the landscape, driven by:

1. MNOs increasingly separating network assets to improve balance sheets
2. Private equity capital being invested in hard infrastructure
3. Willingness of independent "InfraCos" to be involved in active domains based on early commercial successes in the fixed domain
4. Government funding to reach underserved and or completely unserved regions.

In this model, the network is built and potentially operated by a third party, with MNOs buying coverage/capacity through a Network as a Service model. This approach typically required the MNOs to allow the Neutral Host operator access to their spectrum.

This approach is sometimes referred to as a Single Wholesale Network (SWN) and this type of network could be built with some type of private-public partnership in which the network is operated by a neutral host and then multiple parties use the network.

MNOs benefit from reduced capital costs and more working capital to devote to other aspects of the business, such as accelerating rollouts of new services and improving network coverage, as well as the opportunity to spread infrastructure costs over multiple years. Another benefit includes not having to deal with real-estate purchases and permissions.

Using neutral host infrastructure can be a low-cost way for MNOs to enter new markets and geographical areas and can also create a new revenue stream for MNOs prepared to share their infrastructure with other operators.

Neutral host models are also expanding beyond passive elements into active areas of network infrastructure. The natural progression for tower companies has been into the radio access network (RAN), kitting out cell towers with open-access antennas and installing small cells and distributed antenna systems (DAS) for in-building coverage.

Fibre-based neutral hosts like SiFi Networks are eyeing the growing demand for mid-haul and backhaul capacity for 5G networks. Having already invested in last-mile fibre connections to urban homes and businesses, MNOs can then obtain some of that capacity for their cell sites rather than laying their own fibre.[1]

Data centres are a third area of growth, addressing demand for low-latency data processing driven by cloud gaming and other consumer or enterprise real-time services. The shelters at the base of each cell tower are ideal locations for edge data centres, and as tower companies will likely run virtualized RANs there, it makes sense to open the spare compute capacity up to MNOs – and other players, such as equipment vendors or enterprises – on an infrastructure-as-a-service basis.[2]

[1] Neutral Host Delivers the Value of Openness | Nokia
[2] https://www.nokia.com/networks/insights/neutral-hosts-path-to-5G-profitability/

Technology evolution that enables multi-carrier deployments

Through the continuous evolution of technology, radio product capabilities continue to enhance allowing more spectrum bands to be supported by each radio module. In the past a single radio module was required per spectrum band, today multi-band/multi-technology radios such as those available from Nokia can significantly reduce the amount of infrastructure per tower. The benefit of this can be seen below. This also translates to additional savings such as reduced installation cost and power consumption. This is applicable to any of the sharing models mentioned earlier.

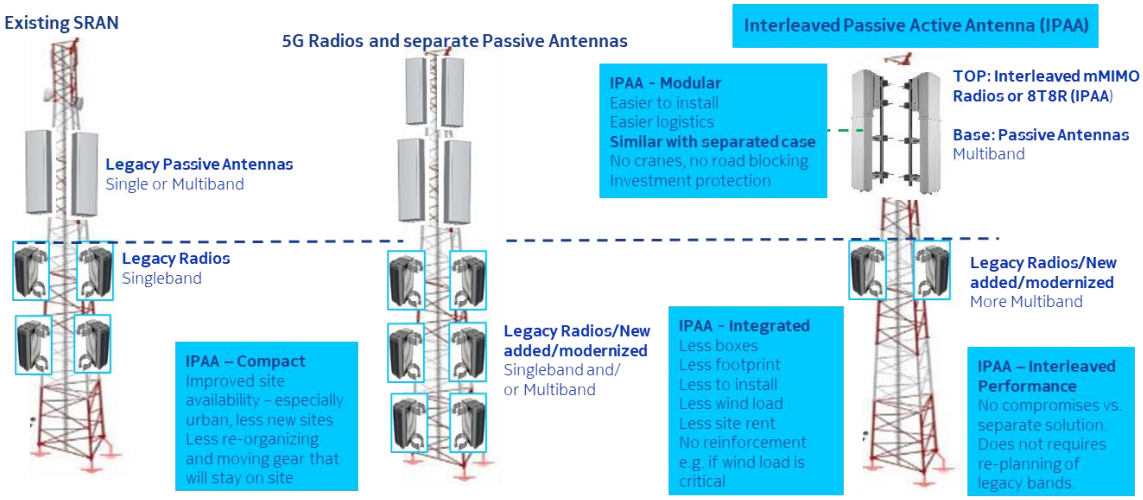

Figure C. – The reduction of infrastructure on a tower through the deployment of multi-band radios

Frequency license Options

The availability of spectrum will continue to be most valuable asset required for a mobile network. There are a number of options for spectrum for the neutral host. They could be such a thing as “bring your own spectrum” where each operator can bring their own spectrum and deploy that carrier on the a radio which is managed by the neutral host. This spectrum can be deployed as MORAN or MOCN depending on each operators need and willingness to share spectrum for the benefit of the regional community.

