Nokia response:

ACMA's Spectrum Management Work Program "Five-Year spectrum outlook 2023-2028"

1 About Nokia

We create the technology to connect the world. We develop and deliver the industry's leading 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-6 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 and 6G research, 5G and 5G Advanced standardisation, technology innovation and offers a world-class portfolio of 5G products and solutions with a strategy specifically designed to support and drive the Australian market. Nokia is proud to be a strong partner in the current roll-out of 5G in Australia, continuing our 120-year presence here. Nokia has been selected by both Optus and TPG Telecom as a key supplier for the network deployments of 5G, including the required radio modules, as well as a major supplier to the National Broadband Network for fixed network technology solutions.

Nokia is also a supplier to various enterprises and industries which have deployed private wireless networks deployed using apparatus licenses, including for example 27 mines with 10 customers in Australia.

Leveraging the work of our research teams in the world-renowned Nokia Bell Labs, Nokia's industrial research lab, we innovate with purpose, pursuing responsible, sustainable technologies that will have a demonstrable impact on society. We are leading and fostering the digital transformation of society and industries by building end-to-end 5G networks that are faster, more secure and energy efficient. 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

2 Summary

Nokia welcomes the opportunity to respond to Australian Communications and Media Authority Consultation Draft, “Five-Year spectrum outlook 2023-2028”. (FYSO) As a leading player in the global communications sector, and contributor to the Australian market over many decades, Nokia is well placed to provide insight on market and technology trends, including industry structure and regulatory practice.

ACMA’s FYSO is a clear signal that all stakeholders should work together to meet the expected demand for spectrum for mobile broadband (public or private) and ensuring the speedy development of 5G. ACMA has identified several spectrum bands to address future needs to make 5G a reality for Australian citizen. Nokia welcomes the effort of ACMA on the regional and international discussions and its clear and transparent process in the planning of spectrum.

Overall Nokia would like to congratulate ACMA for adding three bands to the preliminary replanning stage: 1.5 GHz, the extended L band (1518–1525 MHz and 1668–1675 MHz) and 1.9 GHz as well as exploring the future use of the 1880-1920 MHz for Future Railway Mobile Communication System (FRMCS).

In addition, we also commend the ACMA for their expected to completion of 3 of our 4 mid-band spectrum allocations and progress arrangements to support the fourth allocation of restricted cells. This will facilitate a wide range of use cases including WISP, public mobile telecommunications services, enterprise and campus style private networks, such as mine sites, agricultural uses or industrial uses. Wireless Broadband services and P2P are important technologies for some critical sectors of the Australian economy.

It also supports the emergence of expanding use-cases and emerging technologies as detailed in ACMA’s Statement of Intent in which its working to support the Australian Government’s objectives and priorities such as enhancing regional connectivity and promoting investment, innovation and the adoption of new and emerging technologies.

Underpinning the digital transformation of society and industries is some form of fixed and/or mobile connectivity such as that provided by Passive Optical Networks (such as 25GPON) and 5G. For example, but not limited to, advanced materials and manufacturing, sensing, timing and navigation and transportation, robotics and space. Rail networks globally for example, are looking for improved on-board monitoring systems, for trains equipped with IoT connected sensors. Legacy 2G communications technology for railways such as GSM-R, will be replaced by 5G and FRMCS.

At Nokia, we strongly believe that 5G adoption and digitization of industry will be created by an ecosystem of partners – government, industry and academia – working together to bridge

industries and fuse the digital and physical worlds together. It is industries such as agriculture, transport, energy, smart cities; advanced manufacturing who will lead the adoption of 5G, 5G Advanced and 6G.

5G technology was designed to enable business transformation in addition to providing faster connectivity for consumers. In fact, energy and manufacturing firms show the highest awareness of 5G and are exploring its potential for advanced use cases including infrastructure maintenance, remote machine control, and cloud robotics. However, more needs to be done to demonstrate examples and use cases that meet sector-specific needs.

The 5G Innovation Initiative was just one example of a funding mechanism which provided an opportunity to do just this; cross collaboration between industries plus academic research to bring technological advancements to life. However, a decision was made to axe this initiative.

There needs to be appropriate programs and policies which foster a collaborative ecosystem across industries as well as between industry and academia. In addition, it is critical that these mechanisms do not just consider programs for emerging technology but also current technology such as 5G to ensure Australia is maximising its investment and providing opportunities for industry to test this technology and its applications.

Nevertheless, Nokia is also encouraging ACMA to:

1. Start initial investigation for 600 MHz and explore the whole UHF band (such as 450MHz and 410MHz bands for private broadband networks in Australia)
2. Fast track completion of the extended C-Band 3.3-4.2GHz allocations
3. Ensure an optimal use of the upper 6GHz for IMT use
4. Support mechanisms to drive 5G adoption and digitization

3 Further comments:

3.1 UHF spectrum

Availability of additional UHF spectrum (in the 470-694/698 MHz range) can bring great benefits to achieve improved coverage, capacity and performance in sparsely populated areas and some suburban areas as well as in hard-to-reach locations (e.g., deep indoors). Beside enhanced mobile broadband services, it is necessary to address a growing range of applications requiring good propagation characteristics in an economically efficient manner.

