Nokia response:

ACMA's Spectrum Management Work Program "Five-Year spectrum outlook 2022-2027"

About Nokia

We create the 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.

Nokia is a global leader in 5G standardization and technology innovation with a strategy specifically designed to support 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 nbn for fixed network technology solutions. Nokia is also a supplier to various enterprises which have deployed private wireless networks deployed using apparatus licenses, including for example 27 mines with 10 customers in Australia. Globally Nokia has been selected by more than 150 operators to supply 5G networks.

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. 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

Summary

Nokia welcomes the opportunity to respond to Australian Communications and Media Authority Consultation Draft, *"Five-Year spectrum outlook 2022-2027"*. (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.

In the promotion of 5G, ACMA has an important role especially related the 5G innovation initiative as stated in this draft FYSO. Through the initiative 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.

This sentiment was also shared by the ACMA at the recent CommsDay Congress in Melbourne as well as within the draft FYSO whereby AMCA acknowledge that, *"as a growing number of enterprises place greater value on having dedicated local area wireless broadband networks for* advanced*, secure connectivity, we are seeing increasing interest in accessing spectrum for private LTE, or private networks more generally. The construction and mining sectors were early adopters of private networks, which are now increasingly found in the agribusiness, transport and logistics, utilities, and hospitality sectors."*[1]

While ACMA has also supported the 5G innovative initiative by providing information to prospective applicants on bands where suitable spectrum might be available 'over the counter', Nokia's continues to encourage AMCA to promote the different licensing regime and the suitable spectrum that might be available 'over the counter' for localized use beyond grant opportunities.

Overall Nokia would like to congratulate ACMA for the successful auctions of low-band spectrum in the 850/900 MHz band and the high-band 26 and 28 GHz bands to support a wide range of use cases and services for both 4G and 5G technologies.

In addition, we also commend the ACMA for their ongoing efforts to allocate more spectrum for both localised uses and wide-area uses of wireless broadband through the consultation outcomes for mid-band spectrum in the 3.4–4.0 GHz band as well as exploring the future use of the 1880-1920 MHz for Future Railway Mobile Communication System (FRMCS).

[1] https://www.acma.gov.au/publications/2022-03/speech/speech-linda-caruso-general-manager-communications-infrastructure-commsday-congress-2022

Nevertheless, Nokia is also encouraging ACMA to:

- Start initial investigation for 600 MHz and explore the whole UHF band (such as 450MHz and 410MHz bands for private broadband networks in Australia)
- Fast track optimization of the extended C-Band 3.3-4.2GHz
- Start study on potential use of 4.5GHz/4.8GHz for 5G for additional capacity or for specific localised used cases
- Ensure an optimal use of the 6GHz
- Study the implementation of the FRMCS.

Further comments:

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[2] requiring good propagation characteristics in an economically efficient manner.

Noted in the draft FYSO is the release of the 2021 Regional Telecommunication Independent Review Committee report which highlighted spectrum access as a barrier to competition and innovation in regional telecommunications markets.[3] 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.[4] 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.

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

[2] A study of spectrum needs of C-V2X network-based (V2N) communications (cellular vehicle to everything) indicated that additional service-agnostic sub-1 GHz spectrum would provide connectivity for advanced automotive V2N services in rural environments with affordable deployment costs. The study concludes that: "... c) At least 50 MHz of additional service-agnostic low-band (< 1 GHz) spectrum would be required for mobile operators to provide advanced automotive V2N services in rural environments with affordable deployment costs. d) At least 500 MHz of additional service-agnostic mid-band (1 to 7 GHz) spectrum would be required for mobile operators to provide high capacity city wide advanced automotive V2N services." See: https://5gaa.org/news/the-new-c-v2x-roadmap-for-automotive-connectivity/ .

[3] https://www.infrastructure.gov.au/department/media/publications/2021-regional-telecommunications-review-step-change-demand

[4] https://www.infrastructure.gov.au/department/media/publications/australian-government-response-2021-regional-telecommunications-independent-committee-report-2021

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[5]
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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.

1427 – 1518 MHz band

The 1.5 GHz 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).

As such Nokia will provide further details in response to the review of the 1.5 GHz band consultation paper which was recently released for comment.

1880–1920 MHz band

Nokia responded to the ACMA's discussion paper on exploring the future use of the 1880-1920 MHz earlier this year.

Through our submission we would like to re-iterate on position related to 1880–1920 MHz band. *Nokia welcomes the opening of a discussion related to 1880-1920 MHz and the possible use that include the modernization of train communication system. FRMCS is set to become the global standard for railway communications. This mobile broadband-ready technology will enable you to*

5 https://www.nokia.com/about-us/news/releases/2022/02/14/nokia-chosen-by-450connect-to-supply-network-technology-for-lte450-critical-infrastructure-network-in-germany/

improve safety and operational efficiency, support innovative passenger services and accelerate your digital transformation. FRMCS also minimizes network latency and uses cloud technology, which will help you automate train operation and support broadband M2M communication.