Successful examples and their applicability in the Australian context

The investments needed to deploy or upgrade connectivity, particularly in regional Australia are substantial. And despite higher demand, more network traffic does not necessarily translate into higher profitability for operators to adequately reap the rewards of their investments.

While this makes investment decisions a challenge for the traditional owner-operator, it makes a compelling argument for outsourcing or sharing network infrastructure investment. There is increasing interest in open access networks: networks owned by a "neutral" host and leased to one or more tenants who operate services over the network.

Chorus and the National Broadband Network: "Neutral Host" models for fixed services

In the case of rural expansion, equipment mutualization significantly accelerates and reduces the cost of network deployment, which will allow underserved and or completely unserved regions to be reached. In fact, the biggest examples in the fixed domain are Australia's National Broadband Network (NBN Co) and New Zealand's Chorus network – both open access layer two wholesale networks.

Both Chorus and NBN Co are notable examples of a neutral host model for fixed services; both established by respective Governments to facilitate infrastructure separation, increase competition while making broadband available to underserved areas.

Chorus was formed in March 2008 as a Telecom business unit operating at arm's length from the rest of the organisation, to give all service providers access to the local fixed line network.

Similarly, NBN Co was announced in 2009. The policy aimed to address Australia's broadband availability and performance and to facilitate the structural separation of Telstra by providing an optic fibre alternative to its copper access network.

The benefits of both networks have been far-reaching by providing communities equitable access to connectivity, expanding much needed coverage in regional areas while creating competition through availability of hundreds of retailers.

A similar model could be utilised for mobile wireless coverage where public, private partnership could come together to extend coverage into the regional area. Shared infrastructure models, such as the neutral host model in remote areas is a win-win proposition for operators, governments and consumers.

This is a model adopted by the Victorian Government as part of the *Connecting Victoria Program* which stated that some of the upgrades and new towers would be used by multiple

telecommunications providers and that the agreement to share infrastructure, will give more Victorians a choice of mobile provider and improve competition[3]

In addition, several large cities are exploring the neutral host model because network densification equipment reduces the environmental footprint and visual disturbance.

The same argument applies for indoor 5G mobile coverage, where landlords can negotiate with a single entity instead of separately with each operator, which usually results in long delays and added cost of coverage.

Regional Australia Network [RAN] – FSG Australia

Using a neutral host is a cost-effective way to extend coverage into rural areas: In Ireland, for example, European tower company Cellnex Telecom invites MNOs to register spots that their own infrastructure doesn't reach, so it can consider them in its rollout strategy.

Here in Australia, rural carrier Field Solutions Holdings (FSG) selected Nokia and Mavenir as its primary technology vendors to build Australia's fourth mobile network. Both companies will power FSG's neutral host and domestic roaming trials under MBSP5A – the Federal Government's Mobile Black Spot Program Round 5A.

FSG plans to deliver 4G and 5G services in rural, regional and remote areas of the country. FSG will also be delivering private 4G LTE and 5G service offerings. FSG, has secured 5G spectrum holdings. Specifically, Nokia and Mavenir together will supply FSG with 4G and 5G radio access networks and mobile core.

The rollout of FSG's Regional Australia Network [RAN] will commence in the 2023 financial year, according to the carrier, with the company hoping to deliver its 4G/5G mobile network in rural, regional and remote areas, as well as private 4G/5G networks for agribusiness, mining and government.

By embracing new models, it was claimed, the cost to deliver the solutions could be kept to a minimum. FSG is in the process of delivering 19 new place-based networks across Australia, with the networks comprising of over 100 individual sites, each of which will be 4G and 5G capable, neutral host and roaming ready when delivered in FY23 and FY24.

[3] Boosting mobile connectivity across Victoria | News | About us | Jobs, Precincts and Regions (djpr.vic.gov.au)

Rural Connectivity Group (RCG) New Zealand

In August 2017, the Rural Connectivity Group (RCG) was appointed by the government to be the infrastructure provider to bring 4G wireless broadband, 4G voice calling (VoLTE) and 3G mobile service to rural New Zealand under the Rural Broadband Initiative 2 (RBI2) and the Mobile Black Spot fund (MBSF).