The Government's response notably reinforced that work on the multi-operator national Public Safety Mobile Broadband (PSMB) be progressed by Government and the telecommunications industry. This will require spectrum and while the ACMA has highlighted that the Australian Government has set aside 2 x 5 MHz of spectrum at the lower end of the 850 MHz expansion band, consideration should also be given to exploring usage of the UHF band.

3.1.1 450MHz and 410MHz bands

The 450MHz and 410MHz bands could also be considered for private broadband networks in Australia (initially LTE) e.g. for public safety and the utilities, as this usage is occurring in other countries and so an equipment ecosystem is developing. Additionally, the 380-400MHz historically used for TETRA and Tetrapol public safety networks is another candidate band for private LTE broadband networks.

In Germany, 450connect GmbH is currently building and will operate the fail-safe platform for the digitalisation of critical infrastructures in Germany. The Cologne-based company is thus creating a decisive prerequisite for the decarbonisation and resilience of our national economy. For this purpose 450connect recently received the exclusive assignment of the 450MHz spectrum until 2040. 450connect is backed by more than 70 utilities, including Alliander, E.ON, a consortium of regional energy companies and the Versorger-Allianz 450, which includes numerous public utilities, energy and water suppliers with the participation of the EnBW-subsidiary Netze BW. With 450connect's new nationwide, highly-available and secure LTE450 radio network, operators of critical infrastructures will receive the platform they need to digitalize their infrastructure, implement the energy transition to decarbonization, and further secure the energy supply .

3.1.2 600 MHz

The 600 MHz band is rising in importance in countries in the Americas and in some countries in Asia-Pacific for IoT use in remote areas and for indoor penetration in urban

areas. In the United States, following the Voluntary Incentive Auction of the 600 MHz band, T-Mobile and Nokia completed the world's first 5G data transmission over "low-band" 600MHz radio spectrum back in November 2018. T-Mobile is looking for a broad and potentially fast rollout of 5G services across the United States on this band.

ACMA should consider the feasibility study and potential migration of existing services especially for the whole UHF spectrum. We encourage ACMA to further investigate the potential use of these bands and look to move 600 MHz under initial investigation.

3.1.3 1427 – 1518 MHz band

As Nokia stated in its response to the June 2022 review of the to the 1.5 GHz band, this band could be important in addressing longer-term demand for mid-band spectrum in particular support for new wireless broadband (WBB) and mobile-satellite services (MSS). However, Nokia acknowledges that there is a range of spectrum uses across mobile (aeronautical mobile), fixed (both point-to-point and point-multipoint), radio astronomy, and meteorological satellite services along with support services used to meet Universal Service Obligations (USO).

With regards to the USO, Nokia acknowledges that part of the 1.5 GHz band has been used for fixed point-to-point links and to deploy microwave systems for telephony services to meet USO requirements in remote and low-density areas. However, as Nokia stated in its response, the 2021 Regional Telecommunications Review - A step change in demand, highlighted that one of the key findings was the urgent need to consider the future of the USO to provide reliable voice services to rural and remote consumers.

While it was acknowledged the USO must be continued, the report identified the need for the USO to consider the long-term performance and delivery of voice services in advance of and beyond 2032, particularly in relation to copper continuity and the High-Capacity Radio Concentrator system. The recommendation was to reform the USO and allow for a 'technology agnostic' approach to USO service delivery, providing it exceeds the existing reliability standards of the current solution. This could therefore allow part of the 1.5GHz band to be considered for WBB and or MSS.

Nokia notes, several options have been considered over the last years in L-band. For the 1452-1492 MHz range of this band, the 3GPP band 32 is considered for Supplemental Down link (SDL). Following the last ITU-R World Radio Conference in 2019 (WRC-19), additional options for the entire 1427-1517 MHz band started to be considered, including not only SDL, but also FDD option (e.g., in Japan) and an all TDD option (e.g., as adopted now in the MENA region).

Those options, as defined in the ITU-R Recommendation M.1036, are represented below:

Nokia equally note corresponding 3GPP bands are available for all these arrangements for both LTE and 5G NR:

- SDL bands b32 (1452-1496 MHz), n75 (1432-1517 MHz), n76 (1427-1432 MHz);
- FDD bands b11 (1427.9-1447.9/1475.9-1495.9 MHz) and b12(1447.9-1462.9/1495.9-1510.9 MHz) in Japan, and the n74 (1427-1470/1475-1518 MHz) for Japan;
- TDD bands b50/n51 (1432-1517 MHz) and b51/n51 (1427-1432 MHz).