Nokia strongly recommends that ACMA aligned any technical decision with global standards such as 3GPP. This allows the 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)* [6] 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. Current and future spectrum allocation for railway will be both crucial for support high bandwidth industry 4.0 applications.

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.

As mentioned in the discussion, spectrum is used by different sectors like mining and energy companies. Wireless Broadband services and P2P are important technologies for some critical sectors of the Australian economy. Nokia strongly encourage ACMA to facilitate the use of this spectrum for (private) industrial use.

We also consider that the portion 1880MHz-1900MHz should be further consider and co-existence between DECT(-2020 NR) and other wireless technologies (IMT or MulteFire) should be further study so that business enterprise services operated by private entities within the confines of their own premises may be possible.

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[7]. As Nokia highlighted in its response, A2G is internationally

[6] 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) ECC Decision (20)02 (cept.org)
[7] Replanning the 2 GHz band options paper.docx (live.com)

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.

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 particular 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.

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. Therefore, as outlined in the recent consultation papers for mid-band spectrum, Nokia supports 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.

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. However, it should be noted that Nokia expect demand for new spectrum will be particularly high in regional area 2 and major regional centre zones and suggest the ACMA ensure spectrum in these areas remains available for future private enterprise and innovative use cases.

In regard to the AWLs in remote areas, as highlighted in Nokia's recent submission, Nokia supports ACMA's allocation quantum policy to ensure deployment of new and innovative technology, a range of use-cases and users, and promoting competitive markets. In addition, Nokia also supports the ACMA adoption of an 'allocation window/allocation principles' approach to manage scenarios where demand may exceed supply and apply a principles-based approach rather than first-in-time which would see the allocation outcome decided by the sequence of applications.

With regards to the ACMA's recent *Proposed spectrum re-allocation declaration for the 3.4 GHz and 3.7 GHz bands* consultation, Nokia would like to reiterate its support for Option 3 as it provides for consolidated spectrum licence arrangements as well as consolidating AWL arrangements in regional areas into a contiguous band. It also generally reflects Nokia's previous 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[8].

However, regardless of whether the consolidated AWL arrangements sit within the upper or lower band in regional areas, Nokia expect demand for new spectrum will be particularly high in regional area 2 and major regional centre zones noting that large portions of this band are currently allocated to NBN Co in these areas. Therefore, Nokia suggest the ACMA continue to develop policies to ensure spectrum in these areas remains available for future private enterprise and innovative use cases.

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 such, Nokia again reiterates it support for Option A to develop spectrum licence arrangements for the 3400–3475 MHz band in urban excise areas and AWLs for WBB in the 3800–4000 MHz frequency range, incl. support for 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.

[8] https://www.acma.gov.au/consultations/2020-07/planning-options-3700-4200-mhz-band-consultation-222020#submissions

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.

6GHz (5925-7125 MHz)

Nokia would like to re- iterate our position which is also in line with AMTA's position:

- We 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.
- 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 take into account 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.

We encourage ACMA to support the studies under WRC-23 AI 1.2 towards identification of the upper 6425-7125 MHz for IMT.

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.

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.

Connected industries

It is worth further highlighting that Nokia 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.

The 3GPP has analysed use cases and defined a set of functional requirements[9] and system parameters related to communication services for each use case in each domain. Several of the developed service performance requirements[10] 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.

The 5G Alliance for Connected Industries and Automation (5G-ACIA) addresses[11] major challenges of 5G, highlighting spectrum and operator models. In order to meet extremely demanding latency and reliability requirements, licensed spectrum and protection from harmful interference are highly preferred.

Investment cycles of vertical industries differ from cycles of the telecom industry: cycles for media and entertainment are typically shorter, ranging between 2-3 years, for automotive industry 7-8 years, energy, manufacturing and mechanical industries 25 years, and for oil & gas from 10 to 25 years. Partly due to this difference, vertical industries may prefer to deploy their own networks. Furthermore, the timing for investing in wireless communications depends solely on their own business plans. Vertical industries require the assurance that for their networks there will be a continuity of service, without unjustified price increases, spectrum re-farming or technology upgrades over their planned life span.

On the other hand, deploying and operating a wireless network for IIoT is not their core business, but an enabler for optimizing operations and productivity, enhancing security and safety, and improving planning and decision making. This means that the cost of spectrum should be affordable, suitable authorization process would be application based, and that the applications should be allowed to be submitted any time, based on the business need. It also means, that the license duration should be comparable to the investment cycle, and that overall regulatory certainty is needed for years to come.

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[9] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on Communication for Automation in Vertical Domains (Release 16), 3GPP TR 22.804, V16.1.0 (2018)
[10] 3GPP: TS 22.261, v16.6.0 - Technical Specification Group Services and System Aspects; Service requirements for the 5G system; Stage 1 (Release 16). (2018).
[11] 5G Alliance for Connected Industries and Automation (5G-ACIA): White Paper, 5G for Connected Industries and Automation, (2018).

Spectrum for vertical industries is an increasingly important consideration as 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.

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.