This project is funded by the government's Telecommunications Development Levy, and an additional $75M has been provided by New Zealand's three MNOs – Spark, Vodafone and 2degrees – with CIP managing the distribution of funds to RCG.

New Zealand is the first country in the world where all MNOs will share RAN and antenna on each tower. The unique funding model was established as it was acknowledged no single party could deliver the programmes and that a public/private partnership was the only viable option

RCG is an independent entity established to acquire site locations, build, operate and maintain the wireless network across rural New Zealand. While owned by the MNOs, it has been established to provide wholesale capability and there is a requirement for every site to have capacity for a WISPs. Each MNO also committed equal amounts of spectrum for the network.

The RCG network uses Nokia 4G Multi Operator Core Network (MOCN) which has been deployed successfully with three mobile network operators. This technology allows RCG to deploy one Radio Access Network (RAN) to connect to the three different core networks of Spark, Vodafone and 2degrees.This allows all three mobile networks to provide services to these rural communities from just one cell site that requires only three antennas to operate.

Once the project is complete it aims to deliver coverage to at least 38,000 rural homes and businesses. It will also provide mobile coverage to 1,200 kms of state highways and provide connectivity to at least 152 tourist destinations by December 2022.

NOKIA

Connectivity during natural disasters: Advancing a multi-carrier Public Safety Network

From September 2019 through March 2020, Australia had one of the worst bush fire seasons in its recorded history which was then followed by cyclones and widespread floods in 2020 and 2021, with significant loss of life. Total economic losses have risen into the tens of billions of dollars.

These events here in Australia and subsequent others globally, brought on the urgent need for advanced public safety communications around the world. Public Safety Agencies (PSAs) today often rely on legacy LMR/PMR networks, together with mobile network operators (MNOs) for their voice and data communications. This has resulted in a significant capability gap between the networks used by PSAs and those used by citizens:

- Citizens Command & Control centres are unable to share in real time images, video, and other situational awareness information with first responders that could be used to provide safer and more effective first response.
- First responders are unable to share and analyse images, video, and other situational awareness information among themselves to support safer and more effective first response.

In short, legacy LMR networks are inadequate to meet the challenges of today and the future, which is why PSAs globally are increasingly migrating to public safety mobile broadband (PSMB).

Nokia together with the NSW Telco Authority, TPGT and Optus demonstrated critical functionality and exhaustive testing of a multi-operator service delivery model with a with a dedicated core. This was to ensure it can provide critical communications support needed for frontline staff during emergencies and natural disasters.

Australia will benefit substantially from a multi-use, national, integrated PSMB network to serve its PSA communication needs. This network will support day-to-day operations, incident response, planned events and disaster response and recovery operations

The rollout of a highly reliable, pervasive, mission PSMB network across Australia will create significant value in terms of the disaster management and recovery operations, enhance the operational capability and performance of key government and government enabled agencies, and provide lasting socio-economic benefits.

With the new capabilities provided by a PSMB network, first responders will be able to:

- Access real-time video for enhanced situational awareness
- Share multi-media information to assist in decision-making
- Enjoy enhanced group communications – through push-to-talk and push-to-video functionalities as well as person-to-person communications.
- Use field sensors, IoT devices as well as wearables that will help monitor the situation in real-time and more importantly ensure the safety of public protection and disaster response personnel through use of biometric sensors

Use this rich set of data to digitally represent an unfolding incident or disaster and employ analytics in conjunction with mission-critical applications to realize “intelligent” control rooms, i.e., to prevent, protect and respond according to the nature and scope of different emergenciesThe shared-network approach offers many benefits, including real-time video and analytics for enhanced situational awareness and aligning the communication between all jurisdictions for better, more informed decision making.

It also provides enhanced coverage and reliability thanks to seamless roaming between the PSMB core and carrier networks; and preserved optionality for all RAN deployment models – including dedicated spectrum optionality; and a future-proof public safety core network which is 5G-ready. Notably, this model also preserves past investment by supporting interoperability of new mission-critical push-to-talk over LTE (MCPTT), mission-critical video (MCVideo) and mission-critical data (MCData) with existing legacy P25 based service through an interworking gateway.