If ACMA is to take a decision of the future use if the L-band, Nokia recommends considering the possibility to open the entire 90 MHz of the band 1427-1517 MHz. In case the decision is to proceed with opening only a part of the spectrum for IMT, decision of how to make best use of it should be taken in accordance with the market demand.

3.1.4 1880–1920 MHz band

Nokia has contributed to both the November 2021 discussion paper and the options paper on replanning of the 1.9 GHz band released earlier this year. Through both submissions we re-iterated the position relating to the 1880–1920 MHz and the possible use that include the modernization of train communication system.

The rail sector worldwide is on the verge of a technological leap into the digital future. The rail system of the future will be characterized by data-intensive and partially latency-critical applications, which is one of the reasons why European railway operators are currently striving to soon introduce the 5G-based Future Railway Mobile Communication System (FRMCS).

5G offers a major opportunity for Australian rail operators to transform their operations for the better. Its high speed and extreme traffic handling capacity, together with ultra-low response times, highest reliability and support for massive machine type communication (IoT), will allow rail networks to improve safety, optimize costs and make their services more attractive to passengers in many ways. Such capabilities will make the telecommunication network the cornerstone of railways' ambitions for further digitization and automation.

In support of ensuring alignment between the Australian Rail Industry and FRMCS standards being developed for the Global Rail environment, Nokia recommended that ACMA aligned any technical decision with global standards such as 3GPP to allow licensees to benefit from the associated global economies-of-scale and more diverse product ecosystem, hence supporting overall 5G deployment. The ECC Decision 20(02) Harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR) clearly indicates 1900-1910 Band for FRMCS as a way forward but more importantly is that this band will be part of 3GPP Rel. 17 for the initial planned deployment.

From Australian railway operators' perspective, alignment with the larger European market means access to wider choice of suppliers and User Equipment's. However, it is important to note that GSM-R and FRMCS will co-exist for a certain period.

We also highlighted that the portion 1880MHz-1900MHz should be further considered and co-existence between DECT(-2020 NR) and other wireless technologies (IMT or MulteFire) should be further studied so business enterprise services operated by private entities within the confines of their own premises (i.e. Indoor use only) may be possible. In such a scenario where DECT and other wireless technologies are allowed to coexist in indoor environments in 1880-1900MHz, Nokia recommend that the spectrum from 1910-1920MHz remain as a buffer or guard band.

Railway operators have an opportunity to update their legacy networks and move to a new world of supreme safety, high operational efficiency and on-train mobile broadband. Offering high speed, high capacity and low latency, 5G can provide enormous benefits and will help rail operators move to a new era in automated operations and customer service. The FRMCS, based on 3GPP evolution towards 5G, has been proposed as a single global standard for railway communications. With GSM-R expected to be supported until around 2030, rail operators (including those in Australia) need to start planning early to migrate their existing networks to the new standard if they are to take full advantage of the opportunities.

Therefore, it is essential that spectrum requirements of Australian Rail Operators are addressed on a long-term basis in line with Nokia's responses to Options 3 and 4 which are reiterated below:

Option 3: Introducing arrangements to allow RMR in 1900–1910 MHz

Nokia support this option as this allows Rail Operators to introduce 5G/FRMCS. As there is no change to current arrangements, there are potential Interference concerns, especially in Metro areas closer to Rail corridors.

In such an option, Nokia would recommend the ACMA to consider keeping 1800 MHz for GSM-R and/or keep 1800 MHz for GSM-R/LTE and allow Rail operators to introduce 5G/FRMCS at 1900 MHz. The 1800 MHz spectrum can be released post migration or kept for enhanced operations. Note 10 MHz at 1900 MHz is fairly small allocation especially when considering a 5 MHz + 5 MHz deployment to support geo-redundancy at frequency layer. Rail networks are considered Mission Critical networks and as such required to support availability in the range of 99.9999%.

Examples GSM-R deployed in Melbourne / Victoria at 1800 MHz, GSM-R deployed in Sydney / NSW at 1800 MHz, GSM-R currently being deployed in QLD at 1800 MHz and WA currently being deployment of an LTE 15MHz carrier at 1800 MHz.

Option 4: Extending arrangements for SR WBB to the 1880–1920 MHz

Nokia also supports this option as this allows Rail Operators to introduce 5G/FRMCS. There are potential Interference concerns, especially in Metro areas closer to Rail corridors. This highlights the need for carefully coordination between LA WBB, PTP and other services and proposed RMR services. In such a scenario, Nokia would assume DECT and Multefire would be limited to indoor use, especially in close proximity to Rail corridor.

In addition, for any SR WBB services that are allocated to 1880-1920 MHz, there needs to be careful coordination to minimise interference concerns and proposed RMR Services, especially given that RMR services operating in 1900-1910 MHz band are TDD based and susceptible to interference

3.1.5 2 GHz

Nokia welcomes ACMA's outcomes on the 2GHz spectrum consultation in acknowledging the support for deployment of a complementary ground component (including direct air-to-ground (A2G) communications services . As Nokia highlighted in its response, A2G is internationally deployed in the 1980-1995/2170-2185 MHz (UL/DL) portion of the band and benefits of a complete off-the-shelf ecosystem.

Therefore, while Nokia acknowledges the ACMA comments that demand is likely to exceed supply, Nokia still recommends that at least 15 MHz of paired spectrum in the lower half of the band should be granted to the direct air-to-ground communication service on an exclusive basis, in the same spectrum range used by the European Aviation Network. Assigning the same band by ACMA for A2G services will benefit from the existing ecosystem and the international status: de-facto-standard, roaming, airworthiness-certified equipment.

3.1.6 The (extended) C-Band (3300-4200 MHz)

Global 5G harmonization is happening now, and the 3.3-3.8 GHz spectrum range is at the epicenter of this, being the spectrum for near-term deployment of robust 5G services. The 3.5 GHz range of bands will support a variety of applications, including enhanced Mobile Broadband, Fixed Wireless Access and Industry 4.0, with an ecosystem driven by two 3GPP defined bands: n77 (3300-4200 MHz) and n78 (3300-3800 MHz). Spectrum harmonisation also helps to achieve economies of scale, enables global roaming and reduces equipment design complexity.

The 3300-4200 MHz band offers the unique opportunity for largest amount of spectrum below 6 GHz. The amount of contiguous spectrum that can be made available in the 3300-4200 MHz range offers an interesting opportunity for the exploitation of the innovative capabilities of the latest IMT technologies, with reference to the 5G New Radio air interface which will deliver increased capacity and connectivity. 5G New Radio (NR) Band n77 has been

defined for 3.3-4.2 GHz covering the proposed range of 3.8-4.2 GHz. With demand also from other regions such as USA and Japan, Nokia expect a quickly evolving ecosystem for Band n77.

Nokia has long been an advocate of opening the entire 3.5 GHz range of bands, from 3.3 to 4.2 GHz, for 5G use. Indeed, the speed of 5G network deployment in the mid-bands, such as 3.5 GHz, can be significantly faster due to its propagation characteristics, which generally permit the reuse of the existing macro site grid that uses 1.8 GHz spectrum.

Nokia has also noted in past submissions that ACMA continue to investigate the potential future use of 3800-4200 MHz for private wireless networks. Through discussions with various stakeholders, Nokia are seeing a strong demand from Enterprise customers wishing to deploy 5G private wireless solutions either standalone or through a carrier depending on their use case and buying preference. Spectrum is used by different sectors like mining and energy companies.

Therefore, Nokia welcomes ACMA's proposal to allocate remote areas of the 3.4–4.0 GHz bands in 2022 using apparatus licensing, with additional allocations to occur in 2023 in regional and metropolitan areas through a mixture of spectrum and apparatus licensing.

Nokia noted its support for ACMA's preferred Option 3 as part of its response to ACMA's Proposed spectrum re-allocation declaration for the 3.4 GHz and 3.7 GHz bands. Option 3 proposed consolidation of spectrum licence arrangements between 3400–3800 MHz in metropolitan areas and between 3400–3750 MHz in all regional areas as well as consolidating AWL arrangements in regional areas into a contiguous 250 MHz bandwidth in the 3750–4000 MHz band.

This approach also aligns the entire band and benefits existing and new licensees by enabling the uninhibited deployment of 5G services and the use of mMIMO technology without performance compromise. From an equipment vendor perspective, harmonised solutions are preferred for any service to encourage larger scale deployments and economies of scale. This puts Australia under a framework consistent with other regions of the world and aligned with the outputs of 3GPP, positioning Australia to leverage the global 5G ecosystem to the greatest possible degree.

Option 3 also generally reflects Nokia's previous consultations including its submission to the September 2020 Re-planning of the 3700–4200 MHz band. Options paper which recommended extending the amount of contiguous spectrum available for spectrum licensing in major metropolitan centres as well as making more spectrum available for AWLs in both regional and remote areas within the 3700–4200 MHz band. Under Option 3, Nokia agrees and supports the ACMA's view that available spectrum can be more efficiently used and more AWL operators may gain access to larger contiguous channels.

As Nokia has expressed in previous consultations, this will facilitate a wide range of use cases including WISP, public mobile telecommunications services, enterprise and campus style private networks, such as mine sites, agricultural uses or industrial uses. Wireless Broadband services and P2P are important technologies for some critical sectors of the Australian economy.

It also supports the emergence of expanding use-cases and emerging technologies as detailed in ACMA's Statement of Intent in which its working to support the Australian Government's objectives and priorities such as enhancing regional connectivity and promoting investment, innovation and the adoption of new and emerging technologies.