Making multi-carrier PSMB a reality

Australia’s national multi-carrier PSMB proof of concept (PoC) architecture was designed to utilize PSMB-owned cores while preserving optionality for all RAN deployment models –including dedicated PSMB spectrum. Taking advantage of the MNOs’ radio access networks through a mobile virtual network operator (MVNO) deployment model, the trial exhaustively tested the multi-operator service delivery model and successfully proved this approach could provide critical communications support needed for frontline staff during emergencies and natural disasters.

For the trial’s test delivery models, Nokia provided a 5G-ready core network for the public safety agencies, mission-critical push-to-talk over LTE (MCPTT) and an interworking gateway with the legacy P25 system. The successful PoC will drive the requirements for a national public safety mobile broadband network and provide a future-proof solution as public safety core network running on LTE and 5G-ready. All Australian jurisdictions have agreed to participate in its development.

Australia’s use of two MNOs in the PoC is unprecedented, creating a new level of resilience and reach and capability for large territories.

Investment in public safety benefiting Australia’s regions

In addition, the deployment of a PSMB network could be leveraged as part of Commonwealth and/or State and Territory connectivity programs to expand coverage in regional and remote areas, therefore better maximising government funding.

This is a sentiment shared by Victorian Government in the submission to the 2021 Regional Telecommunications Independent Review (RTIR) where they state, “wherever Commonwealth funds

are made available (to expand carrier coverage), requiring commercial network providers to deploy PSMB capability alongside their networks would assist in the rapid deployment of PSMB."[4]

Due to the geographic nature of Australia, infrastructure deployment in regional and remote locations is cost prohibited, therefore every effort should be made to utilise and leverage government infrastructure. NSW Farmers submission to the RTIR recommended "maximising infrastructure efficiency and introduce roaming in regional, rural and remotes areas."[5]

Impact connectivity can have on climate change

At Nokia, we have a two-pronged approach to fighting climate change. First, we focus on our own carbon footprint, the impact on the environment from our own operations and from the use of our products and solutions. We make progress every day to minimize our footprint, even in the face of a significant increase in demand for our services.

In addition to reducing the footprint of our operations and our customers' operations, Nokia also works closely with our suppliers on reducing emissions in manufacturing, logistics and transportation. We work with our suppliers to develop, innovate and build capabilities to enable a more sustainable and transparent ecosystem, and we demand that our suppliers commit to sourcing materials from environmentally and socially responsible sources. We even encourage innovation in other sectors, for example, through our collaboration on CO2 neutral airfreight using Sustainable Aviation Fuel (SAF) in parts of our logistics.

Second, and by far our biggest impact, is our unique handprint, the positive impact of our technology on others. Nokia enables other industries, society, and individuals to decarbonize in a way that has an exponential positive effect on our world.

We have developed a range of chipsets that are substantially more energy efficient than previous versions, including introducing the FP5 chip which provides up to 75 percent reduction in power consumption of the FP4 chip, which allowed us to meet our 2023 power efficiency goals two years ahead of schedule.

Base station sites alone account for over 80 percent of the use phase emissions. Running idle resources and cooling systems consume a significant part of the energy. This means that energy-efficient radio network products and use of shared infrastructure can make a considerable difference. At Nokia, we have pioneered new liquid cooling systems for base stations, which are exponentially more efficient at transferring heat than traditional air fans, reducing energy consumption of cooling by up to 90 percent and CO2 emissions by up to 80 percent.

[4] Microsoft Word - Victorian Government 2021 RTR submission - FINAL September 2021.docx (infrastructure.gov.au)
[5] rtr2021-submission-no-648-nsw-farmers-pt-1.pdf (infrastructure.gov.au)