Nokia see large economical value in the possibilities for enterprises to invest into private wireless networks using 3GPP technologies on their premises. Additional investment into private networks by private enterprises can significantly speed up the overall 5G take-up.

In fact, the Australian Mobile Telecommunications Association (AMTA) 5G Unleased: Realising the Potential of the Next Generation of Mobile Technology report highlights that "while businesses recognise the importance of 5G for accelerating business growth (62%) while 30% of businesses are not planning to take up 5G-enabled technologies or don't know. In addition, 59% of businesses surveyed had no strategy for exploiting 5G."

We expect that the digitization of the industries will continue to grow and, as such, their demand for spectrum to increase over time across the different sectors. Their spectrum needs will depend on the use cases in terms of coverage, capacity and performances and will be addressed by a combination of local access and wide national coverage, via private networks and public ones. It is therefore important to consider an efficient mechanism to ensure the best usage of the scarce spectrum resources and encourage cooperation between CSPs and industries.

Use of spectrum in urban areas

With regards to the use of spectrum in urban areas (urban excise spectrum), Nokia acknowledges that the ACMA is wanting to support three broad use cases: Wide-area Wireless Broadband (WA WBB); Macro cell local area WBB (LA WBB) and Restricted cell LA WBB.

As Industry 4.0 starts to become the norm, more and more countries for example Germany, are issuing local, private licenses of premium 5G spectrum to enterprises. Nokia see regulators in key industrial nations adopting similar approaches. In the US, deployments of industrial wireless networks are possible in the Citizens Broadband Radio Service (CBRS) band. In the Saudi Arabia, for example, the regulator CITC is investigating how to split the 3.8-4.2 GHz portion of the band between mobile service providers and vertical users. The option CITC is investigating the migration of the FSS stations from the 3.8-4.0 GHz part of the band and release it to MNOs, while proposing a light licensing regime under shared use of the 4.0-4.2 GHz portion for verticals. Other countries like China and Korea are also

investigating ways to use the upper part of this spectrum range. As such, Nokia would like to reiterate its support for Option A which is to:

- Develop spectrum licence arrangements for the 3400–3475 MHz band in urban excise areas.
- Develop apparatus licence arrangements for WBB in the 3800–4000 MHz frequency range, including arrangements to support both macro cell and restricted cell local-area wireless broadband.

Nokia also agrees with the segmentation approach as its likely to lead to more orderly and efficient use of the spectrum, allow different licence approaches to be used in each segment and the fact it has been adopted in some other jurisdictions (for example, in some European countries). Nokia also supports the allocation of 150 MHz within the macro cell LA WBB and 50 MHz within the restricted cell LA WBB

3.1.7 4.5 GHz – 4.8 GHz (n79)

We are observing an interest from countries in Asia to further investigate the potential use of this band. The 4.5GHz has been allocated in Japan in April 2019 and China is also considering this band for future deployment. In 2019, Taiwan's government released 100 MHz of spectrum in the 4.8–4.9 GHz band for public and private organisations to test 5G applications while South Korea has allocated 100 MHz.

it is important to note that in all cases 4.8–4.99 GHz spectrum has been allocated primarily as a back-up or supplementary band to 3.5 GHz, or for specific localised use cases. In Hong Kong and Japan, the main use case is localised private network deployments, with additional use in Hong Kong to provide eMBB coverage in specific locations where there is an issue with satellite interference. As indicated in the ACMA paper, the migration can be challenging, therefore we encourage ACMA to start study on potential use for 5G for additional capacity or for specific localised used cases.

3.1.8 6GHz (5925-7125 MHz)

With the identification of the upper 6 GHz band for IMT and licensed operation, significant economic benefits and boost of the 5G NR development for additional use cases such as industrial use case is expected to arise.

Nokia would like to re- iterate our position which in which it believes in the potential of the 6425-7125 MHz band to become an IMT band, providing a good compromise for coverage and capacity for citywide high-speed capacity. It is also in-line with AMTA's position on the basis that it is:

- Globally allocated to mobile on primary basis

- Good balance between coverage and capacity
- Economies of scale; ensure equipment availability in the long term
- Wide industry support: high priority band for most mobile operators and vendors. 3GPP has started standardization work.
- Demand driven by fixed wireless access, and mobile broadbandis also in line with

We highlight that the 6425-7125 MHz band is under study for IMT identification, as part of the WRC-23 AI 1.2. Studies are also on-going in 3GPP for the use of the 6 GHz range for LTE and NR, as well as in ITU-R for a potential IMT identification at WRC-23 with the least restrictive conditions for the band usage (e.g. highest possible output power targeting macro cell usage). 3GPP has also started a new study on IMT parameters for 6425-7025 MHz.