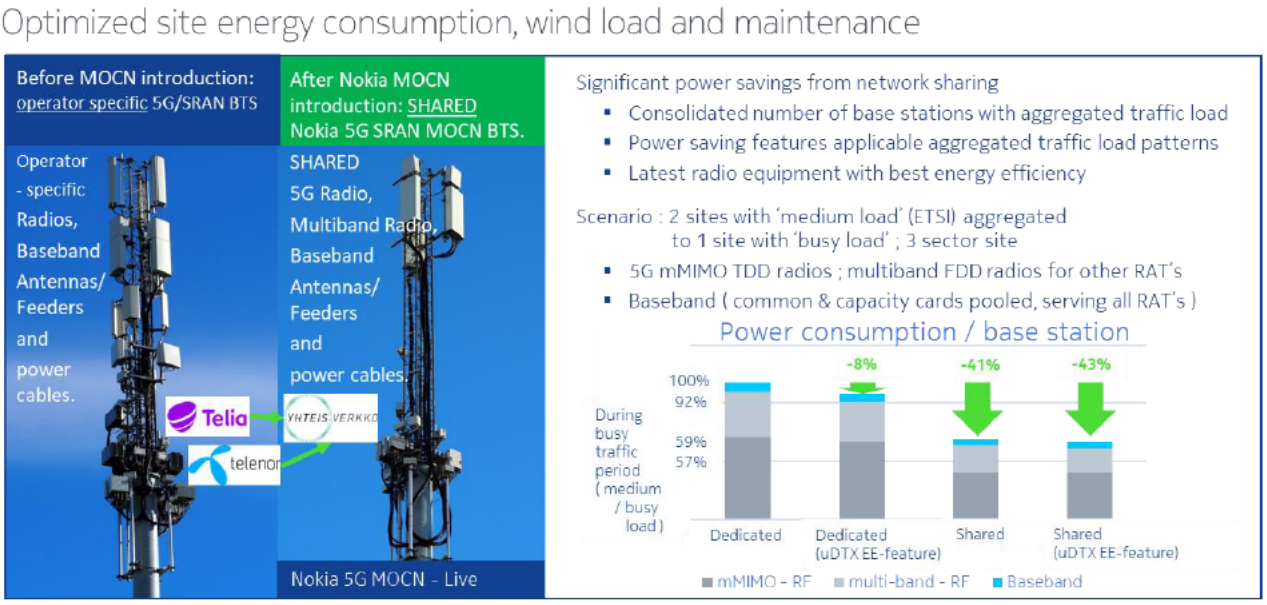

Figure D. – The reduction of power on a site through the deployment of multi-band radios

The above image demonstrates that energy consumption could be reduced by at least 41 percent in an active sharing context. Having shared infrastructure works towards the goal of reducing the regional carbon footprint as typically mobile operators are one of the largest energy consumers in the country. If the largest energy consumers in the country could reduce their carbon footprint because of reduced energy consumption due to infrastructure sharing, this could be a needle mover in Australia's decarbonization efforts.[6]

We also have introduced software, like AVA Energy Efficiency service, which applies Artificial Intelligence (AI) to further reduce energy usage in 5G and multi-vendor legacy networks by up to 20 percent. With fixed access technologies that bring broadband to homes and businesses, we have reduced power consumption by 38 percent since 2007, while speeds have increased 64x.

Enhanced connectivity and digitalization allow cities, industry, and society to be more sustainable. Nokia estimates that only around 30% of the world's economy is fully digitalized. That means that, through digitalization, we can make most of the global economy more productive and less wasteful. Connectivity and digitalization are key to many of the levers of industrial pathways to net-zero emissions.

Connected, digital solutions, capitalizing on the low-latency of 5G networks enable different industries to monitor and manage emissions, control power consumption and materials, and optimize their operations to reduce their carbon footprint. In fact, GSMA industry research has found that the mobile communications industry can enable other industries and society to reduce their emissions by up to 10x more than the mobile industry's own footprint. This multiplier effect of broadband adoption for fighting climate change cannot be overstated.

[6] Maximising energy efficiency - AMTA | The Voice of the Australian Mobile Telecommunications Industry

Policymakers can help facilitate the adoption of policies, practices, and technologies that will make a significant impact.

First, policymakers should officially recognize that digitalization and connectivity are green investments. There is a need to recognize the enabling effect of digitalization and connectivity solutions to help reduce the environmental footprint of economic activities across sectors, and hence to encourage public sector investments into such solutions and their timely deployment.

Second, governments should integrate green transformations into their own operations. Governments and industry should increasingly invest in "smart" infrastructure, incorporate renewable and decarbonized energy solutions, digitalization and connectivity, and circularity of products and materials.

Third, a critical part of digitalization is robust connectivity. The rollout of 5G and leading-edge fibre networks is the foundation upon which decarbonization can thrive. Through robust connectivity, society can accelerate the rollout of sensors, AR/VR, cloud, and analytics to maximize the sustainable benefits delivered through advanced technologies. Policies that encourage broadband adoption and the digital transformation of industry, that maximize the availability and the efficient use of spectrum for connectivity, and that enable rapid deployment of digital infrastructure will help meet climate change goals.

Fourth, policies should be consistent across all regions of the globe, where feasible, to maximize their impact and enable comparability and repeatability. Existing international standards and recognized global measurement methods should always be prioritized above the creation of new measures.

Fifth, governments, companies, and academics must work together. We need to collaborate across industries and through public and private sector partnerships so that all stakeholders can deploy their unique skills collectively in order to maximize our positive impact on climate change.