The lower 5925-6425 MHz band is outside of the WRC-23 framework. One option is to consider opening the band and providing a level playing field to both 3GPP (5G NR-U) and IEEE (Wi-Fi) technologies to coexist in this spectrum. We, therefore, recommend the adoption of technology neutral rules for this sub-band. However, when defining the technical rules for usage in the band, ACMA can consider the different international developments to avoid equipment and market fragmentation.

We also reiterate the need to consider the protection of the incumbent users for the fixed links, in the entire band 5925-6425/6425-7125 MHz. Nokia encourage ACMA to support the studies under WRC-23 AI 1.2 towards identification of the upper 6425-7125 MHz for IMT. Therefore, Nokia's supports ACMA's decision to refocus their attention to future arrangements in the upper 6 GHz band (6425–7125 MHz) after considerations at the International Telecommunication Union's (ITU) World Radiocommunication Conference (WRC) 2023 (WRC-23)

Nokia are supportive of technical rules that are harmonized at a greater extent with other markets for this band, to ensure the development of a harmonized ecosystem. Moreover, we note a momentum within the mobile industry to set 6 GHz as priority for future IMT spectrum.

3.1.9 40 GHz (37–43.5 GHz)

The 37-43.5 GHz band presents an excellent opportunity for global harmonisation and implementation (also by use of a tuning range). The 37-40 GHz band (39GHz) has already been decided in the United States and Nokia considers that this band will be used for early deployment. In Europe, the 40.5-43.5 GHz frequencies are not extensively used by incumbents and therefore, could provide large additional 5G capacity in subsequent upgrade steps to 5G networks as more and more services will be put onto 5G networks.

3.1.10 100 GHz (Terahertz)

Nokia has been a major contributor in 6G and Terahertz communications in various standards bodies and industry fora (e.g., 3GPP, ITU, Hexa-X, Next G Alliance, ITU-R Vision 20230 etc.) and is also providing guidance to regulatory agencies (e.g., as a member of the Technological Advisory Council of the Federal Communications Commission).

Recent research in Terahertz spectrum has opened up many new avenues to overcome the inherent limitations of this spectrum band, and thus raised the possibilities of implementing new services that were unimaginable even a few years ago.

There are many use cases that are either not realizable or cannot deliver the required user experience in today's networks, including 5G, through the lower parts of the radio spectrum currently in use. It is expected that some of these applications will be implemented with 6G networks and through accessing higher frequency bands such as the Terahertz that can provide the necessary quantities of contiguous spectrum.

Global harmonization of Terahertz spectrum to encourage allocation of similar frequency bands globally will pave the way for collaboration among different countries to bring this fledgling technology to maturity. ACMA should consider its role given Australia's strong position in spectrum management.

Possible fragmentation may be due to diverse frequency allocations by national regulatory agencies across the regions, various authorization schemes and/or regulatory frameworks. Terahertz technologies being in such a nascent stage, this type of fragmentation can lead to innovation silos, not conducive to a global ecosystem, resulting in higher cost of solutions and eventually slowing down the technology growth.

It should also be noted that it is likely a major early adaptor of Terahertz spectrum technologies would be vertical industries and large enterprises who often have a global presence. Therefore, it would be desirable for such entities to have same spectrum range available across borders to be able to operate similar sets of equipment with same specifications in different countries.

International consensus is thus critically important for the evolution of THz spectrum technologies. Given the nascent nature of the technology, economy of scale will be critical for nurturing it. Without the support of a globally harmonized ecosystem, its development will be fragmented, and its benefits will take a very long time to reach the society.

With regards to technical standards, Nokia believe by bringing together different industry (e.g., telecommunication, satellite, as well as manufacturing, automobile, aviation, XR etc.) sectors together to form a joint development forum would likely bring about a set of common requirement specifications which will lead to harmonized evolution of the ecosystem.

A common set of standards will ensure seamless interoperability across terrestrial and non-terrestrial (including satellite) communications. All industries dependent on the lifeline of communications (including sensing and imaging) will benefit from a common set of rules and guidelines.

One crucial element of a potential activity could the development of a common international set of radio spectrum regulations. It is highly desirable that standards and regulatory bodies from all relevant industry sectors (e.g., 3GPP, ITU, IEEE, satellites etc.) are brought together in a common forum to agree upon a common set of requirements.

Finally, it should be noted that some countries are already allocating certain segments of the THz spectrum to provide opportunities for new technology development. An example is the decision from Ofcom to enable greater access spectrum in the 100-200 GHz frequency range on flexible service neutral basis. As another example, the Federal Communications Commission (FCC) in the United States has created a new category of experimental licenses for the 95 GHz to 3 THz range (called Spectrum Horizons License) and stated “These licenses would offer increased flexibility compared to conventional experimental licenses by providing for longer license terms, license transferability, and the ability to sell equipment during the experimental term. 21.2 gigahertz of spectrum within this range has also been made available for unlicensed use (116-123 GHz, 174.8-182 GHz, 185- 190 GHz, and 244-246 GHz) to encourage innovation and solutions testing.”

Nokia considers essential access to the THz spectrum should be done in a timely and affordable manner to allow for the testing of technologies, applications and ensuring innovation can happen.

4 Technology supporting growth in major industries

Nokia's technology supports growth in major industries such as agriculture, energy, smart cities, transport, bringing new economic opportunities and prosperity to communities around Australia. While today's 5G networks are starting to bring the future to life, 5G-Advanced and 6G are in great demand to fully realise it. In fact, Nokia anticipates 5G-Advanced will contribute up to $8 trillion in global GDP in 2030.

Real-life use cases include:

Mining and energy

TPG Telecom signed a Memorandum of Understanding (MoU) with Nokia in a partnership to develop mobile private network (MPN) innovations for the mining and energy sectors. The agreement will collaborate across both companies' extensive portfolios to provide flexible technology solutions and encourage digital and operational technology transformation in mining.

It is expected new innovations will come from the partnership, specifically in productivity and worker safety, as 5G terminals will connect machinery and sensor assets to an internet of things (IoT) or operations platform to monitor productivity and safety of workers.

Agriculture and on-farm connectivity

TPG worked with Nokia to demonstrate how 5G networks can complement image processing, computer vision and edge computing technologies to deliver benefits and improve efficiencies to the agricultural sector. Livestock counting is a critical component of livestock management.

Livestock including sheep are manually counted at exchanges and ports, with the potential for errors and inconsistencies. The project uses 5G to enable multiple high quality 4K video streams to count livestock at regional exchanges, automating the process and removing human error. A supporting 5G edge network process the counting on-site and relay the data in real time back to farmers on a tablet or mobile device. By minimising counting errors, especially during unfavourable conditions, will directly contribute over $13.2 million to the livestock industry each year.

Smart and sustainable cities

Nokia and the City of Melbourne conducted trials using Nokia Scene Analytics artificial intelligence (AI) technology to develop a deeper understanding of waste disposal behaviour. This allows the City to tackle the issue of waste dumping more efficiently and keep laneways

– the busy and narrow city streets and pedestrian areas – even more clean, safe and free of garbage.

Under its 'emerging technology testbed' initiative, the City of Melbourne worked with Nokia to leverage an existing network of installed cameras as internet of things (IoT) sensors to monitor one of the compactors. The Nokia Scene Analytics solution employed an AI-powered algorithm to filter and collate data from the cameras, while also combining other data sources, such as operational data on the compactor itself, to create real-time alerts and produce reports. Initial trial results demonstrate that Scene Analytics can support the City's objectives for better, safer citizen experiences while simultaneously lowering maintenance and down time costs for waste management services.

Nokia and City of Melbourne trial AI technology to keep city streets safe and clean | Nokia

Transport

In Perth, Western Australia Nokia was selected by the Public Transport Authority of Western Australia to modernise rail communications with private wireless and mission critical IP/MPLS covering 250 km of railway track and tunnels. The project includes designing and building and 5 years of maintenance for the PTA's communications system, with options for two additional lots of 5 years of maintenance.

Nokia selected by The Public Transport Authority of Western Australia to modernize rail communications in Perth with private wireless and IP/MPLS technologies | Nokia

At Nokia's National Incubation Centre in South Australia, Adelaide Airport is focusing on the introduction of 5G and AR/VR for the purposes of remote inspection and safety monitoring, incorporating real-time, high-quality and interference-free video streaming.

The Airport Control Centre (ACC) and Airport Operations Officers (AOOs) who provide 24/7 numerous safety and emergency response coordination will look to utlise 360-degree cameras on the AOO vehicles to reduce the number of trips by support personnel to assess and diagnose problems.

Nokia opens 5G Industrial | Department for Trade and Investment (dti.sa.gov.au)

Robotics

The '5G Connected Cobot' project located at the University of Technology, Sydney demonstrates how the higher speeds and lower latencies made possible by 5G technologies can enable cobots to interact with their surroundings – including nearby humans – in real-time.

Initial testing has shown that utilising Nokia's 5G capabilities to offload the processing required from the cobot to a computer "at the edge" extended its battery life as well as enhanced its performance. This approach can lead to significant power and cost savings, all while increasing the capabilities of the cobot.

During the testing phase of the project, the team added a variety of sensors measuring the world around the cobot. Multiple lidars were used to view the world as a dense collection of 3D points, similar to how autonomous cars operate. This allowed the robot to easily measure the distance and direction to people and objects around it with high accuracy.

Early findings suggest that fitting the cobot with a 5G modem to allow off board processing of its data marks a significant step towards ensuring collaborative robots can be the co-workers we want them to be in the future.

Nokia and UTS open the door to a 5G future with new research facility | Nokia

The Federal Government's 5G Innovation grant was just one example which provided an opportunity to bring technological advancements to life, by demonstrating their real-life application in industries such as agriculture, transport, energy, smart cities; advanced manufacturing etc; it is these industries who will lead the adoption of 5G+ and 6G.

In addition, these types of initiatives also help to enable digital skills of the future; Nokia alongside the University of Adelaide is assisting with the creation of the 5G training course; a great example of academia working with industry to build skills in the tech industry which is a key focus for the Australian Government in achieving their goal of 1.2million tech jobs by 2030.

And while digitisation of the industries will continue to grow and, their demand for spectrum will increase. However, their spectrum needs will depend on the use cases in terms of coverage, capacity and performances and will be addressed by a combination of local access and wide national coverage, via private networks and public ones. It is therefore important to consider an efficient mechanism to ensure the best usage of the scarce spectrum resources and encourage cooperation between CSPs and industries.

The 3GPP has analysed use cases and defined a set of functional requirements and system parameters related to communication services for each use case in each domain. Several of the developed service performance requirements have an impact on preferred spectrum management approach. High communication service availability can be reached through exclusive access to dedicated spectrum assignments and through protection from harmful interference.

Access to wide bandwidths is needed. The required service areas are typically geographically limited, covering one or several, local or regional areas, ranging from indoor coverage, up to few km². This means that frequency ranges below 4 GHz with sufficient transmit powers are preferred if outdoor coverage is required. Depending on the application, traffic may range from symmetric up to very asymmetric, in either direction requiring uplink/downlink ratio (UL/DL) flexibility from the technology, the deployment and the band regulation. Use of time division duplex (TDD) technology can provide the required duplex flexibility, though adjacent networks may need to be synchronized, which would limit the applicability.

5 Adoption of technology for a Greener Economy

Nokia also welcomes the Australian Government's commitment to achieving net zero emissions by 2050. In addition, it also welcomes the ACMA's comments that the "efficient use of spectrum can help in the effort to reduce emissions in a variety of ways through smart technologies.

Enhanced connectivity and digitalization allow cities, industry, and society to be more sustainable. However, 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 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. The multiplier effect of broadband adoption for fighting climate change cannot be overstated.

Below, are some examples of the critical role of connectivity and digitalization in driving sustainable transformation:

Agriculture

The world already produces enough food to feed the current population, but over-production, over-consumption, and supply chain issues lead to huge amounts of waste in some regions while other regions suffer from a food scarcity and malnutrition. According to some estimates, 30-40% of the world's food is lost or wasted during production, making up 8-10% of the greenhouse gas emissions. Connectivity can help us grow smarter, helping to get more food to those in need, while minimizing the negative environmental impact of agriculture.

Specifically, precision and vertical farming is using 5G connectivity, wireless remote monitoring, private networks, digital sensors, and AI-based analytics to minimize pesticide, fertilizer, water, and energy use, while also maximizing crop yields. Bell Labs Consulting estimates that if 15-25% of all farms adopted precision farming by 2030, it would lead to: (1) an increase in yields by as much as 300 million tons each year; (2) a reduction in farming costs of up to $100 billion annually; and (3) a reduction in water use by up to 150 billion cubic meters annually.

Manufacturing

A study commissioned by Nokia in 2021 found that conversion to smart manufacturing could contribute between 10–20% CO2 reduction by 2030 while improving productivity, operational efficiency, and providing other environmental benefits. We are working to help enterprises design, implement and manage private networks, increasing the flexibility of high-performance networks to support new applications like remote configuration and control, predictable uptime, and video as a sensor that enables remote diagnostics, remote predictive maintenance of machines, AI/ML inclusion for sensing faults during production, and remote assisted services with user experiences that incorporate AR/VR.

Smart Communities

Connectivity is driving a new paradigm in transformation services to communities. Pervasive mobile and fixed broadband can connect systems, assets, people, and machines at scale to drive greener, prosperous, safer communities which emphasize inclusion and access to services and opportunity for all.

The combination of 5G, next generation infrastructure, and neutral host models (i.e., shared infrastructure) provide a platform for economic development, inclusion, public safety, optimizing use of resources, and environmental benefits.

For example, transportation and logistics management drive traffic efficiency on roads and in ports, while reducing emissions. Smart sensors allow real time situational awareness for city services, improving resource use and reuse as well as waste management and overall efficiency, so that services and maintenance are provided only on an as-need basis, and ideally remotely where possible. Similarly, sensors combined with modeling and AI can aid in predictive maintenance, reducing failures of critical systems, such as water pipes and power lines.

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 (such as the smart communities use cases described above). 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 fiber 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 of technology. Policies that encourage broadband adoption and the digital transformation of industry, that maximize available 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. Existing international standards and recognized global measurement methods should always be prioritized above creation of new measures.

Fifth, governments, companies, and academics must work together. As identified in the use cases above, we have seen what the power of collaboration can do. 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.